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TESTING THE QUALITY OF THE ORTHOFOTO DMC III LARGE FORMAT CAMERA AERIAL PHOTOGRAPHY FOR BASE MAP ACCURACY SCALE 1:5000

Muhammad Farhan[1], Wikan Jaya Prihantarto[2]

[1]Student of the Remote Sensing Technology Study Program, Universitas Negeri Padang,
[2]Lecturer in Remote Sensing and Geographic Information System, Universitas Negeri Padang
email: mfarhan171202@gmail.com

ABSTRACT: This study discusses the quality testing of the DMC III LFAP camera for base map accuracy at a scale of 1:5000. The objectives of this research are to analyze the resolution quality of DMC III LFAP orthophoto images and to assess the geometric accuracy of DMC III LFAP orthomosaics based on Independent Check Points (ICP) measured in the field.This research employs both qualitative and quantitative methods. The study focuses on two main aspects: the resolution quality of orthophoto images and geometric accuracy based on ICP measurements. The research data includes DMC III aerial photographs from 2021 and field ICP observations. The methods used in this study involve orthophoto processing, ICP measurements using Geodetic GPS, and geometric accuracy analysis with the Root Mean Square Error (RMSE) method. Accuracy evaluation is conducted by comparing orthophoto coordinates with field observations.The results indicate that the resolution of the generated orthophoto images meets the quality standards for a scale of 1:5000 based on Per BIG Number 1 of 2020, with a reliable level of accuracy. However, geometric accuracy testing shows that the orthomosaic results have an error level exceeding the tolerance limits set by Per BIG Number 6 of 2018, making them unsuitable for base map accuracy at a scale of 1:5000.

Keywords: DMC III Camera, Aerial Photography, Orthomosaic, Map Accuracy, RMSE, ICP

1.INTRODUCTION

In this modern era, the increasing demand for aerial photo mapping across various fields has led to the development of diverse methods in aerial mapping. The emergence of advanced camera technologies and aerial imaging platforms, along with their rapid progress, has significantly influenced mapping processes, time utilization, efficiency, and the overall quality of the results. The use of manned aircraft platforms is increasingly being abandoned due to their limitations compared to drones, such as higher risks related to human resources, greater operational costs, and the technical expertise required to operate them. These factors have become major considerations when evaluating investment in manned platforms equipped with large-format cameras (Al Ayyubi et al., 2017).

The mapping requirements for a 1:5000 scale demand data quality that is strongly influenced by the platform and camera used. One example of such an application is the Detailed Spatial Planning (RDTR). The use of manned aircraft for aerial photography can be the most suitable option when considering the need for spatial data with wide-area coverage, high precision, and high accuracy, all of which can be achieved within a relatively shorter timeframe.

The Leica DMC III is a manned aerial platform-based camera system categorized under Large Format Aerial Photography (LFAP). One of its key advantages lies in the integration of panchromatic and multispectral CMOS sensor technology, offering a cross-track resolution of up to 25,000 pixels. This capability enables the acquisition of highly detailed imagery, making it particularly suitable for large-scale mapping applications such as spatial planning. Despite these advantages, the utilization of LFAP systems employing the Leica DMC III requires further evaluation, particularly concerning resolution quality and its applicability in generating base maps at a 1:5,000 scale to support detailed spatial planning (RDTR) data requirements. Geometric quality is assessed based on positional accuracy or field measurements, whereas resolution quality is evaluated through the accuracy of processed aerial imagery.

2.METHOD

2.1. Tools and materials used

The following are the tools and materials used in the research.
For the tools, namely:

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a. Hardware
   - Hi-Target V60 Geodetic GPS was employed for Independent Check Point (ICP) measurements.
   - A Personal Computer (PC) was utilized for processing LFAP DMC III data as well as for handling ICP observational data.

b. Software
   - AgiSoft
   - Global Mapper
   - Microsoft word & Excel 2019
   - ArcMap
   - Hi Target Geomatics dan Trimble Bussinese Center (TBC)

