# LOW-COST LIDAR TLS-100 COMPARISON WITH LIDAR IPAD PRO FOR 3D MAPPING

**Yanto Budisusanto[1], Muchammad Rizki Ubaidillah[1], Mokhamad Nur Cahyadi[1], Daud Wahyu Imani[1], Imam Wahyudi Farid[2]**

[1]Department of Geomatics Engineering, Faculty of Planning and Earth Civil Engineering, Sepuluh Nopember Institute of Technology, Surabaya, Indonesia

[2]Department of Automation Engineering Technology, Faculty of Vocational Studies Sepuluh Nopember Institute of Technology, Surabaya, Indonesia

E-mail: budisusantoyanto@gmail.com

| | | |
|---|---|---|
| **Received:** March 21, 2022 | **Accepted:** June 16, 2022 | **Published:** June 16, 2022 |
| **DOI:** 10.12962/j27745449.v2i3.430 | **Issue:** Volume 2 Number 3 2021 | **E-ISSN:** 2774-5449 |

**ABSTRACT**

Currently, creating a 3D model of an object has undergone relatively rapid development, especially in technology. Several technologies that can be used to create 3D models are total stations, LiDAR, UAVs, terrestrial laser scanners, and various other products. There are also various methods for obtaining 3D models, such as aerial photogrammetry, close-range photogrammetry, terrestrial, and satellites. This study focuses on comparing the TLS-100 from aerial portraits with the iPad Pro LiDAR product from Apple Inc. The results to be analyzed are the resulting data format, the speed of data retrieval, the quality of the data obtained, and statistical analysis. This study is expected to assist in proving the quality of low-cost LiDAR and iPad Pro LiDAR products.

**Keyword:** LiDAR, Low-cost

## Introduction

Making a 3D model of an object at this time has experienced relatively rapid development, especially in the field of technology. Several technologies can be used to create 3D models, including total stations, LiDAR, UAV, Terrestrial Laser Scanner (TLS), and various other products. There are also various methods that can be used to obtain 3D models, such as aerial photogrammetry, close-range photogrammetry, terrestrial, and using satellites. TLS is a product that is currently often used to create 3D models with the data obtained in point cloud or .ply format. However, this product has a very high price, and only a few users can take advantage of this technology.

The LiDAR product used to create this 3D model uses a time of flight (ToF) system. ToF is a method for measuring the distance between the sensor and the object. The distance calculation is obtained from the difference in signal transmission and when the signal sent is received back by the sensor.

The signal sent is in the form of a packet consisting of microwaves with a unique pattern, so the sensor will be able to recognize the signal. It takes a wave with a unique pattern so that the sensor can recognize between the waves sent by the sensor or interference from other waves.

This device can generate multiple positioning points in a single scan, but this product has a problem in terms of its high price. The current development of LiDAR technology is not only trying to produce high accuracy but also efforts to reduce costs. This low-cost LiDAR tool is an alternative to mass-produced 3D models due to its low cost and relatively high accuracy. Utilization of this low-cost LiDAR product can be used to create 3D models of rooms, gardens, and assets belonging to a company.

One of the low-cost LiDAR products is the aerial portrait-made TLS-100. This device has a scanning distance of 100 m, 1000 points/second for scanning speed, with a weight of less than 1 kg, and ascii data output. The LiDAR system can also be integrated with various other devices such as UAVs, drones, fixed wings, and GPS. New products currently on the market are products from Apple. Inc that has been integrated with LiDAR. Apple has launched mobile products that have been integrated with LiDAR, namely the iPhone 12 Pro Max and iPad Pro, since 2020. These devices can produce data outputs in the form of cloud points, obj, photos, XYZ-RGB ascii, and others.

LiDAR on Apple products uses a direct time of flight (DtoF) system, where this system works by shooting light waves at objects and then reflecting them back to the sensor. The distance and time calculations used in this process are utilized as position values.

In this study, researchers will compare the TLS-100 from aerial portraits with the iPad Pro LiDAR product from Apple Inc. The results to be analyzed are the resulting data format, the speed of data retrieval, the quality of the data obtained, and statistical analysis. This activity is expected to help prove the quality of low-cost LiDAR and iPad Pro LiDAR products.

## Equipment and Material

**TLS-100 Aerial Portrait**


**Figure 1.** TLS-100

The TLS-100 LiDAR is a unidirectional laser range finder based on time-of-flight (ToF) technology. It consists of special optical and electronic devices which integrate adaptive algorithms for indoor and outdoor application environments. This tool has a price of 25 million rupias with the following specifications: Voltage Range: 4.5V-6V Communication Interface: UART (TTL) Working Range: 50 m. This product has a working system that takes 15 minutes in 1 scan.

