

## USE OF TOPOGRAPHIC TECHNIQUES AND TECHNOLOGIES IN THE MANAGEMENT OF STORED WASTE VOLUMES

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**Abstract:** *Waste generation is the indicator that best illustrates the extent of the interaction between human activities and the environment. Waste generation usually follows consumption and production trends and monitoring of landfills in landfills for large urban agglomerations is a key parameter for waste management over a period.*

*To this end, this paper addressed the topic of calculating the volume of waste deposited, using topographic techniques and technologies.*

**Keywords:** *waste, UAV, volume, aerial imagery, digital terrain model, orthophotoplan*

### 1. Introduction

National waste management policy must be in line with the objectives of European waste prevention policy and aim at reducing resource consumption and the practical application of the waste hierarchy. The generation of household waste (quantity / inhabitant) increases with the increase of the living standard, and the increase of the economic production, but also the inefficient management of the resources, lead to the generation of large quantities of waste. In this sense, waste management refers to education on waste collection, transport, treatment, recycling and storage.

The use of topographic techniques and technologies in the determination of landfill volumes involves the approach of combined methods specific to the field of land measurements.

Photogrammetry is the science that deals with the determination in time and space of fixed, mobile or deformable objects and their photographic, graphic or numerical representation (by coordinates) based on special photographs called frames.

If classical photogrammetry deals with the determination in time and space of fixed, mobile or deformable objects and their photographic, graphical or numerical representation (by coordinates) based on special photographs called frames, UAV photogrammetry is an alternative method to classical photogrammetry, which deals with the aerial recording by means of a drone, of the terrestrial data from low and medium heights. With the help of UAV technology, data can be obtained over a large area in a short time, including on hard-to-reach or inaccessible land areas, in safe conditions.

The new trend in collecting geospatial data for the preparation of orthophotos, regardless of the types of land and the category of use, is the use of aerial images taken with UAVs.

## 2. Materials and Methods

The objective of the project was to carry out a topographic survey with UAV equipment of a landfill to calculate the volume of filling and the realization of the three-dimensional surface with the help of specialized programs.

The elaboration of the Digital Terrain Model and the orthophotoplan will be done by collecting data from the field and performing office operations.

The collection of field data was performed by performing land and air topographic measurements.

The acquisition of aerial data by capturing the Images presupposed the completion of some stages, namely:

- Requesting the necessary approvals for sending the drone into the airspace;
- Identifying the site by conducting field visits and establishing work areas. During this stage, the optimal terrain / space for the location of the launch and landing stations of the drone is identified;
- Flight planning for the area of interest including information about the trajectory of the UAV, the flight altitude, the place of takeoff and landing, the number of flights necessary to cover the requested area of the studied area of interest;

