

MODERN METHODS AND TECHNIQUES FOR COLLECTING AND PROCESSING GEOSPACE DATA OF AN OBJECTIVE

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Abstract. The studied building is located in the central area of Timișoara, being bordered to the north and east by Ferdinand I Boulevard, to the south by the Bega canal, to the west by the December 16, 1989 boulevard, located approximately north-central in the Cathedral Park. The Cathedral of the Metropolitan Church of Banat in Timișoara is included in the List of historical monuments in Romania with the classification code SB-II-m-A-12147. It is also the largest religious building in the western part of the country, dedicated to the "Three Hierarchs". All the buildings in the central area of Timișoara have updated the cadastral data, having the outline implemented in the Land Book. That is why the identification of the land of the disposition of the Timișoara Metropolitan Cathedral in the bases of OCPI was easy. An MMS Leica Pegasus Backpack was used to carry out the work. All the steps from the recognition of the land and the objective, the execution of the field works and the post-processing of the data to the level of a compatible file for the architectural programs that will benefit from these data in order to restore the objective have been completed. The field stage performed with the Leica Pegasus Backpack scanner was materialized on 12.12.2019, because it was considered that the visibility towards the objective is better due to the lack of vegetation adjacent to the objective. Preparing for actual work consists of 2 steps: the first step is static initialization for 5 minutes which consisted of calibrating the GNSS antenna, updating the GNSS almanac and adjusting the image of the 5 cameras; the second step consisted of dynamic initialization for 2-3 minutes to calibrate the IMU (Gyroscope and Accelerometer to improve accuracy) and was performed by traveling a circular distance near the target area with the scanner in the back, with satellite aperture, until when the message INS Good appeared on the tablet. The automation of specialized works involves quite high costs, in terms of purchasing and owning a professional MMS equipment and dedicated software. Although the acquisition cost is high, these costs are much easier to justify, because the volume of data processed is large and easy to obtain in the field, through the short time of execution of works. Thus, the results obtained are used to analyze problems of a wide variety.

Keywords: MMS equipment, LIDAR sensor, post-processing steps.

INTRODUCTION

The most important qualities and strengths are the possibilities of automating works in the field of spatial analysis compared to graphically oriented systems: computer graphics processing. These possibilities of automating such works allow geographic reference data to be created and used in different fields of activity.

The automation of specialized works involves quite high costs, in terms of purchasing and owning professional MMS equipment and dedicated software. Although the acquisition cost is high, these costs are much easier to justify, because the volume of data processed is large and easy to obtain in the field, through the short time of execution of works. Thus the obtained results are used to analyze problems of a great variety.

MATERIAL AND METHODS

An MMS Leica Pegasus Backpack was used to carry out the work.

Most MMSs rely on light detection and variation sensors (LIDAR) as a 3D mapping unit, but are usually also equipped with cameras for capturing scanning color information (HAALA, N. et al., 2017).

The Leica Pegasus Backpack combines two laser cameras (Velodyne PUCK™ VLP-16) synchronized with five cameras, a triple-band GNSS receiver (NovAtel ProPak6™) and a fiber optic gyroscope (FOG) (NOCERINO ERICA et al., 2017).

Each VLP-16 laser profilometer has 16 laser / detector pairs, mounted in a rotating housing that provides a 360 ° field of view. The device is also equipped with five high-dynamic range cameras, placed to acquire a 360 ° x 200 ° field of view.

Currently, the popular solutions available on the market for research laboratories are portable MMS backpacks. These systems typically have a conventional positioning and navigation unit that integrates GNSS sensors (global satellite navigation system) and IMU sensors (inertial unit of measurement); however, there are solutions only with IMU or even without positioning and navigation components (HERON). Some systems are also equipped with cameras that provide spherical panoramic video or still images (UltraCam Panther), such as the Leica Pegasus Backpack mobile scanner (Figure 1) (ŞMULEAC, A. et al., 2019).