**IPAD Pro LiDAR**

**Figure 2.** iPad Pro LiDAR

Since 2020, Apple has launched mobile products that have been integrated with LiDAR, namely the iPhone 12 Pro Max and iPad Pro. This device can produce output data in the form of a point cloud, obj, photos, XYZ-RGB ascii, and others. The device used in this study is the iPad Pro LiDAR 2021. This product has an 11-inch screen specification using the M1 processor. The iPad Pro LiDAR is equipped with a truedepth device. This system uses LEDs to project an irregular grid of more than 30,000 infrared dots to record depth in milliseconds with real-time visualization.

## Methodology

The research was conducted using the TLS-100 device from Aerial Portrait and the iPad Pro LiDAR 2021 from Apple inc. The TLS-100 performs a static scan with a data recording time of 15 minutes, while the iPad Pro performs a mobile recording. The object used in this research is the garage room. In this garage room, several forms of objects can be observed, such as shoe racks, windows, and others. LiDAR is utilized in these two products using a ToF system. ToF is a method for measuring the distance between the sensor and an object calculating the distance obtained from the difference in signal transmission and when the signal sent is received back by the sensor. The structure of the activity can be seen in the diagram below.

TLS-100 and iPad Pro LiDAR are used to scan objects, namely garages. These two tools have different output results.

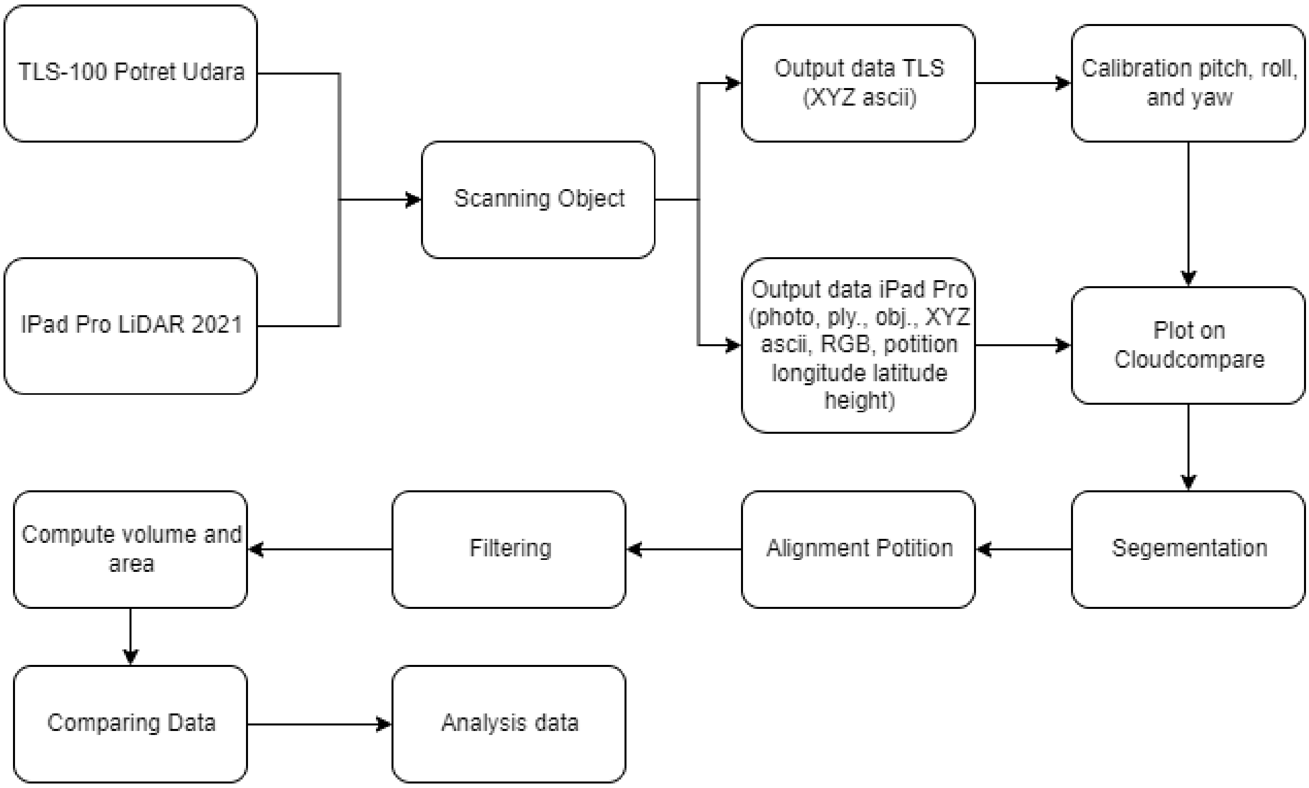


**Figure 3.** LiDAR Research Activity Diagram

TLS-100 only has x, y, and z data in ascii form. Meanwhile, iPad Pro LiDAR has various data output formats such as ply., obj., xyz ascii, and photo. After getting the data, the TLS-100 needs to be calibrated to get the appropriate position value.

