

# CREATION OF THE POINT CLOUD AND THE 3D MODEL FOR THE ABOVE-GROUND INFRASTRUCTURE IN THE CITY OF CHISINAU BY MODERN GEODETIC METHODS

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**Abstract:** *This study proves the effectiveness of laser scanning and the importance of its application in the point cloud creation and 3D model building, designing thus a model aiming to reorganize the above-ground infrastructure of the "Petro" Oil Base in Chisinau. A comparative study of combined terrestrial laser scanning and aerial laser scanning methods will be presented, managing to offer a high quality final product, ensuring a certain level of precision for the redevelopment and reconstruction of municipal networks. The terrestrial laser scan of the entire object was performed from 53 stations, and 604 photogrammetric images were taken during the airborne laser scan. Following the data processing through certain specialized software, the 3D model was created, with an accuracy estimate of 0.0015 m - 0.002 m.*

**Key words:** *Point cloud, terrestrial laser scanning, aeroscanning, Leica BLK 360, DJI Phantom 4.*

## 1. Introduction

Nowadays, terrestrial and aerial laser scanning is considered as a revolutionary technology in the field of geodetic measurements. The development of sensors prepared to ensure quickly collecting 3D surface information has made it possible to perform high-precision measurements. Laser scanning technologies display field data in the form of a point cloud on a screen, thus using it as a guide, we gather large amounts of information to render the field as accurately as possible [3]. The point cloud is represented in a 3D space by a rectangular coordinate system (X, Y, Z) [5]. The scanner automatically collects the 3D coordinates of the field object in a systematic manner.

A 3D scanning equipment consists of: 3D laser scanning system, computer and software for scanning, transferring and processing downloaded data [8].

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Laser scanning can be: static, when the position of the instrument is fixed during data acquisition; and in dynamic mode, when the instrument is mounted on a mobile platform [7].

Two laser scanning systems were used for comparison in this study, a system used in static mode Leica BLK 360 Scanner (BLK Edition) and a system used in dynamic mode DJI PHANTOM 4 RTK. The Cyclone Register BLK360 Edition specialized software was used to process the data following the terrestrial laser scan, and the AgiSoft Metashape software was used for the data processing following the aeroscanning.

At the present stage, laser scanners are an outstanding solution for performing measurements in many areas of activity, such as: architecture, urbanism, archeology, natural hazards, construction designing and monitoring, evidence analysis and restructuring of roads, bridges, tunnels, restoration of historic sites etc. [1], [2], [4], [6].

This work aims to perform comparative analysis of the possibilities of using two laser scanning systems, by demonstrating their efficiency and necessity, but also by describing the obstacles encountered during the entire process of conducting this study. The main purpose of the study is to create the point cloud and the 3D model for the reorganization of the above-ground infrastructure of the "Petrom" Oil Base in Chisinau.

## 2. The Study Area

The "Petrom" Oil Base is located in Chisinau, 34 Industrial Street in the Ciocana sector, located on the outskirts of the city. The work area covers a territory of 2.46 ha (Figure 1), and the object to be scanned, especially tanks and above-ground networks, covers an area of approximately 1 ha [9].



Fig. 1. Object of study location on the "Petrom" Oil Base area

This object is strategically localized and has the purpose to ensure advantageous logistics and distribution of oil gases in the Republic of Moldova.

### 3. Data Collection

During the process of data collection, Leica BLK 360 with 150 Mega pixel spherical image generation scanner was used for terrestrial laser scanning,  $360 \cdot 10^3$  laser scan set points per second and 3D point accuracy  $6 \text{ mm} / 10 \text{ m} \div 8 \text{ mm} / 20 \text{ m}$ . The scanning field in the horizontal plane is  $360^\circ$  and  $300^\circ$  in the vertical plane [11]. A tablet with Leica Cyclone FIELD 360 control panel was also used in the field [12].

For the aerial laser scanning, a DJI PHANTOM 4 RTK was used with a built-in digital camera capable of taking images with a resolution of 12 MP and  $4864 \times 3648$  pixels [10].

For georeferencing, the design of a spatial geodetic network determined by GNSS technology was chosen, thus offering a unique precision for all three 3D components (X, Y, Z). The geodetic network was designed on four control points exactly materialized within the work area. The position of these points was determined using a Trimble R8s GNSS receiver in the national MOLDPOS positioning system [13]. Hence, the coordinates of the points are determined in the national reference coordinate system MOLDREF99 [14] and the Baltic Sea altitude system for the municipality of Chisinau.