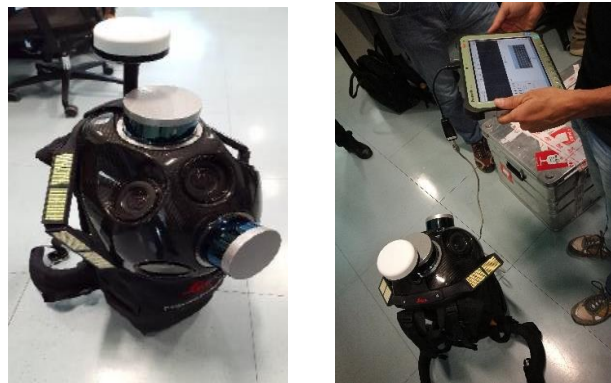


Figure 1. Leica Pegasus Backpack

Source: http://www.topgeocart.ro/platforme-mobile/leica-pegasusbackpack_97.html

For post-processing, the specialized program (software) Pegasus Manager was used (https://leica-geosystems.com/products/mobile-sensor-platforms/software/leica-pegasus_webviewer). This is the desktop software program for mobile mapping, thus being a single application for processing, analyzing and extracting functions from point clouds and images acquired by Leica Pegasus mobile mapping systems. It consists of different modules and allows a customized software suite, aligned to your business or project goal. Precise mission planning, data processing, automatic feature extraction, integrated quality reporting and online publishing make Pegasus Manager a unique and efficient workflow for high-precision deliveries. As an option, Pegasus Manager can publish Jetstream files that allow Cyclone users to combine multisensor projects into a single file for efficient data sharing (ŞMULEAC, A. et al., 2018).

RESULTS AND DISCUSSIONS

Recognition for topographic works performed with Leica Pegasus Backpack equipment

For the work with the Leica Pegasus Backpack scanner, the mission planning was performed according to the scanning possibilities obstructed by the close arrangement of the arboreal vegetation in the lateral and back area of the targeted objective and the decision was

made together with the beneficiary by the executor, respectively S.C. PROCAD S.R.L. Timisoara, subsequent execution of the scan only on the main (frontal) facade of the lens.

Collection of field data with Leica Pegasus Backpack equipment

The field stage performed with the Leica Pegasus Backpack scanner was materialized on 12.12.2019, because it was considered that the visibility towards the objective is better due to the lack of vegetation adjacent to the objective. This was also approved by the staff of Timișoara Metropolitan Cathedral through its representatives, respectively the architect who will take over the data for the architectural processing of the restoration plan of the objective.

In order to prepare the data acquisition plan, the Mobile Data Acquisition (MDA) program on the scanner tablet was used. Thus, the best time for data collection was calculated - based on satellite constellations, solar position, GNSS base station locations and GNSS coverage affected by city buildings.

Then, the Leica Viva GS 08 GNSS equipment was installed at the base point, considered the Master Base ground control point, determined by the static method, on a day prior to the scan.

Following the static method, the ground control point was also determined by the RTK method in order to make a comparison of the coordinates between the 2 methods. On the day of the scan, the GNSS equipment, by installing on a tripod at the known point, parked for the entire working time executed with the Leica Pegasus Backpack scanner, in order to generate RINEX data recorded at 1 Hz, for data processing in the post-processing stage. (Figure 2).



Figure 2. Leica Viva GS 08 GNSS equipment

Preparing for actual work consists of 2 steps:

- The first step is static initialization for 5 minutes which consisted of calibrating the GNSS antenna, updating the GNSS almanac and adjusting the image of the 5 cameras.
- The second step consisted of dynamic initialization for 2-3 minutes to calibrate the IMU (Gyroscope and Accelerometer to improve accuracy) and was performed by traveling a circular distance near the target area with the scanner in the back, with satellite aperture, until when the message INS Good appeared on the tablet (Figure 3).



Figure 3. Leica Pegasus Backpack Scanner Calibration Route

After initialization, the actual scan was performed, consisting of the established route (Walk A) in front of the Cathedral with a very good accuracy with a visibility to 13 satellites and a high clarity of the LIDAR sensor and the pictures resulting from the 5 cameras (Figure 4).