The data that has been obtained is then entered into the cloudcompare software. In this software, the first thing to do is segmentation. Segmentation is an activity of choosing which area to analyze, as shown in figure 4. The following process after segmentation is alignment position.

**Table 1**. Size Result Comparison Between Roll Meter,iPad Pro, and TLS.

| Tools | Length (m) | Wide (m) | Height (m) |
|---|---|---|---|
| Rol Meter | 4.20 | 3.00 | 4.00 |
| IPad Pro | 4.00 | 2.95 | 3.96 |
| TLS 100 | 3.87 | 2.81 | 3.81 |

Alignment position is the process of equalizing the position of the two tools to simplify the analysis process. The following process is to do filtering for both data. Filtering is done to remove point data that is not needed according to a predetermined algorithm. After the filtering process is carried out on the two objects, the area and volume are calculated. In cloudcompare software, there are several features provided to analyze data. This feature is used to see and compare the results of both objects.

The data obtained from the LiDAR scan is the calculation of the distance between the object and the sensor. The coordinates obtained from the LiDAR data scanning process are as shown in figure 5.

Figure 6 shows the data collection results using the iPad Pro and low-cost LiDAR. iPad Pro generates more data formats such as photos, xyz positions, and RGB values. Meanwhile, low-cost LiDAR only produces xyz position data. In terms of data retrieval time, the iPad Pro is more efficient than the TLS-100. iPad Pro can complete the scanning process in less than 5 minutes in a room of less than 10 m2, while the TLS-100 has a regular scanning speed (in 1 scan, it takes 15 minutes).

The results of the x, y, and z positions in this measurement provide information regarding the shape of the building that has been scanned. However, the building height information provided is not appropriate, so analysis is carried out using cloudcompare software. This software has tools that can determine the height of an object by determining at least the three lowest points on the building object. This activity can produce a high range in the form of a histogram, as shown in Figure 7. The cloudcompare software also provides tools to calculate volume and area.