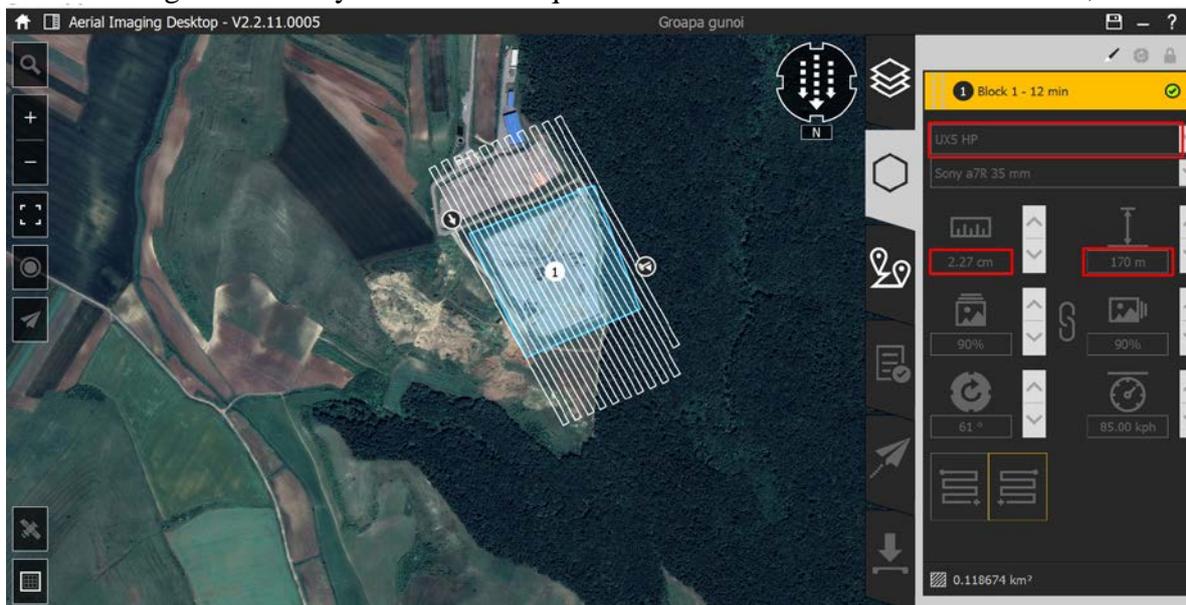


Fig. 1. Software-Arial Imaging- Overflight planning

- Execution of flights: launching the UAV in aerial space, collecting aerial images and collecting GPS data necessary for image processing. The ground altitude of the drone will be 170 m, altitude that allows the determination of points with a precision in the horizontal plane between 2.27 cm, with a pixel size (GSD) of 1.3-2.6 cm / pixel. Capturing aerial images for areas of interest will be done with a 36MB Fujifilm full-frame camera built into the body of the UAV, the density of the cloud of points obtained being up to 1000 points / m<sup>2</sup>.



Fig. 2. Launch of the UAV

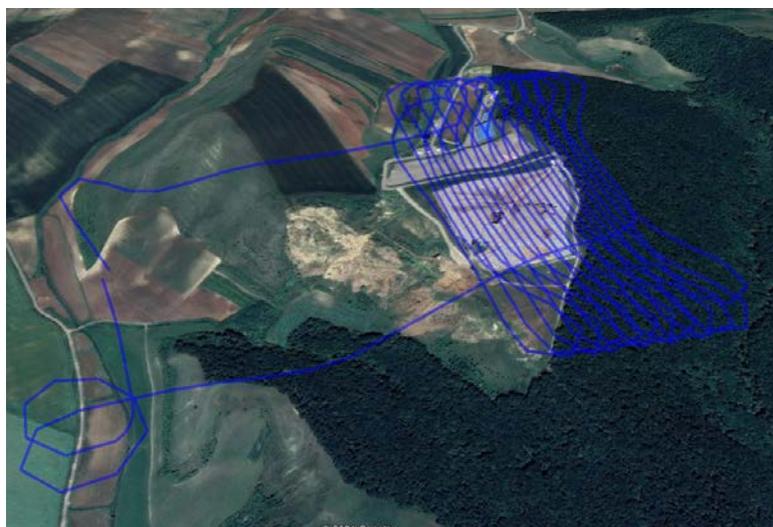


Fig. 3. Software-Arial Imaging- Planned trajectory for UAV UX5HP

- Download the data recorded by the UAV after the flyover using the Trimble Aerial Imaging software and the RINEX files from the GPS station, their storage and archiving on electronic hard disk support.

The acquisition of topographic data by terrestrial measurements involved the following:

- Determining the common points between the two aerial and terrestrial topographic surveys;
- Recording the coordinates (X, Y, Z) of the common points (control points) between the two aerial and terrestrial measurements with GPS equipment. The working method used for terrestrial measurements with GPS equipment is Real Time Kinematic determining the coordinates of the points with an accuracy of + - 2 cm in the vertical plane and + - 1 cm in the horizontal plane;
- Topographic surveys with the total station in the unusable areas of the frames (eg areas covered by the crown of the trees). Depending on the location of the site, the details will be collected from the field by designing a geodetic network or closed road;
- Download the recorded data and field cards from GPS and the total station, their storage and archiving on electronic hard disk support.



Fig. 4. Verification and validation of individual frames

### 3. Results and Discussion

During the office stage, the RINEX files were downloaded from the GPS station and those recorded by the UAV after the flyover using the Trimble Aerial Imaging software, and their processing was done using the Trimble Business Center software.