For the terrestrial laser scanning, there were 53 proportionally located stations used in the work area (Figure 2a, b), so that the scanning station guarantees maximum coverage and accuracy, while reducing the number of settings.

The position of each scan is defined in the scanner coordinate systems. In order to be able to align different scan positions, it is necessary to establish the exact position and orientation of these scanner coordinate systems according to a local coordinate system [7].

In this specific case, the position and orientation of the 53 stations were determined according to the four control points in the national system MOLDREF99, so the georeferencing of the entire data set was related to a fixed coordinate system.

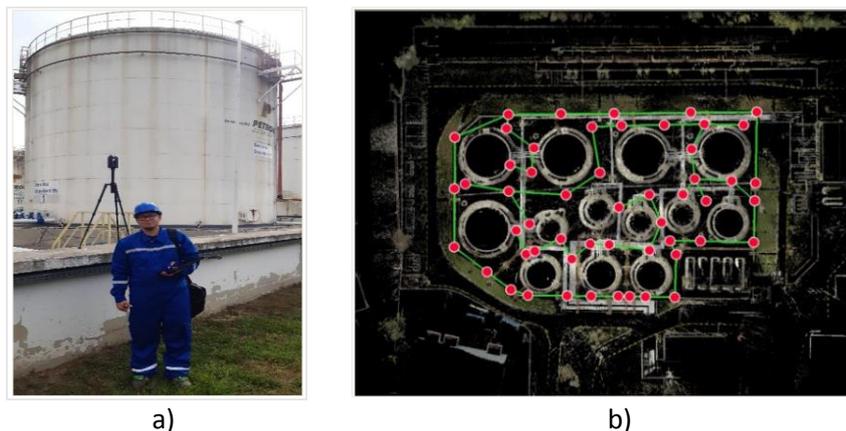


Fig. 2. Location of the 53 terrestrial laser scanning stations:  
a) an optimal position of the scanner; b) scanner stations in the work area

Correct setting is crucial for recording data and obtaining a high-precision 3D model. Given that the Leica BLK 360 (BLK Edition) scanner is a mini scanner and has a modern calibration system (compensator), being centered and set before starting the scan is

essential for determining its position in the local coordinate system. Meanwhile, the DJI Phantom 4 RTK requires positioning on the road surface, as follows: the drone rotates vertically and horizontally, then horizontally at 360° until the warning message on the control panel disappears.

Before starting the measurements and data collecting, the scanners are connected to the control panel (Figure 3a, b) which can receive and store all the data provided by the scanner, thus verifying the properties of the scanner. Figure 4 shows the view on the Leica Cyclone FIELD 360 control panel of the S2 station, for example the S2 station.

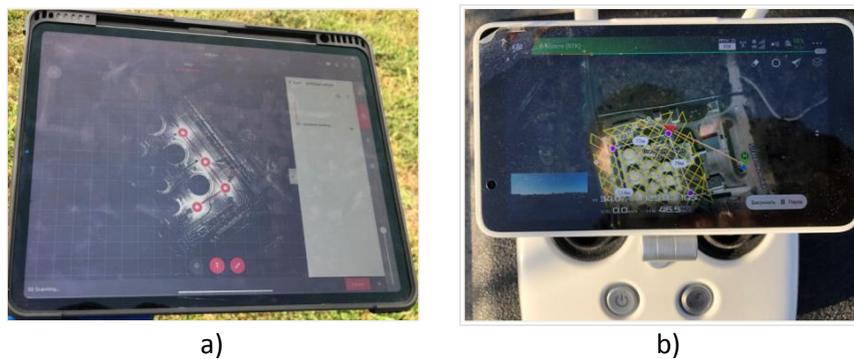


Fig. 3. Control panel: a) *Leica BLK 360*; b) *DJI Phantom 4 RTK*

When the scanning process starts, the scanner identifies the starting point and proceeds to collect the points. These points are stored on the control panel where they can be viewed live, having internet connection and a cloud connected to both the control panel and a desktop computer.

Engineers can view data remotely and store it from the scanner's internal memory. By connecting the scanner to a computer, it is possible to view the scanned points directly on a screen and get an overview of the area that has already been scanned.

After completing the whole scanning process, a scan is performed for all unforeseen obstacles that cause occlusive areas on the final product. The scan control software sets the parameters in such a way that several regions can be scanned at different resolutions [7].