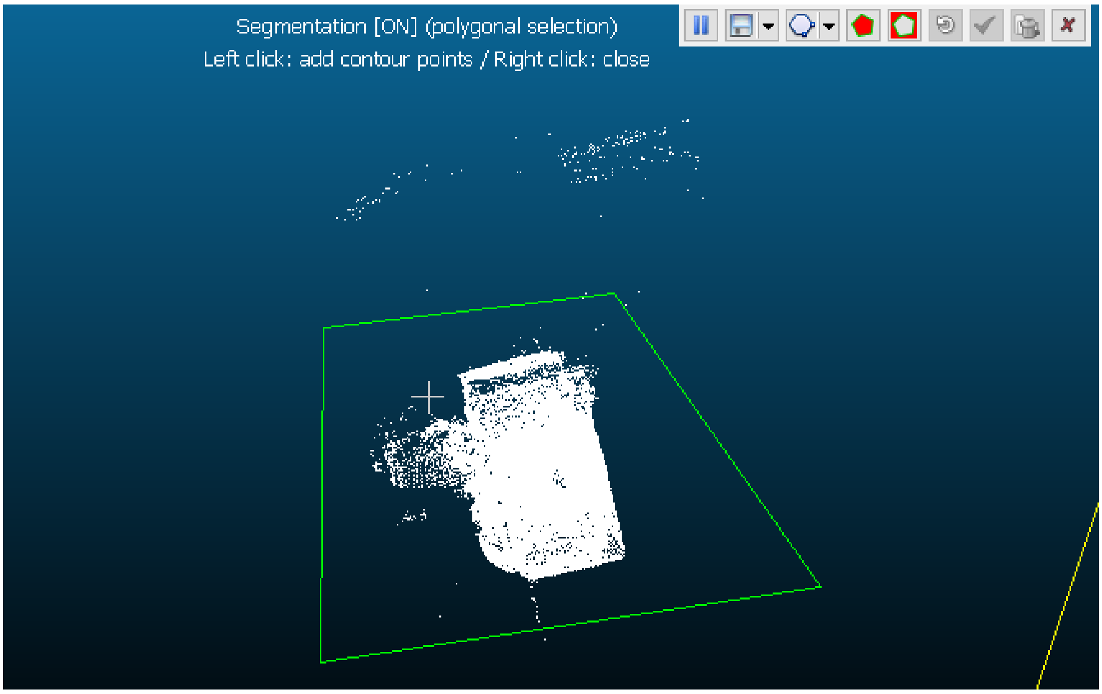


**Figure 4.** Segmentation process on LiDAR data

| coord. X | coord. Y | coord. Z |
|---|---|---|
| 24.00 | 0.75 | -17.98 |
| 25.60 | 0.83 | -19.18 |
| 25.60 | 0.86 | -19.18 |
| 26.40 | 0.91 | -19.78 |
| 26.40 | 0.94 | -19.78 |
| 26.40 | 0.97 | -19.78 |
| 26.40 | 1.00 | -19.78 |
| 26.40 | 1.02 | -19.78 |
| 26.40 | 1.05 | -19.78 |
| 26.40 | 1.08 | -19.78 |
| 26.39 | 1.11 | -19.78 |
| 45.58 | 2.05 | -34.16 |
| 45.58 | 2.10 | -34.16 |
| 45.58 | 2.15 | -34.16 |
| 45.58 | 2.20 | -34.16 |

**Figure 5.** Coordinate Sample Data Generated By TLS-100

The 3D objects generated by each tool are calculated using the tools available on cloudcompare, with the results shown in Figure 8.

Next, the density analysis generated from the two tools was carried out. Cloudcompare provides tools to calculate density values. Several density values can be calculated, such as surface density, volume density, and roughness density.

Surface density (Sv) is the most useful parameter. It is an expression of the surface area of the featuredivided by the volume of the reference space. Theestimate is obtained by calculating the intersectionof the test line probe and the relevant surface of interest. The surface-to-surface ratio (Ss) can be obtained using a similar approach.