1. Research stage

Problem identification is a critical process undertaken to highlight the core issues addressed in this study. It serves to define and delimit the scope of the research problem, thereby guiding the investigation toward specific objectives and facilitating the derivation of meaningful results. The literature review serves as a methodological approach in this study, involving the utilization of various written sources to collect, analyze, and interpret information. Its primary objective is to develop a comprehensive understanding of the research topic. Key areas explored include Large Format Aerial Photography (LFAP), LFAP DMC III data processing, geometric accuracy assessment, and the use of Ground Control Points (GCP) and Independent Check Points (ICP). These topics are examined through references such as books, scholarly journals, and academic papers authored by researchers and experts, particularly in the field of photogrammetry. Pre-survey preparation was conducted in light of the constraints that prevented direct acquisition of aerial imagery for this study. Accordingly, the preparatory phase focused on the collection of Independent Check Point (ICP) coordinates in the field, which serve as the most recent dataset to be evaluated.

Data Acquisition This stage corresponds to the preceding phase, focusing on the collection of relevant data, which includes:

1. Measurement of Independent Check Point (ICP) Coordinates This activity was conducted to obtain field-based positional data (X, Y, Z), serving as reference points for evaluating the geometric accuracy of DMC III aerial imagery.
2. Download of DMC III RAW Data The dataset utilized comprises raw imagery acquired over the Padang urban area in 2021. As direct image acquisition was not feasible, the downloaded imagery from the DMC III camera was first converted into RAW format. The extracted data were organized into four partitions or folders, containing GNSS-IMU records and aerial photographs.

a. Data Processing

1) Aerial imagery data processing in this research are:

1. The initial stage in Agisoft involves the photo alignment process within the workflow menu, where radiometrically corrected images are imported into the software.

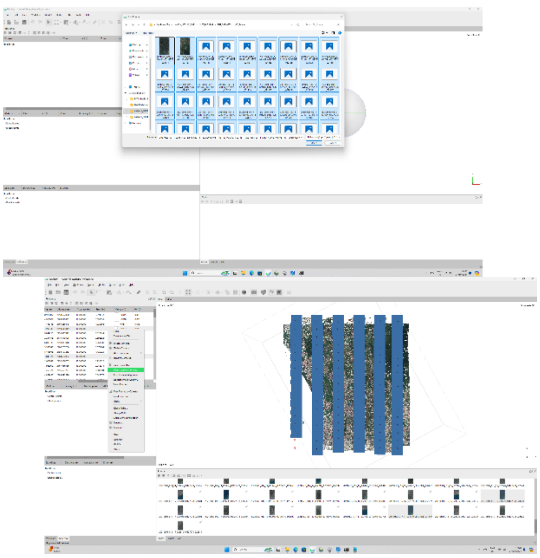

Figure 1. Align Photo Processing

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2. Subsequently, Exterior Orientation Parameters (EOP), comprising six parameters, are input and adjusted accordingly, followed by the integration of Ground Control Point (GCP) coordinate data.

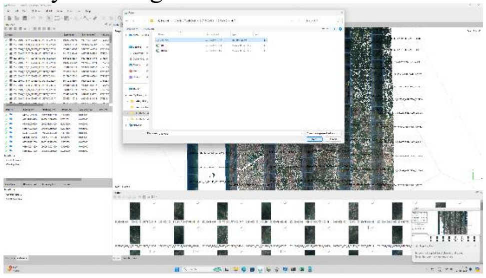

Figure 1. Input EOP and GCP

3. The next step entails georeferencing the aerial imagery using field-acquired GCP measurements.

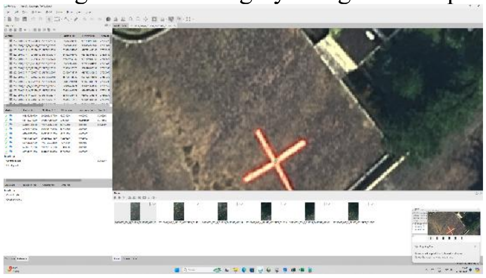

Figure 2. Georeferencing

4. The workflow continues with the generation of Dense Cloud, Mesh, and Texture Model, which are integral components of the 3D reconstruction process in photogrammetry. These steps aim to produce a precise digital representation or surface model of the object. However, due to practical constraints, the settings were modified to 2.5D, resulting in a non-fully 3D output. This limitation may be attributed to errors encountered during the aerial triangulation (AT) phase.