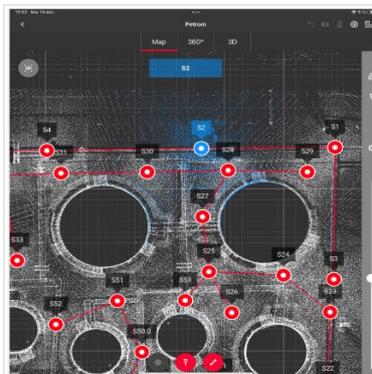


Fig. 4. *S2 station viewing on the Leica Cyclone FIELD 360 control panel*

In the present work, the highest resolution was set for the terrestrial scanning, so the whole scanning process lasted up to 6.50 minutes.

Concerning the aeroscanning, several factors are taken into account: the flight altitude, camera resolution and weather conditions. For aeroscanning the area, the drone was set at an altitude of 30 m from the ground, at the highest resolution, resulting in 604 photogrammetric images. The weather conditions in some places were disadvantageous, either because of the strong wind or because of the clouds that covered the sun's rays not allowing the light to the focusing camera. These factors had a significant influence on the scanning time, so the aeroscanning took place over a period of 24.50 minutes.

#### 4. Data Processing

After completing the object scanning process, the obtained data will be processed on a computer for 3D modeling. This can be done directly from the scanner connected to the computer by copying data from the cloud, or by connecting the control panel to a secure IP address. The data processing step is actually the recording of all scans, so that it is a common coordinate system for the entire point cloud, which will represent, on a 1:1 scale, the object of study.

3D modeling of field data was performed using Leica Cyclone REGISTER 360 (BLK Edition) specialized software (Figure 5) for terrestrial laser scanning and AgiSOFT metashape software for aeroscanning (connected via USB cable) (Figure 6).

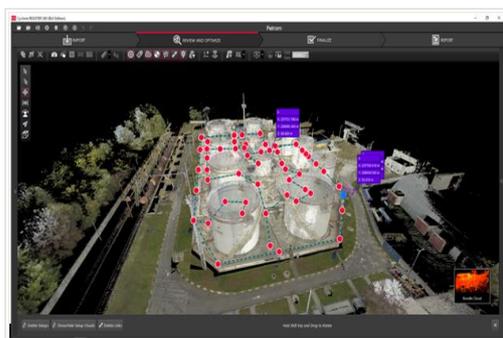


Fig. 5. Earth Scan Data Processing

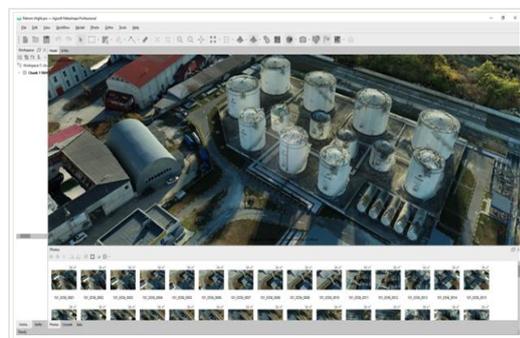


Fig. 6. Aeroscan data processing

The 3D modeling process starts from creating a connection with the scan database where the scanned information is being stored in. The first step in data processing involves creating a new storage file.

The import or connection step is one of the most automated and also the most expensive of all processing steps. In order to import data from the terrestrial laser scanner, a connection is made through a computer-generated IP address.

The import of aeroscanned data is performed only with the control panel, via the USB cable, and finally the data will be imported into specialized software. For this reason, it is necessary to upload the data related to the division of the fully recorded set of points and the images taken by the camera.

After importing the data into the software, the next step can be performed: *Review and Optimize* (Figure 7). In this section, you can optimize, model, edit, detect scanned errors, delete erroneous points and geo-reference the work area (in this case the “*Petrom*” Station) in the MOLDREF99 coordinate system.



Fig. 7. *Editing and optimizing works section*

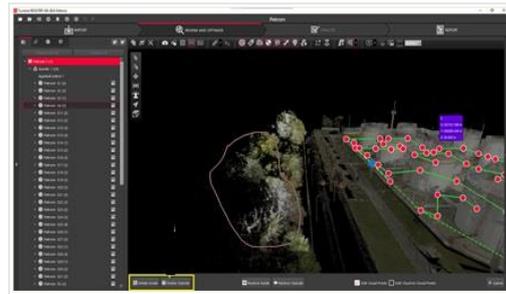


Fig. 8. *Unwanted points deleting*

The *Review and Optimize* function allows you to edit unwanted objects in the scan product. By accessing *Edit*, choose the *Polygonal* option and select unwanted objects on the desktop that can be easily deleted by simply clicking on *Delete Inside/Outside*, (inside selection/outside selection) (Figure 8).