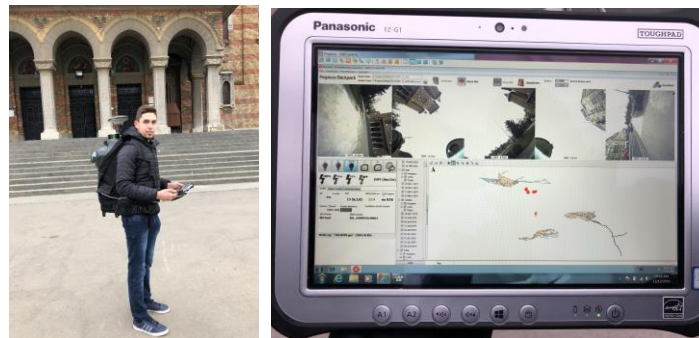


Figure 4. Scan route using the Leica Pegasus Backpack Scanner

Post-processing of data obtained using the Pegasus Manager program for Leica Pegasus Backpack

For the post-processing of the data obtained with the help of the Leica Pegasus Backpack Scanner, the dedicated Pegasus Manager computer program was used.

1. In the first step, the raw data was downloaded from the hardware unit of the scanner, respectively using the tablet to an external storage medium, namely a USB stick. Also, at the data download stage, raw RINEX data were obtained from the Leica Viva GS08 GNSS equipment (Figure 5).

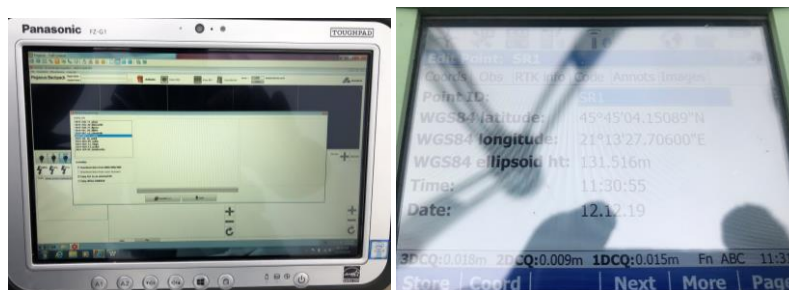


Figure 5. Download raw data

Based on the Pegasus Manager desktop version for post-processing from the office, the raw data on the USB stick was imported and a flow of processing steps shown in Figure 6 was followed, namely Navigation preparation (importing RINEX data and setting the parameters of processing); Import scanner file (import LIDAR data); SLAM Processing (adjusts the trajectory in the absence of the GNSS signal - not used, due to high accuracy); JPEG extraction (extracting pictures from 5 cameras); Time alignment (correlation of pictures with GNSS location); Import Trajectory Data (importing the processed trajectory and setting the Stereo 70 reference system). At the same time, the quality of the raw data from the field was checked, as well as the images taken by the 5 cameras of the scanner.

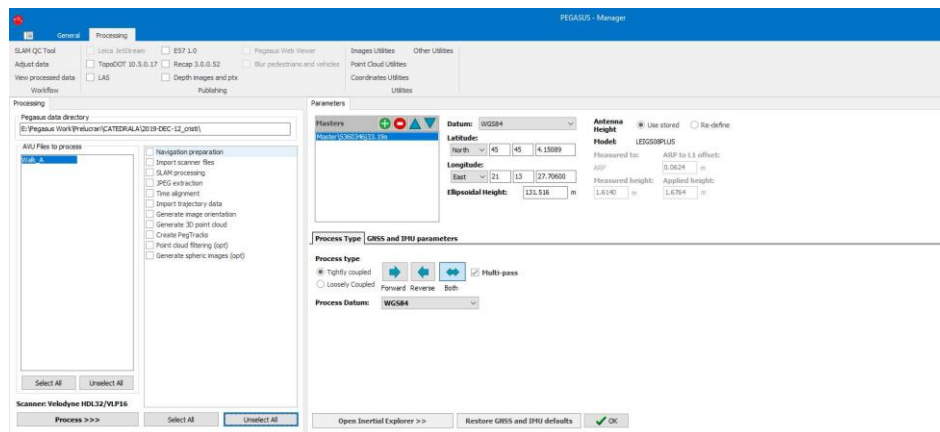


Figure 6. Processing steps flow

The scan path highlighted by the color blue was processed as much as the initialization path of the scanner performed in a circle (Figure 7).