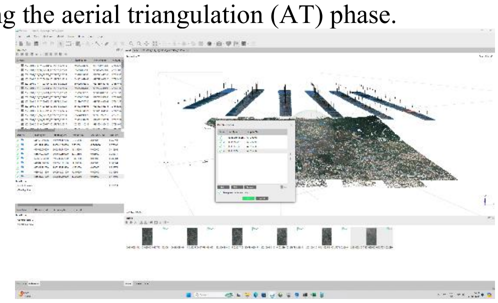

Figure 3. Batch Methode

5. The process proceeds with the construction of a Digital Elevation Model (DEM), which serves as the basis for generating an orthomosaic. The orthomosaic is then used to produce the final orthophoto.
6. A measurement plan is developed to acquire coordinate data that will serve as reference points for evaluating the geometric accuracy of the resulting orthophoto, specifically through Independent Check Points (ICP).

Figure 4. Distribution of GCPs/ICPs on the Model and Field ICP Acquisition

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7. Field acquisition of ICP coordinates was conducted using a static method, with data processing performed in radial mode. A total of seven samples were collected.
8. Geometric accuracy assessment was performed by comparing positional data. The ICP coordinates were used as benchmarks against the model and the latest field measurements. Accuracy evaluation employed RMSEr and RMSEz formulas, where RMSEr represents horizontal error in the 2D plane (X, Y coordinates).

   RMSE Horizontal = $\sqrt{\frac{D^2}{n}}$ $D^2 = \sqrt{\text{RMSE}X^2} + \text{RMSE}Y^2$

   $D^2 = \sqrt{D[(X\ DATA - X\ CEK)^2 + (Y\ DATA - Y\ CEK)^2/n}$

   And vertical (Coordinate z)

   RMSE Vertical = $\sqrt{\frac{(Z\ DEM - Z\ CEK)^2}{n}}$

   The geometric accuracy standards applied in this study refer to the Regulation of the Geospatial Information Agency (Perka BIG) Number 15 of 2014, which adopts the United States National Map Accuracy Standards (US NMAS) as a reference. According to these standards, the evaluation of horizontal and vertical accuracy is based on the Root Mean Square Error (RMSE) values derived from the comparison between orthophoto data and field measurements.

2) Geometric Accuracy Assessment of Orthophoto
   The geometric quality assessment was conducted to address the research question concerning the geometric accuracy of orthophoto data generated from aerial imagery captured using the Leica DMC III LFAP system. The evaluation of geometric accuracy was carried out by comparing the orthophoto coordinates with Independent Check Point (ICP) measurements. This assessment was guided by the standards outlined in the Regulation of the Geospatial Information Agency (Peraturan BIG) Number 6 of 2018.
3) Data Visualization and Result Presentation Stage
4) This stage involves the presentation of outcomes derived from the preceding data processing steps. The Root Mean Square Error (RMSE) values, reflecting geometric accuracy, are presented in tabular format. Additionally, the Agisoft-generated report for the Leica DMC III orthophoto is included to support the findings. This stage also encompasses the formulation of conclusions and the interpretation of results in response to the research questions and hypotheses, based on the conducted analysis.

3. RESULTS AND DISCUSSION

3.1 Image Processing and Orthomosaic Generation

The aerial photo processing using the DMC III LFAP camera resulted in 105 images, with a flight altitude of 2.84 km and a total coverage area of 162 km². The processing workflow included handling the raw data downloaded from the DMC III camera to obtain the necessary parameters for orthomosaic generation in Agisoft Metashape. The input aerial photographs were initially not tied to ground GCP coordinates; therefore, the output produced at this stage is considered an uncontrolled orthophoto. After the GCPs were incorporated and georeferenced, the orthophoto became fully controlled. The following is the DEM processing output as generated in the Agisoft report:

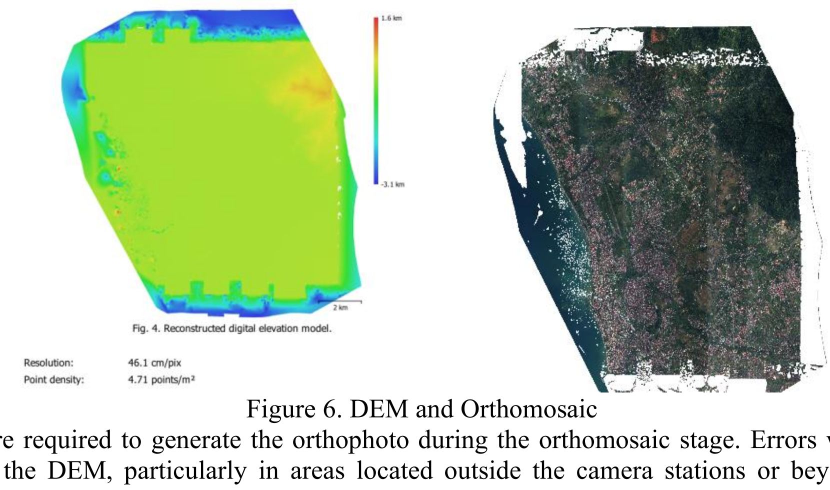

Figure 6. DEM and Orthomosaic

The DEM results are required to generate the orthophoto during the orthomosaic stage. Errors were identified along the edges of the DEM, particularly in areas located outside the camera stations or beyond the image acquisition coverage of the aerial platform; therefore, these erroneous sections needed to be removed. The processed DEM can be used as a fundamental dataset for determining or analyzing surface elevation within the study area. The resulting orthomosaic is presented in Figure 3.1, generated from the Agisoft report. The final output produced a mosaicked orthophoto, in which the spatial reference was established by tying the Ground Control Points (GCPs) to the orthophoto.

Figure 7. Orthomosaic of the Koto Tangah Area, and Parts of Kuranji and Nanggalo

Following the orthomosaic process, the orthophoto was clipped to focus on a specific area of interest, as shown in Figure 3.2. The selected region includes parts of Koto Tangah and Kuranji subdistricts, located between the coordinates 0°52'33.44"S, 100°22'15.53"E and 0°52'34.38"S, 100°24'8.58"E. This clipping was performed due to military and security considerations, as the orthophoto contains sensitive infrastructure and strategic objects.

3.2 GCP and ICP Measurements

The Ground Control Point (GCP) measurements were obtained from field observations conducted in Padang City in 2021, carried out concurrently with the aerial photography campaign. As shown in Figure 4.4, a total of nine GCPs were distributed evenly across the survey area, and their positions were plotted on the orthophoto. The ICP measurements were used to evaluate the geometric accuracy of the orthophoto by comparing them with the model ICPs that had already been integrated with the previously referenced GCPs.

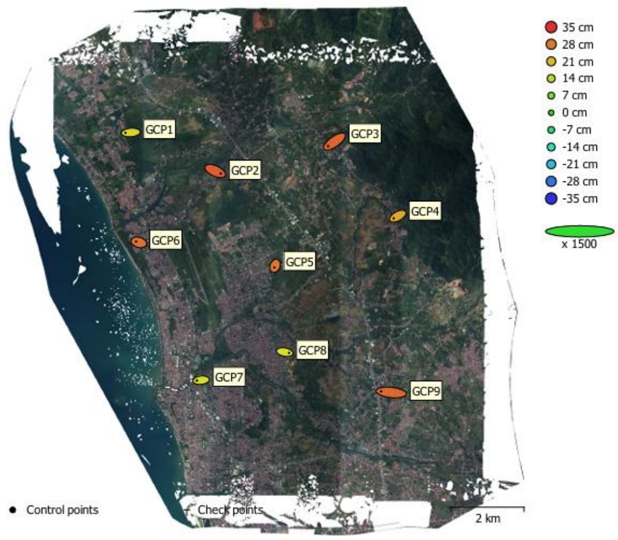

Figure 8. Orthophoto with GCP

In collecting GCP data in the field, several important aspects must be considered, particularly the parameters that influence the accuracy of the measurements. These parameters are crucial for achieving coordinate precision with a low RMS error, typically less than 5 cm. Additionally, the spatial distribution of the GCPs within the survey area must be carefully planned to minimize geometric distortion. Another important parameter is the physical identification of the GCPs, such as ensuring that the measured objects remain stable and unchanged over long periods of time, are clearly recognizable, and are visible in the orthophoto. Furthermore, the measurement method used also plays a significant role. The following presents the resulting RMS error values.