AgiSOFT Metashape has no option to delete moving objects, however there is a manually unwanted points deleting option available, giving permission to access any option without being in one operation mode or another (Figure 9).

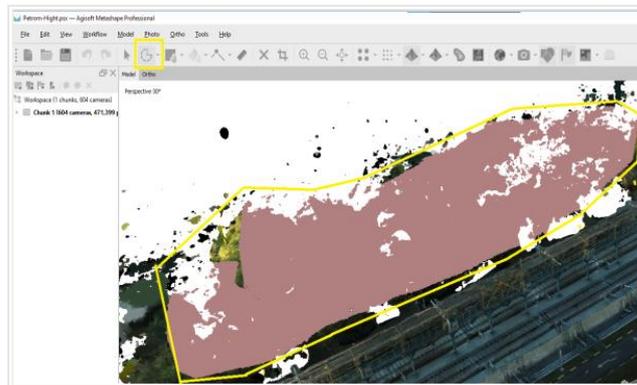


Fig. 9. *Unwanted points deleting with AgiSOFT Metashape*

For such edits, it is recommended to use the TruSlicer tool (not available in AgiSOFT Metashape) (Figure 10), which allows a cross-section of the recording to be finalized for review. This is useful, for example, if two scans were recorded simultaneously on a wall: you can move the cutting tool up and down to check if the wall is flat at each data level.

Unlike the Cyclone Register 360, the AgiSOFT Metashape software offers the possibility to perform a multitude of operations: Build Mesh, Build texture model, Building tiled model, Building digital elevation model, Build Orthomosaic.

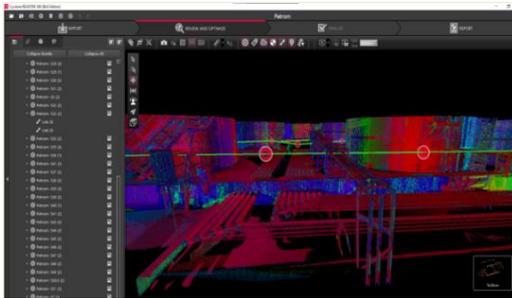


Fig. 10. Using the TruSlicer tool

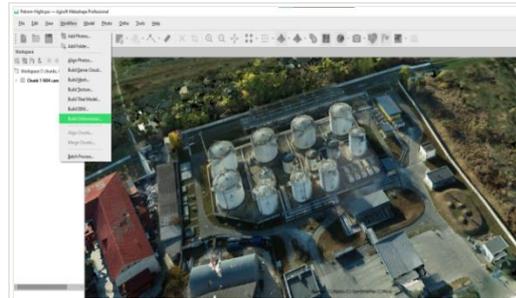


Fig. 11. Creating the orthophoto image

Build Orthomosaic provides the orthophoto image, which can be used to view, measure and analyze objects in the field at different scales (Figure 11). On the other hand, the amount of information provided by the section orthophoto image is much more limited, which allows us to perform cadastral measurements on a specific, limited created section.

## 5. Creating the Data Evaluation Report

After performing the steps of creating, modeling, editing and cleaning of unwanted objects, the final optimization of the data is carried out (Figure 12) and the final data evaluation report is created.

Results accuracy evaluation can be noticed from the performance of the classifiers that are analyzed by creating the coverage ratio of the scanned object based on the point cloud.

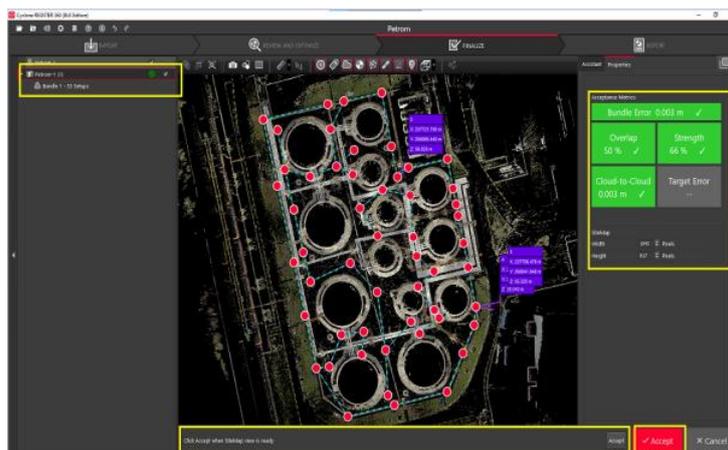


Fig. 12. Creating the data evaluation report using Cyclone Register 360

Data accuracy is calculated by the ratio between the coverage/set of correctly labeled common points and the total number of data, while the error rate results from the ratio between the number of incorrectly labeled data and the total data number.