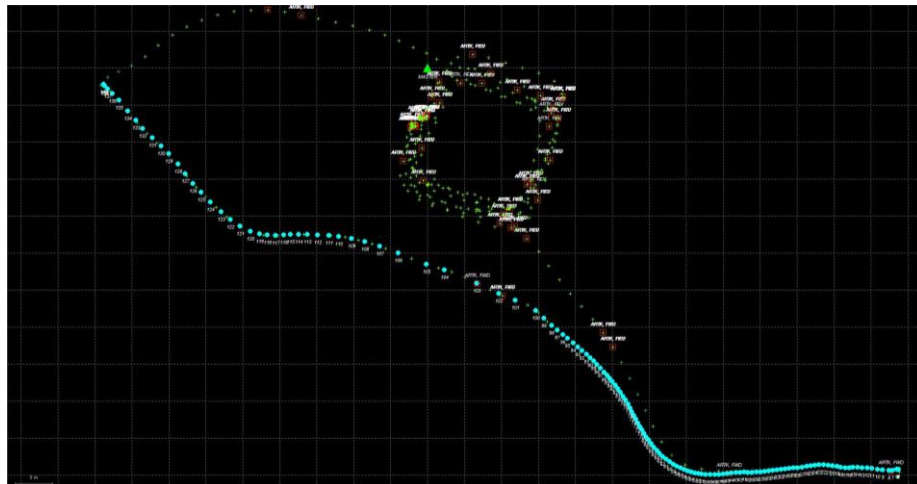


Figure 7. The route processed for calibration and scanning

The verification of the data accuracy was performed with the software Novatel Inertial Explorer. Because the GNSS signal was very good throughout the measurement session, it was not necessary to compensate the scan path using the SLAM (Simultaneous Localization and Mapping) algorithm, so the scanning accuracy was less than 3 cm (Figure 8).

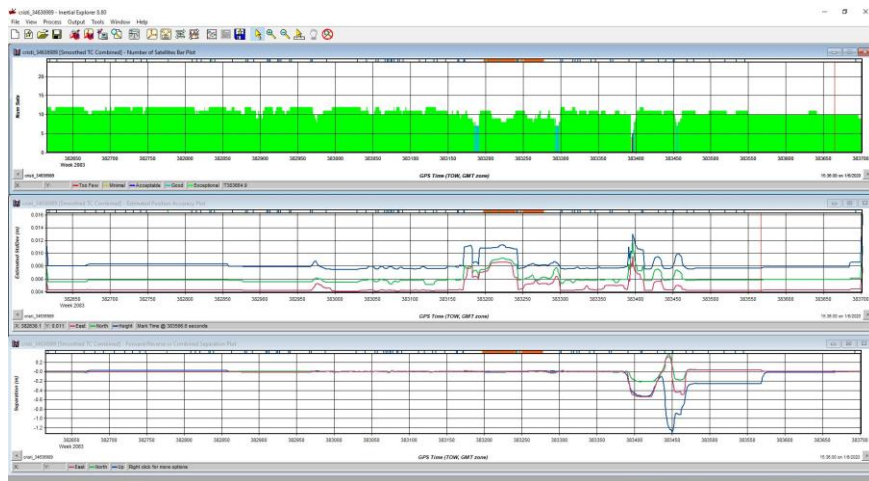


Figure 8. The level of accuracy of the IMU and the scanner's GNSS antenna

Subsequently, due to the high accuracy of the previously processed data, it was possible to generate the 3D point cloud using Scanner Range (distance between scanner and objective) between 1.3 and 60 meters (Figure 9).