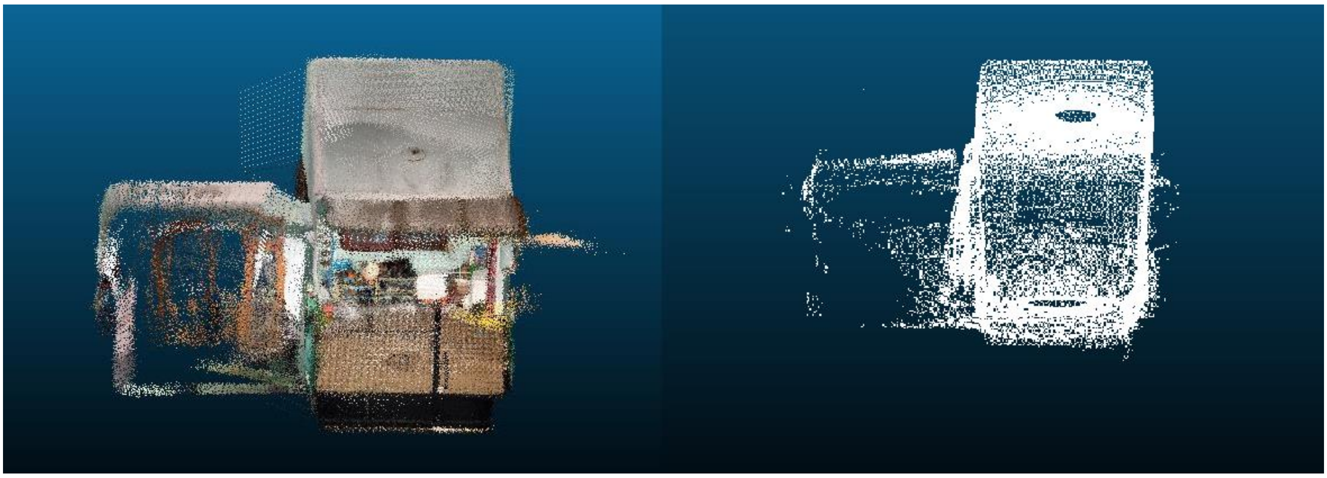

**Figure 6.** Data Collection Results Using iPad Pro LiDAR and Low-Cost LiDAR TLS-100.

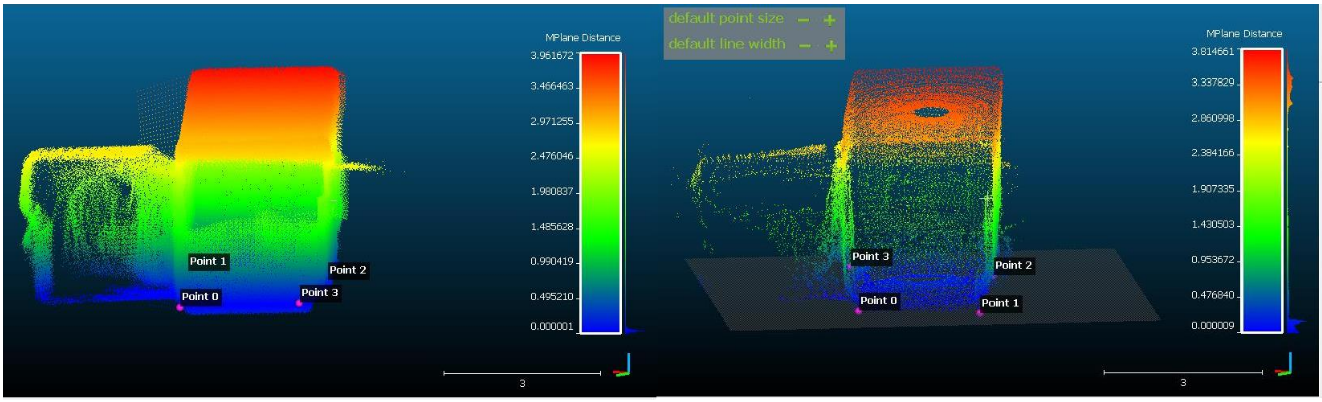


**Figure 7.** Graph Shows Altitude Gained from iPad Pro LiDAR and Low-Cost LiDAR TLS-100.

**IPad LiDAR Pro 2021**

- Volume: 16.296 m3
- Surface: 64.000 m2

**TLS-100 Potret Udara**

- Volume: 30.4667 m3
- Surface: 81.0000 m2

**Figure 8.** Volume and Area Calculation Results.

The estimation of surface and length parameters is very sensitive to anisotropy, and the solution to the associated sampling bias involves using the IUR section and the vertical section.

Roughness is a component of surface texture. It is measured by the deviation in the direction of the actual surface normal vector from its ideal shape. If this deviation is large, then the surface is rough; if it is small, it is smooth. In surface metrology, roughness is usually considered to be the high- frequency and short-wavelength components of the surface being measured. However, practically,it is often necessary to know the amplitude and frequency to ensure that the surface is suitable fora purpose.

Volume is a three-dimensional space enclosed by a closed surface. Density is mass per unit volume. The relationship between density and volume is directly proportional. This relationship means thatany volume change will result in a change in density and vice versa.

These methods are benchmark methods. They randomly extract neighbors in spheres (orcylinders) to evaluate the speed of the environmental extraction process in CC.

This method is used to compare the distance between two-point clouds. When the Cloud/Cloud distance computing dialog appears, CloudCompare will first calculate the approximate distance (which is used internally to automatically set the best octree level to perform the actual distance calculation - see below). The reference cloud is hidden, and the cloud being compared is colored with the approximate distance.