The figures below show the total evaluation reports of the results following the application of the 3D classification for the case study. Figure 13 shows the evaluation of the accuracy of the terrestrial laser scan performed with the Leica BLK 360 scanner (BLK Edition), and Figure 14 shows the report of the evaluation of the accuracy of the airborne scan performed using the DJI Phantom 4 RTK drone.

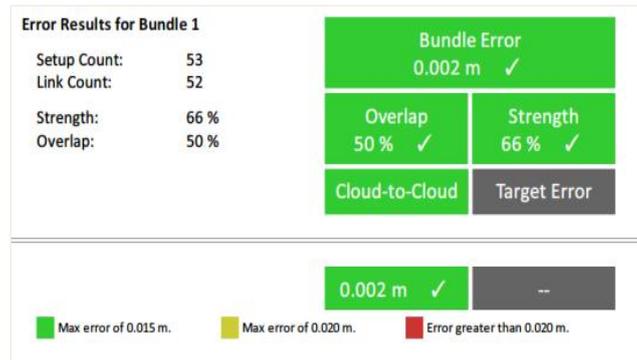


Fig. 13. Average evaluation of terrestrial laser scanning errors

Type	Resolution	Focal Length	Pixel Size
<b>Frame</b>	<b>5472 x 3648</b>	<b>8.8 mm</b>	<b>2.41 x 2.41 µm</b>

	Value	Error	F	Cx	Cy	K1	K2	K3	P1	P2
<b>F</b>	<b>3689.09</b>	0.044	1.00	0.05	-0.96	0.22	0.05	-0.05	0.03	-0.88
<b>Cx</b>	<b>-37.7743</b>	0.015		1.00	-0.06	0.00	0.01	-0.01	0.93	-0.03
<b>Cy</b>	<b>-38.9036</b>	0.049			1.00	-0.33	0.05	-0.03	-0.05	0.95
<b>K1</b>	<b>-0.0157934</b>	1.8e-05				1.00	-0.92	0.86	-0.01	-0.36
<b>K2</b>	<b>0.000404168</b>	5e-05					1.00	-0.98	0.01	0.07
<b>K3</b>	<b>0.007753</b>	4.5e-05						1.00	-0.02	-0.06
<b>P1</b>	<b>-0.00267907</b>	1.3e-06							1.00	-0.03
<b>P2</b>	<b>-0.00313601</b>	2.9e-06								1.00

Fig. 14. Calibration coefficients and correlation matrix

The accuracy of the 3D modeling created from the scanned images depends on the technical characteristics and type of the digital camera, the geometry of the network of point stations for taking the images, the accuracy of the process of identifying the object points and their number.

After estimating the camera in the three-dimensional position (X, Y, Z) for airborne scanning, the errors shown in Table 1 were obtained.

Average camera location error

Table 1

X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total error (cm)
1.23961	1.26366	1.1811	1.77016	2.12802

## 6. Data Export

AgiSOFT Metashape software supports the export of processing results in different representations: point clouds, camera calibration and camera orientation data, mesh, orthomosaics, and digital elevation models (both DSM and DEM). The point cloud and camera calibration data can be exported immediately after photo alignment is complete. All other export options are available after the appropriate processing step.

If you intend to export the results (point cloud / mesh pattern / tiled) for the unreported snippet, it must be considered that the resulting file will be oriented according to a default coordinate system. Therefore, the model may look different from what is seen in the Metashape window.

When it comes to exporting data for Cyclone Register 360 software, the user has many publishing options for how they want to share their project. The registration report will always be created as .pdf, however the user can optionally choose to publish the project on TruView Local or in any other format: .e57, .PTS, .PTG, .PTX, .RCP.

## 7. Conclusions

The use of modern terrestrial and airborne laser scanning methods inevitably leads to a comparative study between them. At the present stage, traditional scanning methods are complemented by innovative devices and software tools, which are making a real revolution in the field. Thus, thanks to the equipment used for this work, Leica BLK 360 BLK Edition and DJI Phantom 4 RTK, completed with additional features and options, the duration of the scanning process has been considerably reduced, the final product being beyond any doubt, of the highest quality.