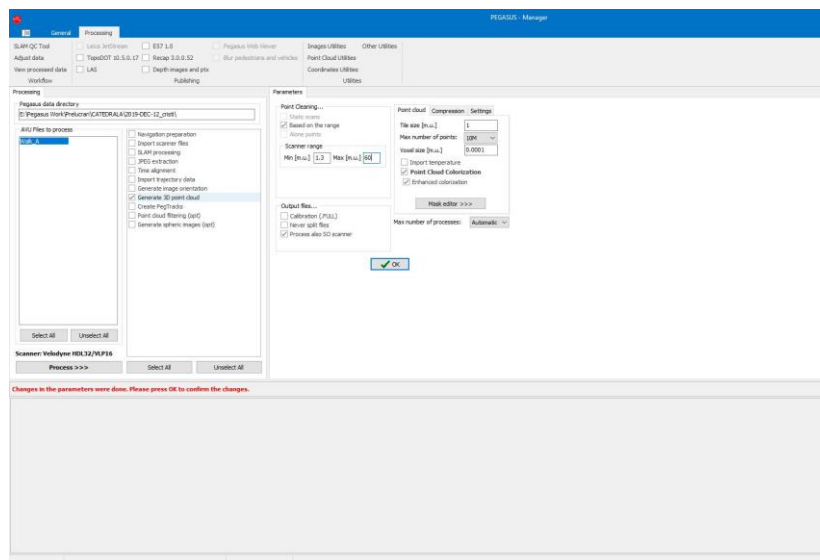


Figure 9. 3D point cloud creation

The result obtained from data processing is a dense cloud of points in 3D format of the facade of the Cathedral and the area near it, represented in natural RGB colors, which were extracted from pictures and correlated with LIDAR data (Figure 10) (ŞMULEAC, A. et al., 2015) .

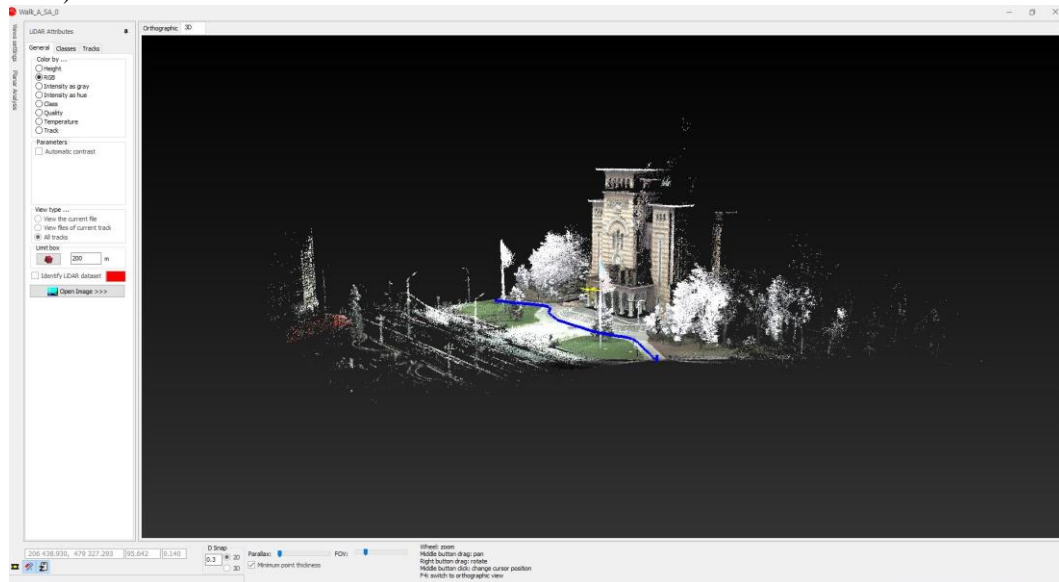


Figure 10. The point cloud obtained in RGB format

The point cloud can be visually represented in several coloring formats such as Height (depending on height) highlighted in the image in Figure 11.