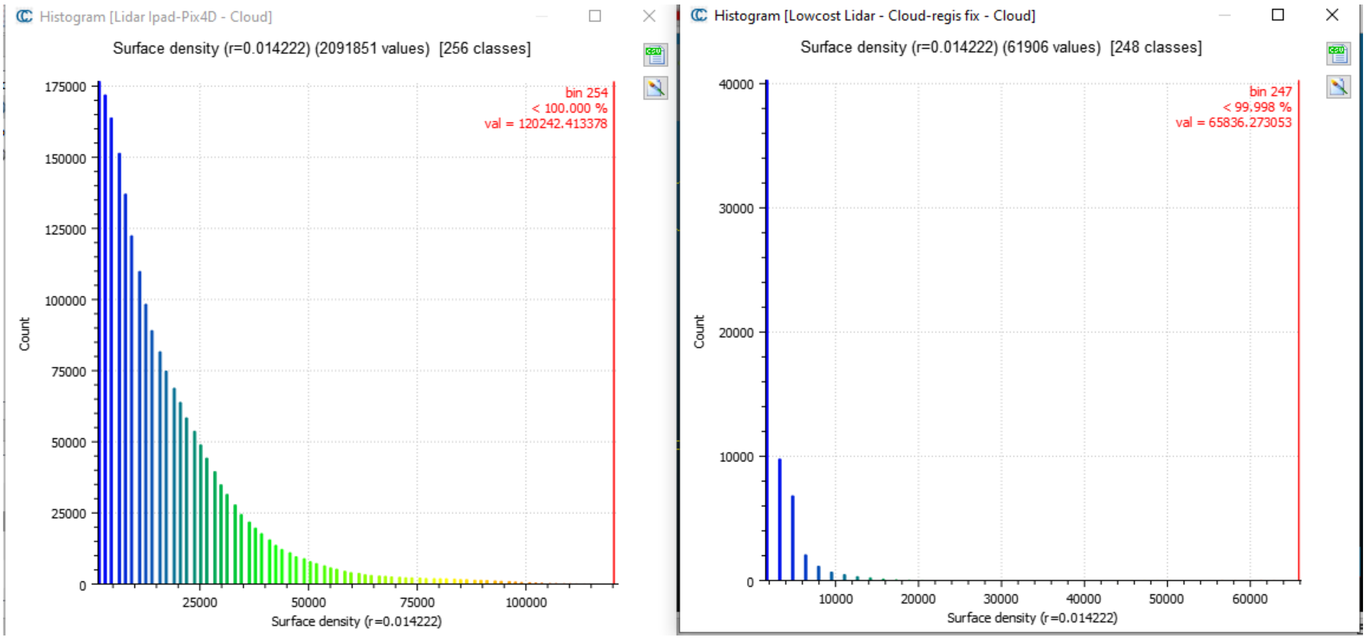


**Figure 9.** Surface Density

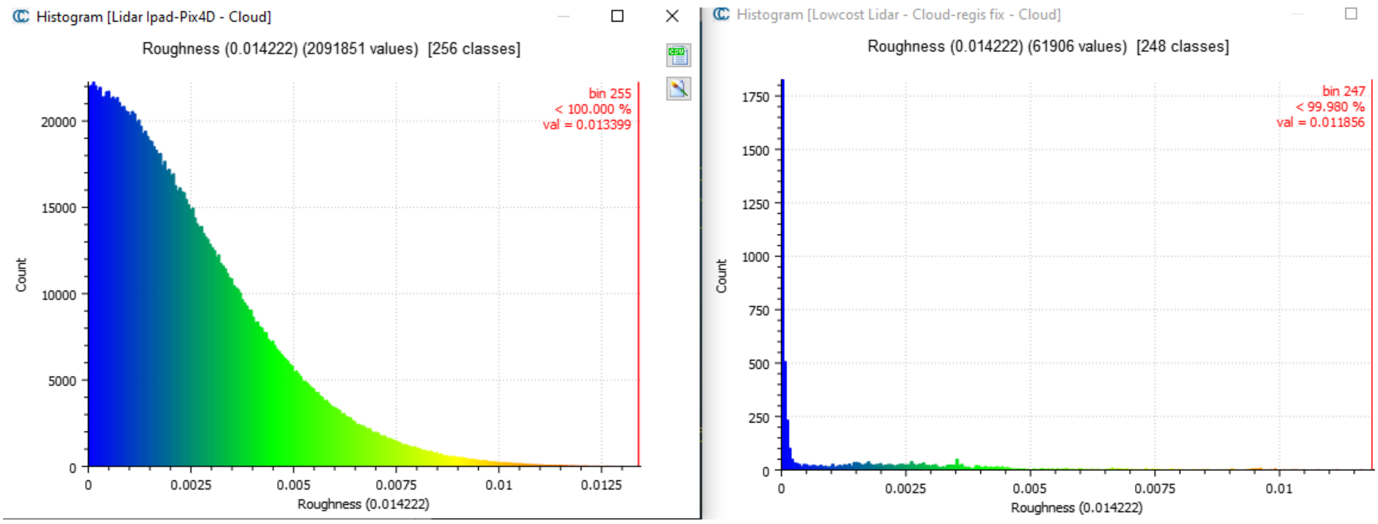


**Figure 10.** Roughness Density

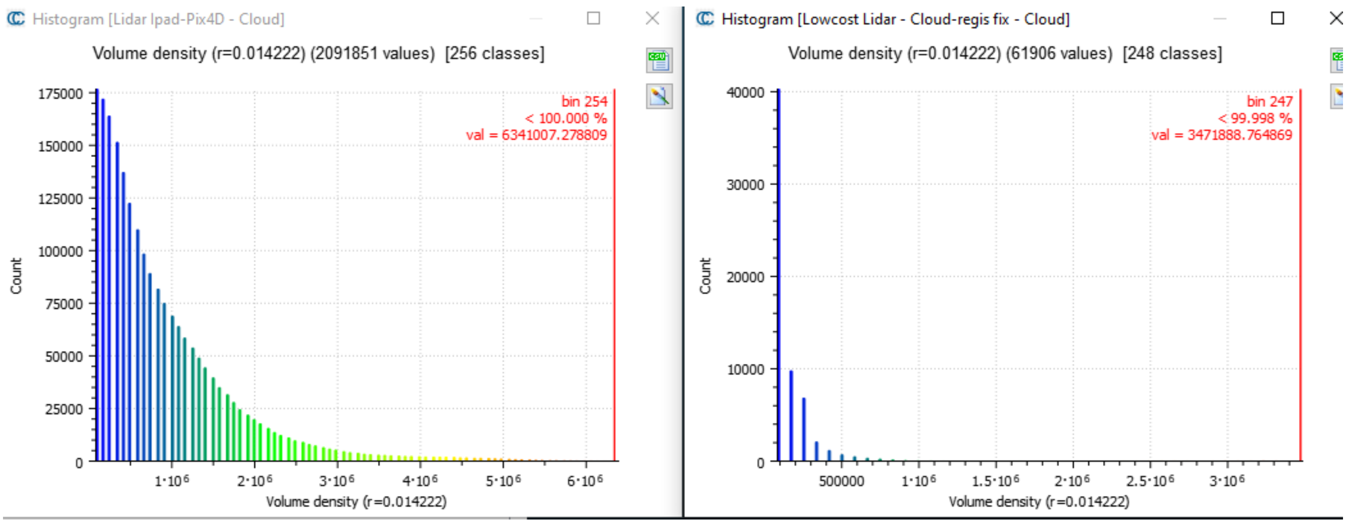