The following aspects were considered for the office part:

- Processing, analysis, validation, processing and interpretation of collected data;

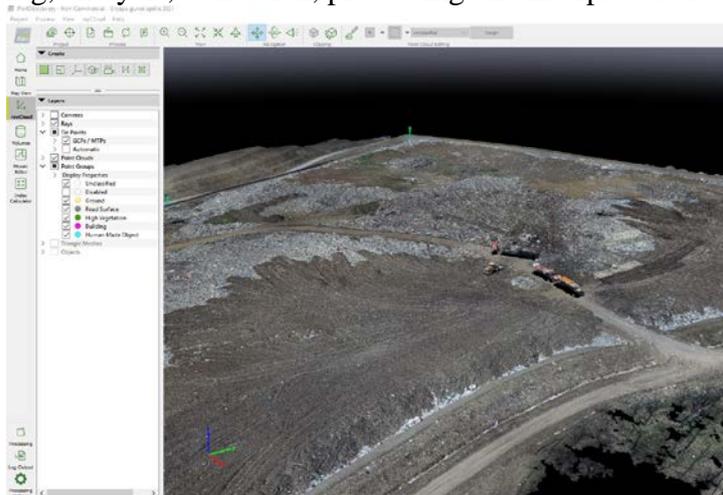


Fig. 5. Software-PIX4D- creating the Point Cloud

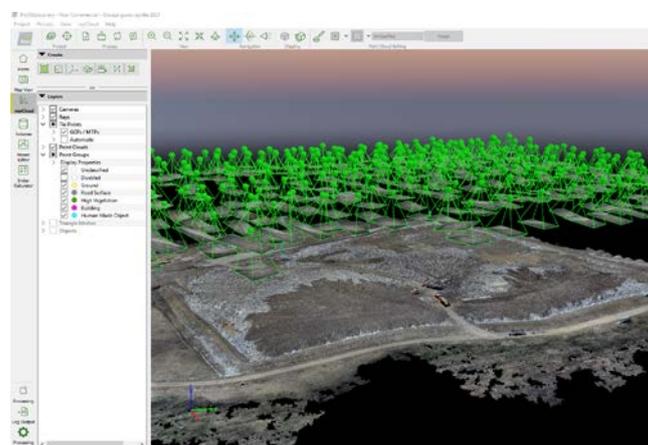


Fig. 6. Software-PIX4D- creating the connection points of the frames

- UAV image processing with Trimble Business Center, Pix4D
- Generation of the orthophotoplan.

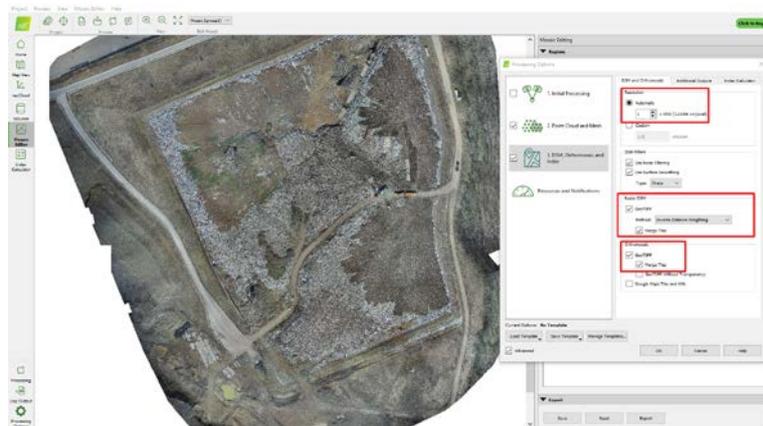


Fig. 7. Software-PIX4D- create Orthophotoplan

After obtaining the orthophotoplan related to the measurements performed on the landfill, the georeferencing of the orthophotoplan was performed and its correlation with the terrestrial topographic surveys.

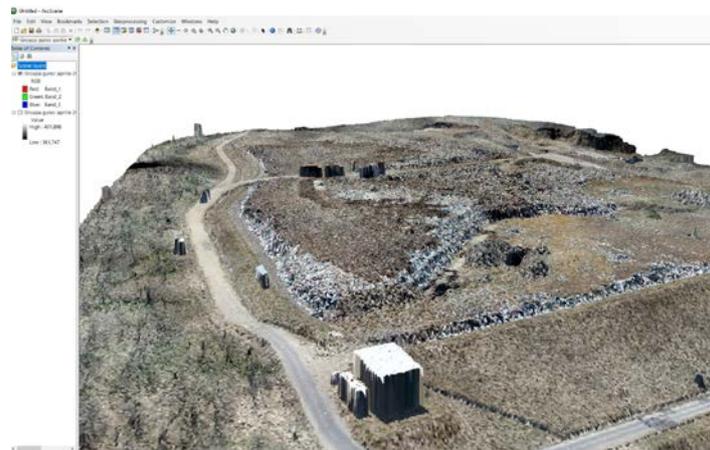


Fig. 8 Three-dimensional visualization of the orthophotoplan in ArcScene software