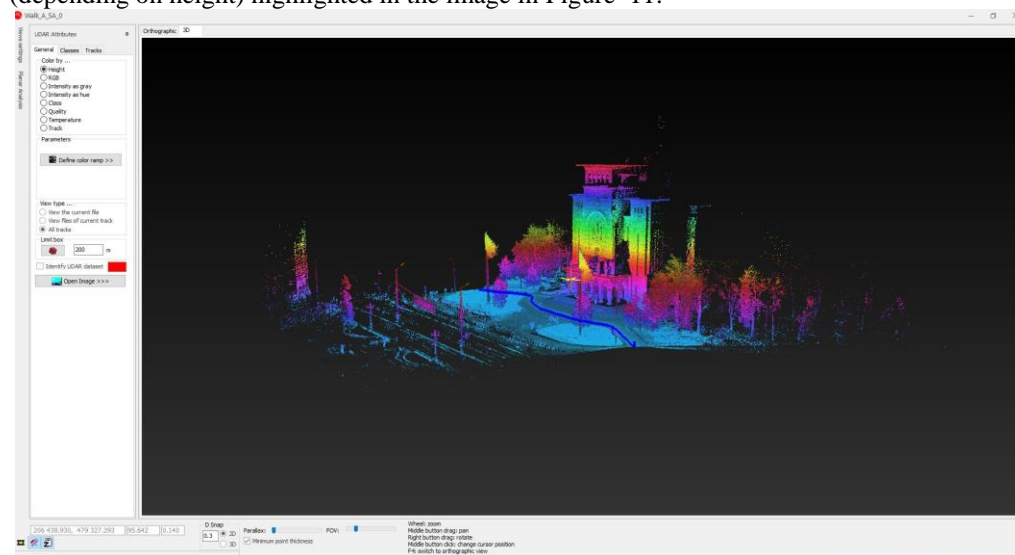


Figure 11. The point cloud obtained in Height format

At the same time, a detail of the front of the objective was executed by emphasizing the position of the point cloud for certain architectural elements such as arches, windows, columns, access doors, etc. (Figure 12).

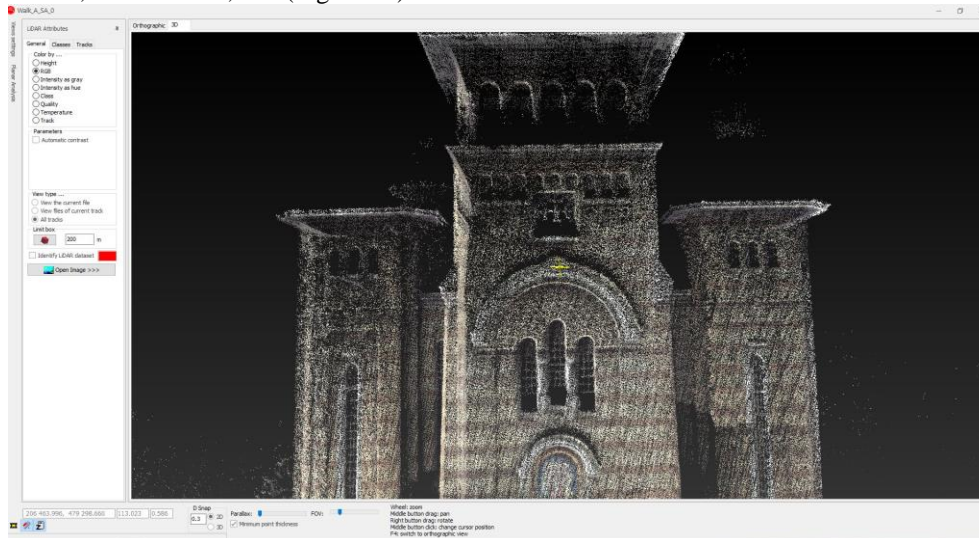


Figure 12. Presentation in detail of the point cloud for architectural elements

In order to verify the accuracy of the working mode, some dimensional comparisons were made between the point cloud and the images taken by the scanner, resulting in a perfect association shown in Figure 13.

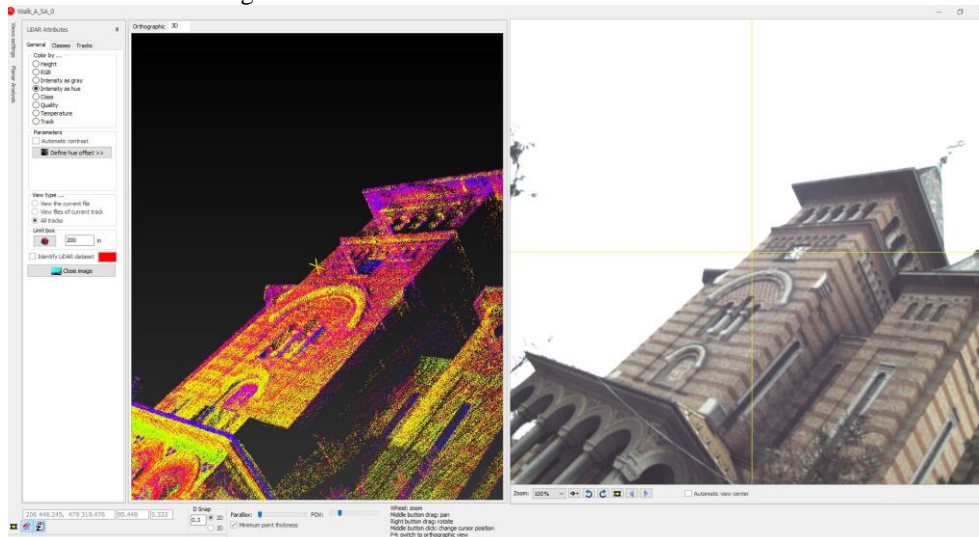


Figure 13. Example of correlating the rooms with the point cloud

After post-processing the data, some determinations could be performed using the Pegasus Manager software program, namely measuring the dimensions of some architectural elements from the coordinates found in the dense cloud of points (Figure 14-15).