**Figure 11.** Volume Density

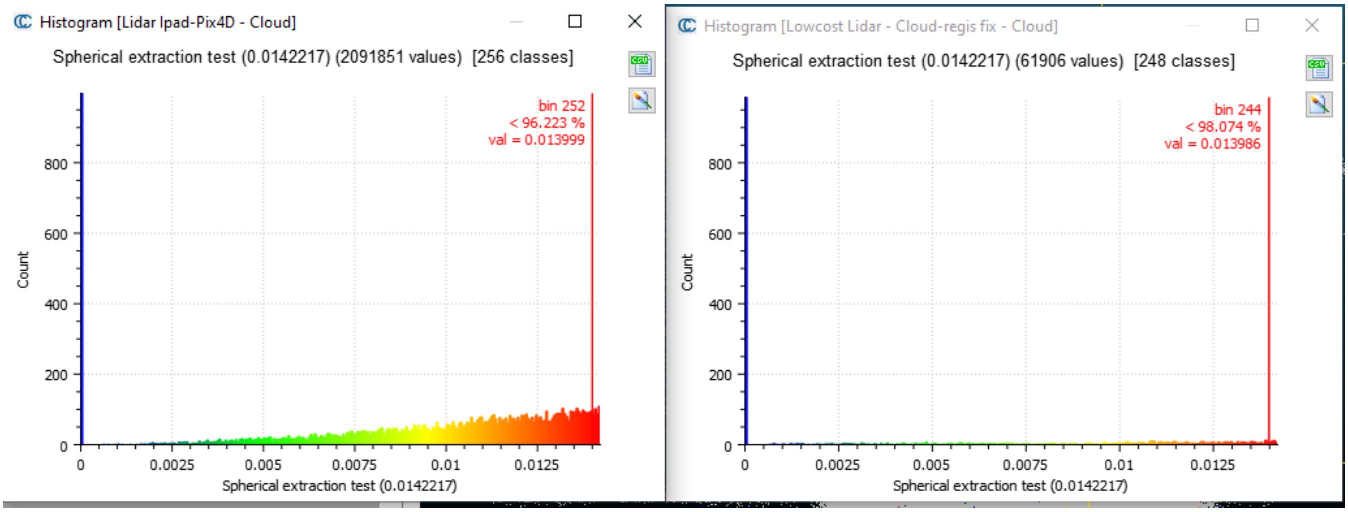


**Figure 12.** Spherical Extraction Test. SNE = 'Spherical Neighborhood Extraction' testCNE ='Cylindrical Neighborhood Extraction' test.