Count	X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total (cm)
9	19.6153	7.38162	25.1674	20.9582	32.7513

Table 1. RMS Error Control Point

Nama	X (m)	Y (m)	Z(m)
GCP 1	9906921.4877 m	648550.7997 m	-2.9753 m
GCP 2	9905814.5968 m	651149.9169 m	8.7532 m
GCP 3	9906561.1450 m	654082.0005 m	46.1555 m
GCP 4	9904590.6502 m	655874.0382 m	12.1356 m
GCP 5	9903246.4225 m	652613.9740 m	-2.4213 m
GCP 6	9903955.0015 m	648834.8880 m	-4.8902 m
GCP 7	9900158.9281 m	650501.7020 m	-4.3536 m
GCP 8	9900915.9219 m	653012.5112 m	-0.4605 m
GCP 9	9899864.2603 m	655531.3312 m	13.0803 m

Table 2. Field GCP Coordinates

Errors were obtained from the GCP measurements conducted in the field in 2021, with a total of nine deteted GCPs. The resulting errors were 19.6153 cm in the X direction, 7.38162 cm in the Y direction, 25.1674 cm in the Z direction, and 20.9582 cm for the XY error, with a total combined error of 32.7513 cm. These results are based on the Agisoft Metashape generated report.

The GCP measurements were carried out prior to the aerial photo acquisition, with a total of nine control points. However, for the geometric accuracy assessment of the DMC III orthophoto, the evaluation was limited to the predefined analysis area. Because the orthophoto was clipped to a specific boundary, only several GCPs within this area were included in the accuracy test, and these GCPs are highlighted in orange in the table.

ICP Model Coordinates (m)				Ground ICP Coordinates (m)			
Name	X	Y	Z	Name	X	Y	Z
ICP 1	655.100,32	9.900.269,56	49,6288	ICP 1	655100	9900270	15,465
ICP 2	653.378,64	9.901.206,35	40,6731	ICP 2	653379	9901210	12,43
ICP 3	654.133,56	9.902.984,74	42,5455	ICP 3	654134	9902980	-3,185
ICP 4	654.901,67	9.902.250,65	45,6528	ICP 4	654902	9902250	15,158
ICP 5	654.768,64	9.903.986,45	46,0685	ICP 5	654769	9903990	8,772
ICP 6	654.282,71	9.905.438,43	52,7802	ICP 6	654283	9905440	15,869
ICP 7	652.884,93	9.903.495,53	41,0634	ICP 7	652885	9903500	9,551

Table 3. ICP Model and Field Comparison

In Table 3, the ICP field observations were conducted in Koto Tangah District and partially in Kuranji District, using seven sample points. The observations were carried out with a Hi-Target V60 geodetic GPS receiver using the static absolute positioning method, which employs only a single receiver. The measurement procedure followed the Geospatial Information Agency (BIG) standard for Order-5 class surveys, which includes a 25-minute observation duration, single-frequency phase measurements as the primary data for position determination, a radial observation setup, and a data recording interval of 5 seconds. The Z-coordinates on the model or orthophoto were obtained from the DEM generated during the orthomosaic processing. These values were extracted in ArcToolbox by matching the X and Y coordinates of the orthophoto, which revealed a significant gap or discrepancy when compared to the field-measured coordinate.

3.3 Spatial Resolution/GSD Quality of the DMC III Orthophoto

Based on the processing of the DMC III raw data and the resulting mosaicked orthophoto, the final orthophoto achieved a spatial resolution or Ground Sample Distance (GSD) of 11.5 cm per pixel. The total coverage area was 162 km², acquired at a flight altitude of 2.84 km, using 105 images captured over Padang City in 2021.