This work presents the effectiveness of laser scanning and the importance of applying it to both simple and complex geodetic measurements. In the laser scanning process, the aim was to perform works oriented towards maximum precision, obtaining a high quality final product. Based on the results obtained after the laser scan, the resulting errors were within the limits of 1.5 - 2 mm.

Due to the achievement of the proposed objective, the following ideas can be outlined:

- the position of the checkpoints and station should be placed, as close as possible to the area of interest, in order to remove cover and shadows;
- when performing measurements with laser scanning systems there is minimal operator intervention, for Leica Cyclone REGISTER 360 (BLK Edition) it is necessary to set, center and set the scan parameters, and for DJI Phantom 4 RTK it is necessary to be positioned on the road surface and having the scan parameters accordingly set;
- the acquired spatial data are recorded automatically, eliminating random errors caused by the engineer;
- the acquisition of a large number of points in a short period of time helps us to correctly interpret the scanned objects even the small ones;
- laser scanning systems can produce high resolution images, which can be georeferenced and used for data analysis and processing;

- the data processing software purchased Cyclone Register BLK360 Edition and AgiSOFT Metashape comprises several methods of analysis, reporting/interpretation and offers a wide range of possibilities so that the user chooses the appropriate method of processing according to the purpose, as well as exporting and importing data in various formats;

- the selection and optimization of the resulting data (point cloud), which involves the elimination of points that are not subject to the scanned area, the removal of obstacles, the exclusion of points to close, is done automatically at user-defined parameters.

## References

1. Căţeanu, G.M.: *Using Lidar for the Generation of Digital Elevation Models in Forested Terrain*. In: PhD Thesis Summary, Braşov, 2019.
2. Ceausu, C.C., Dregheci, S.A.: *3D Modeling Techniques for the Restoration and Conservation of Historical Buildings*. In: Rev. CAD **29** (2020), p. 13-18.
3. Heritage, G., Large, A.: *Laser Scanning for the Environmental Sciences*. Wiley-Blackwell Publishing Ltd. ISBN: 978-1-405-15717-9, 2009.
4. Loghin, A.M.: *Research on the Use of Laser Scanning Technology on Watercourses*. In: PhD Thesis Summary, Iaşi, 2018.
5. Neagu, M., Vasilca, D.: *Using 3D Laser Scanning in the Architectural Field*. In: Journal of Geodesy, Cartography and Cadastre **7** (2017), p. 34-44.
6. Oniga, V.E., Breaban, A.I., Pfeifer, N., Diac, M.: *3D Modeling of Urban Area Based on Oblique UAS Images - An End-to-End Pipeline*. In: Remote Sens. **14** (2022), p. 422. <https://doi.org/10.3390/rs14020422>.
7. Santana Quintero, M., van Genechten, B., de Bruyne, M., Poelman, R., Hankar, M., Bames, S., Caner, H., Budei, L., Heine, E., Reiner, H., et al.: *Theory and Practice on Terrestrial Laser Scanning*. Training material based on practical applications, version 2, 2006 and version 4, 2008.
8. Savu, A.: *Improvements to Topographic and Geodetic Works in the Field of Communication Routes*. In: PhD Thesis Summary, Bucureşti, 2010.
9. Tiganu, E.: *Point Cloud Generation for the PETROM Oil Storage Depot Terrestrial Infrastructure*. In: Master Thesis, Chisinau, TUM, 2022.
10. \*\*\* DJI PHANTOM 4RTK Information. Available at: <https://www.dji.com/phantom-4-rtk>. Accessed: 10.12.2021.
11. \*\*\* Leica BLK360 Imaging Laser Scanner. Available at: <https://leica-geosystems.com/products/laserscanners/scanners/blk360>. Accessed: 12.12.2021.
12. \*\*\* Leica Cyclone FIELD 360. Available at: <https://leica-geosystems.com/products/laser-scanners/software/leica-cyclone/leica-cyclone-field-360>. Accessed: 12.12.2021.
13. \*\*\* *Regulation on the National Positioning System*. Approved by the Decision of the Government of the Republic of Moldova, no. 307 of April 28, 2011.
14. \*\*\* *Regulation on the transition to the global and reference coordinate systems and the respective cartographic projections*. Approved by the Agency for Land Relations and Cadastre (ALRC), and implemented by order no. 185 of July 10, 2001.