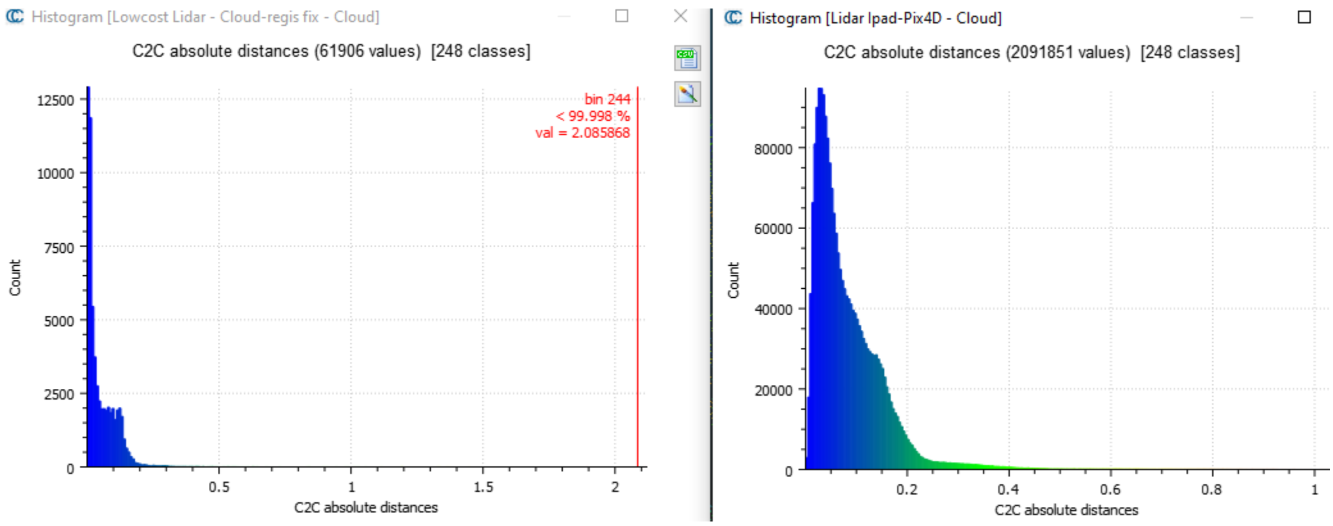


**Figure 13.** C2C Absolute Distance

The main parameters for the calculation are:

- **Octree rate:** The octre division rate at which distance calculations will be performed. The octree rate is set automatically by CloudCompare by default and should be left as is. Changing this parameter only changes the computation time. The main idea is that the higher the level of the subdivision, the smaller the octree cells. Therefore, the fewer points in each cell, the less computation must be done to find the closest one. On the other hand, the smaller the cell and the more cells that have to be searched (repeatedly), it becomes very slow if the points are far apart (i.e., the compared point is far from the nearest reference point). So a large cloud will require a high octree level, but if the dots of the cloud being compared are a bit far from the reference cloud, then a lower octree level is better.
- **Max dist.:** if the maximum distance between two clouds is high, the computation time may be very long (the farther the point is, the more time it will take to determine its nearest neighbor). Therefore, it is better to limit the search below a reasonable value to shorten the computation time. All points further than this distance will not be calculated as the actual distance, and a threshold value will be used instead.
- **Signed distance:** signed distance is not available for cloud-to-cloud distance.
- **Normal flip:** normal flip is not available for cloud-to-cloud distances.
- **Multi-threaded:** whether to use all available CPU cores (warning: computer may not be fully responsive during computing).
- **Dividing X, Y, and Z components:** yields three more scalar planes corresponding to the (absolute) distance between each compared point and its

closest reference point along each dimension (this corresponds to 3 components of the deviation vector).

## Conclusion

This study showed that Fin stabilizer modular NR 30 has the best ship maneuvering because it meets all the criteria. While other types of fin stabilizers have a value that exceeds the maximum criteria, namely the roll movement. The researcher also found that the fin stabilizer NR 30 has a smaller MSI value in all wave directions. Besides, the addition of a fin stabilizer can affect the motion of a ship because it can affect the direction of the waves that hit the side of the ship.

## Acknowledgements

None.

## References

[1] Asyikin et al. Spatial mapping with LiDAR-based Simultaneous Localization and Mapping (SLAM) method, *Urban and Regional Planning Study Program, Pasundan University. Palembang* (2020).

[2] Handoko EY, et al. Low-cost single frequency GPS RTK positioning assessment. IOP Conference Series: Earth and Environmental Sciences. Vol. 280. No. 1. TIO Publishing; 2019.

[3] MN Cahyadi et al. Comparative analysis of accuracy and precision on the GNSS K706 OemBoard and GPS Topcon HiperPro, *IOP Conference Series: Earth and Environmental Sciences.* **4** (2019).

[4] MN Cahyadi et al. Comparative analysis of cheap OEM GNSS Boards K706 AND BX316, *IOP Conference Series: Earth and Environmental Sciences* (2020).

[5] M Taufik et al. Analysis of the accuracy of GNSSobservations, *IOP Conference Series: Earth andEnvironmental Sciences*. **4** (2019).

[6] Yuwono et al. RTK GPS single frequency low- cost assessment, *IOP Conference Series: Earth and Environmental Sciences. Indonesia*. **4** (2019).

[7] NOAA. What is LIDAR, *National Oceanic and Atmospheric Administration.* (2014). Available from:https://oceanservice.noaa.gov/facts/lidar.html.

[8] Panjwani et al. LiDAR phenol low-cost lidar-based 3D scanning system, *Frontiers in plant science.* **10** (2019) p. 147.