Referring to the standards issued by BIG, both the United States Geological Survey (USGS) and the Geospatial Information Agency of Indonesia (BIG) specify that the required spatial resolution for base maps at scales of 1:5,000 to 1:10,000 ranges between ≤ 25 cm and 50 cm per pixel. GSD represents the size of one pixel on the photographed object and serves as a key indicator of the quality of an aerial image, describing the ground area represented by a single pixel. The spatial resolution or GSD value can be assessed using the following basic equation:

$GSD = S \times \frac{H}{F}$

- S = Sensor Pixel Size per Pixel (in mm), for example: 4.53 - 5.05 µm
- H = Camera Height Above Ground (in mm)
- F = Camera Focal Length, for example 92 mm for the DMC III
- If the flight altitude is 2,834 meters
- GSD = 4.53 x 2.840.000 mm / 92 = 13cm

With a derived GSD of 11.5 cm/pixel from the DMC III orthophoto, the data falls within the scale class of 1:5,000 (as indicated in Table 4.5) up to 1:10.000. Thus, the DMC III orthophoto meets the maximum spatial resolution (GSD) requirement for base map production at 1:5,000 scale (PERBIG-No-1-Tahun-2020, n.d.)

Base Map Scale	Resolution Value (cm)
1 : 10.000	≤ 30
1 : 5.000	≤ 15
1 : 2.500	≤ 10
1 : 1000	≤ 8

Table 1. Standard Spatial Resolution (GSD) for Orthophotos According to BIG Standards

3.4. Accuracy Test of Geometric Precision for RBI Maps

According to BIG (Indonesian Geospatial Information Agency) in *Regulation of BIG Number 15 of 2014*, map accuracy represents the degree of conformity between the position and attributes of an object depicted on the map and its actual position and attributes in the real world. Geometric accuracy refers to the value that indicates the level of uncertainty of the positional coordinates of a fixed object on the map compared to the positional coordinates of the object's actual location (ICP), which is regarded as the true reference.

In this study, the geometric accuracy of the orthophoto produced by the DMC III camera is assessed using field-surveyed Independent Check Points (ICP) as reference data. In principle, the evaluation is performed by comparing the field-measured ICP coordinates with the corresponding coordinates extracted from the orthophoto.

The values of CE90 (Circular Error at 90%) and LE90 (Linear Error at 90%) are calculated based on the procedures outlined in the Indonesian Geospatial Agency (BIG) Regulation Number 15 of 2014. The process begins by computing the RMSEr (horizontal RMSE) and RMSEz (vertical RMSE). These RMSE values are then converted into CE90 and LE90 according to the US National Map Accuracy Standards (US-NMAS) using the following formulas:

$$CE90 = RMSEr \times 1.5175$$

$$LE90 = RMSEz \times 1.6449$$

The US-NMAS defines CE90 and LE90 as positional accuracy thresholds that encompass 90% of the tested data, thereby representing the horizontal and vertical accuracy of the orthophoto or elevation model being evaluated.

RMSEr (Root Mean Square Error for horizontal accuracy) represents the mean squared positional error in the X and Y components, while RMSEz (Root Mean Square Error for vertical accuracy) indicates the positional error in the Z component. In general, RMSE (Root Mean Square Error) is defined as the square root of the average of the squared differences between the coordinate values of the model data and the coordinate values from an independent reference source (ICP).

RMSE describes the magnitude of positional deviation between the modelled spatial data (such as orthophotos or DEMs) and the field-measured coordinates that are considered as the true reference. A lower RMSE value indicates higher spatial accuracy of the evaluated dataset.

This calculation resulted in a horizontal accuracy value of 4.874 meters. According to the accuracy class requirements for base maps as specified in Geospatial Information Agency (BIG) Regulation No. 6 of 2018, the DMC III orthophoto does not meet the geometric accuracy criteria required for mapping at a scale of 1:5000. Therefore, it cannot be used for products requiring this level of positional accuracy.