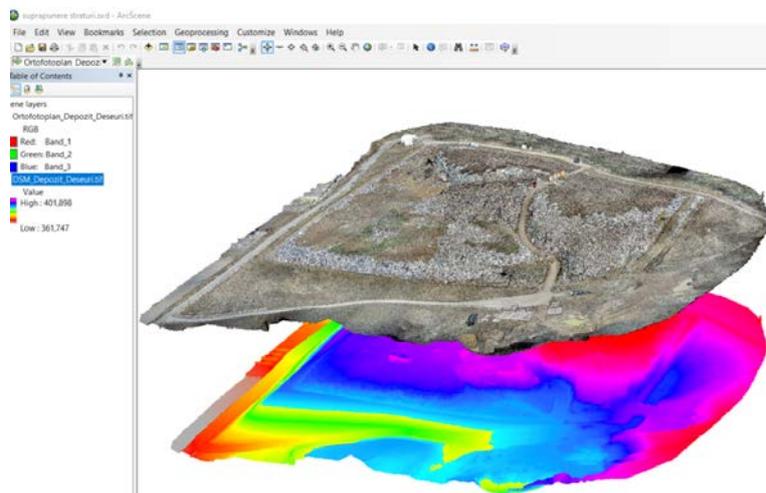


Fig. 9. Three-dimensional view of orthophotoplan and DTM in ArcScene software

The generation of the Digital Terrain Model was done through the Pix4D software, where it was possible to move to the stage of volumetric calculation of the filling layer.

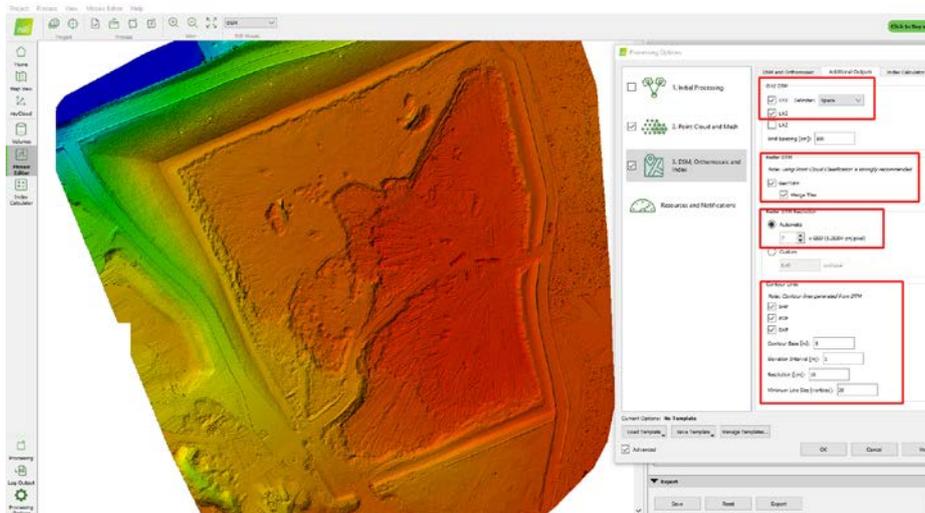


Fig. 10. Software-PIX4D- create DTM and DSM

In determining the volume, reference data and quotas were generically called "zero quotas".

In this stage, the contour of the surface of the area of interest was created for the calculation of the filling volume, a contour that must be identical with the reference contour "cotazero".

Two DTMs were created, one with basic quotas and one with quotas determined by previous processing. These were cut according to the measured contour so that only the area of interest was included when extracting the differences between the two DTMs.