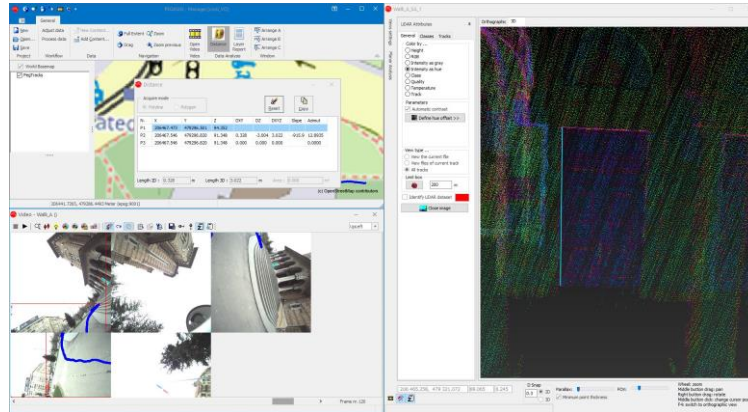


Figure 14. Example of application on the point cloud on obtaining the height of a window from coordinates

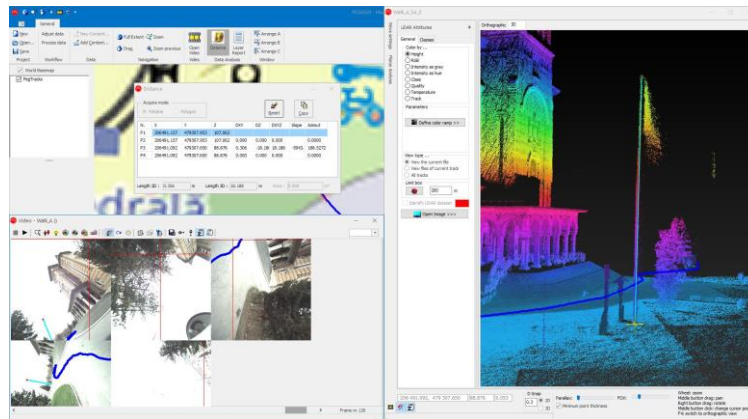


Figure 15. Example of application on the cloud of points regarding the obtaining from coordinates of the height of the flagpole in front of the Cathedral

In the final stage, the post-processed data, ie the point cloud, was exported to a multicompatible data file of type "*.las". The goal is to be accessible to others who don't have the Pegasus Manager program, using free graphical software applications accessible from the Internet.

CONCLUSIONS

The paper represents a model of acquisition and processing of data obtained by using the portable mobile scanning equipment (MMS), Leica Pegasus Backpack, in order to perform outdoor scans. The advantages and applicability of using the proposed model are the speed with which measurements are made for data acquisition and processing.

The precise degree of picking up the details from the field, offers the possibility to use the images obtained in projects such as constructions, design, road infrastructure, geodesy and general cadastre, architecture, cartography, etc. Superior performance could be achieved in the

future by using new versions of the equipment used or more advanced equipment with a higher degree of accuracy.

In the post-processing stage, the data were processed with programs specific to each piece of equipment, then exporting the data into files of the same type, compatible with common post-processing programs, thus overlapping point clouds and obtaining a complex overall work with a detailed image.

The use of MMS Leica Pegasus Backpack has the advantage that it does not require much effort in performing the field stage compared to other types of scanners and data collection methods, which require a larger number of operators and a long downtime at certain points station.

Scanning with this MMS and obtaining the frontage 3D model of the Timișoara Metropolitan Cathedral building which can be highlighted both in RGB mode with natural colors, or high dependence color has been used successfully for future architectural determinations made by specialists in building restoration.

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