		Map Accuracy at 1:5,000 Scale		
Accuracy	CE90 Test Results	Class 1 (m)	Class 2 (m)	Class 3 (m)
Horizontal	4,87	1,5	3,0	4,5

Table 5. Horizontal CE90 Accuracy Assessment for 1:5000 Base Map

The resulting vertical accuracy value obtained is 58.275 meters. Based on the accuracy class requirements for base maps as stated in *Geospatial Information Agency (BIG) Regulation No. 6 of 2018*, the vertical accuracy of the DMC III orthophoto does not meet the criteria required for mapping at a 1:5000 scale. Therefore, it cannot be used for products requiring this level of vertical positional accuracy.

		Map Accuracy at 1:5,000 Scale		
Accuracy	CE 90 test results	Class 1 (m)	Class 2 (m)	Class 3 (m)
Vertical	58,275	1	1,5	2,0

Table 6. Vertical LE90 Accuracy Test for 1:5000 Base Map

In two-dimensional mapping, the coordinates $(X, Y)$of each check point must be evaluated against their actual positions in the field. The Root Mean Square Error (RMSE) is used to analyze the positional accuracy between these two sets of points, representing the difference between the ICP coordinates extracted from the orthophoto and the true ICP coordinates measured in the field.

4. CONCLUSION

Based on the results of this study, it can be concluded that:
An accuracy assessment was conducted on the orthophoto generated from the LFAP DMC III camera over the study area in Padang City, Koto Tangah District, for base mapping at a scale of 1:5,000. Based on the evaluation of seven sample Independent Check Points (ICP) used in the orthophoto, the DMC III LFAP camera orthophoto does not meet the horizontal and vertical accuracy standards specified in BIG Regulation No. 6 of 2018 for any accuracy class at the 1:5,000 mapping scale.

The DMC III orthophoto has a high spatial resolution with a GSD value of 11.5 cm, and according to BIG Regulation No. 1 of 2020, it meets the spatial resolution requirements for a 1:5,000 scale map, which specifies a maximum allowable GSD of ≤ 15 cm.

REFERENCES

[1] Al Ayyubi, A. S., Cahyono, A. B., & Hidayat, H. (2017). Pemetaan Foto Udara Menggunakan Wahana Fix Wing UAV (Studi Kasus : Kampus ITS Sukolilo. *Jurnal Teknik ITS*, *6*(2). https://doi.org/10.12962/j23373539.v6i2.24518

[2] Geografi, J. T., Simanungkalit, K., Damanik, M. R., Parlaungan, D., Jurusan, L., & Geografi, P. (n.d.). *Optimalisasi Foto Udara Unmanned Aerial Vehicle (UAV) Sebagai Media Pembelajaran Penginderaan Jauh*. http://jurnal.unimed.ac.id/2012/index.php/tgeo

[3] *Geospatial Positioning Accuracy Standards Part 3: National Standard for Spatial Data Accuracy Subcommittee for Base Cartographic Data Federal Geographic Data Committee*. (n.d.).

[4] Hutton, J. (n.d.). *Photogrammetric Week 2005 10 Years of Direct Georeferencing For Airborne Photogrammetry*.
[5] Kasus, S., Purworejo, K., Purworejo, K., & Tengah, J. (n.d.-a). *UJI AKURASI KETELITIAN PETA ORTHOFOTO MENGGUNAKAN PESAWAT UAV UNTUK TATA GUNA LAHAN*.
[6] *Leica DMC III product specifications*. (2017b). www.leica-geosystems.com
[7] Leksono, B.-E., & Susilowati, Y. (2008). *TS 1E-Cadastral Information Management Bambang-Edhi Leksono and Yuliana Susilowati The Accuracy Improvement of Spasial Data for Land Parcel and Buildings Taxation Objects by Using the Large Scale Ortho Image Data Integrating Generations FIG Working Week The Accuracy Improvement of Spasial Data for Land Parcel and Buildings Taxation Objects by Using the Large Scale Ortho Image Data*.
[8] Mueller, C., & Neumann, K. (2016). Leica DMC III calibration and geometric sensor accuracy. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, *40*(3W4), 1–9. https://doi.org/10.5194/isprsarchives-XL-3-W4-1-2016
[9] Rokhmana, C. A. (2015). The Potential of UAV-based Remote Sensing for Supporting Precision Agriculture in Indonesia. *Procedia Environmental Sciences*, *24*, 245–253. https://doi.org/10.1016/j.proenv.2015.03.032