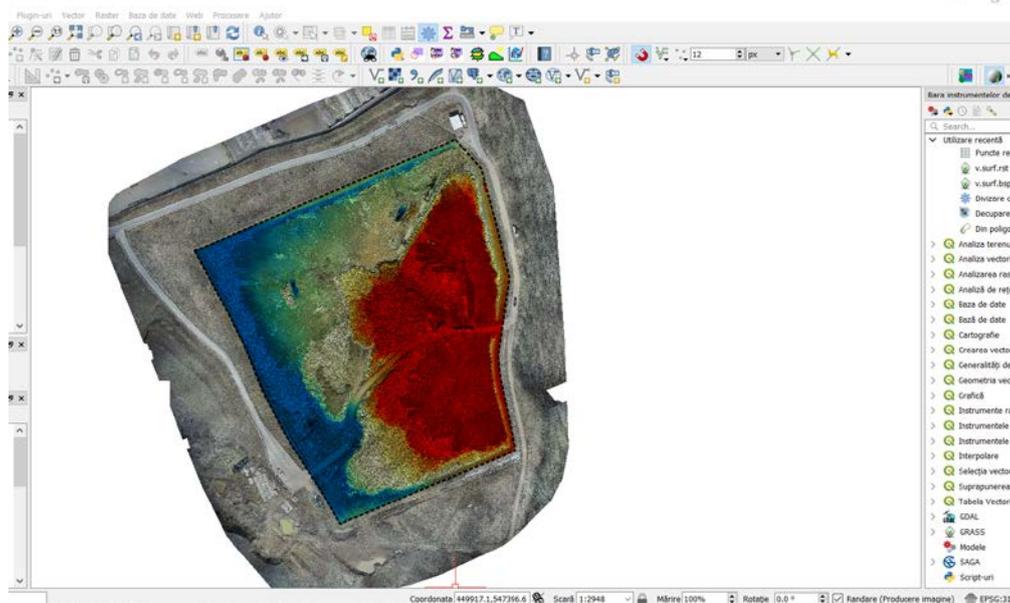


Fig. 11. Software-QGIS- area determination for volume calculation

The calculation of the volume of stored waste was performed by introducing the two DTMs in the QGIS software, the volume obtained from the waste filling being 658,320 m<sup>3</sup>.

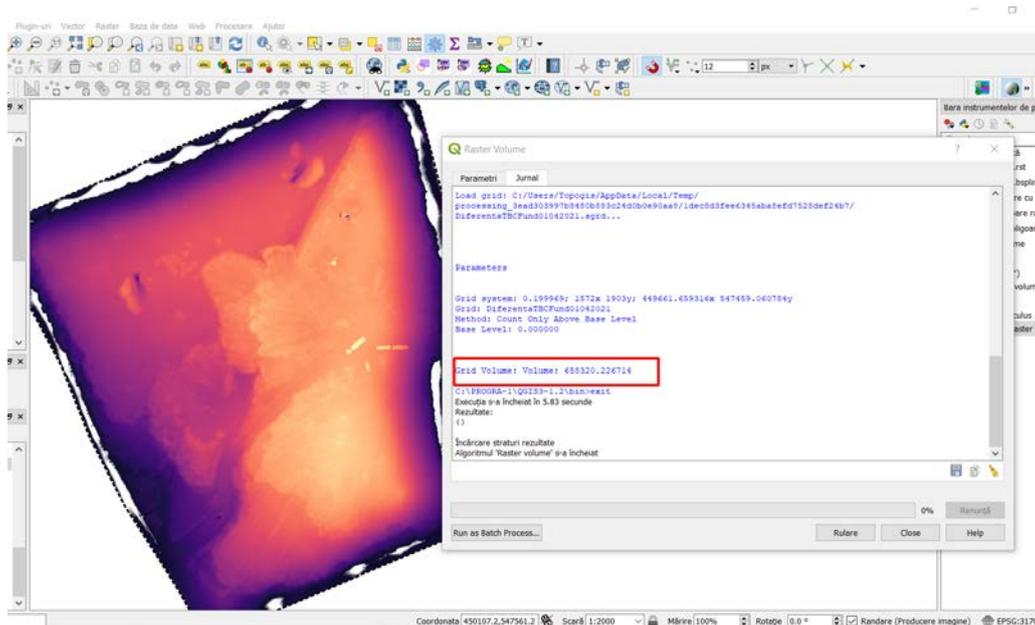


Fig. 12. Software-QGIS- the result of processing the volume calculation

#### 4. Conclusions

Based on the accomplishment of this paper, a number of aspects have been identified regarding the operation of UAV-type instruments in the measurement works in general and those for determining volumes in particular, namely:

- UAV technology offers major advantages over the classic method by reducing much of the time of data collection and processing;
- Depending on the equipment used, the measurements performed provide a very high horizontal and vertical accuracy, a result verified by comparing the coordinates measured on the ground using GPS and the coordinates of the points in the resulting DTM;
- Realization of the digital terrain model (DTM), the digital surface model (DSM), of the orthophoto plans and the three-dimensional model with low costs;
- Calculation of excavation and filling volumes on a certain area or on the whole studied surface and extraction of longitudinal and transversal profiles with a high density of points;
- Possibility of regular monitoring of the area.

However, this exposure may be limited by a number of factors, the most important of which are:

- The type of UAV instrument used that influences the space required for take-off and landing;
- Limitation of increase time and measured area depending on the type of batteries used.

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