

## USING UAV'S TECHNOLOGY IN THE MINING INDUSTRY

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### **Abstract**

*This paper presents a workflow from the stage of acquiring images from the field using UAVs, to the ready-to-use products/results that provide the user with accurate view of all the activities in the exploitation area. What is also highlighted in this paper is the drastic reduction of processing times - from days to hours. Applications of this technology include: sustainable management of natural resources, identification of new mineral deposits, transport monitoring, open pits supervision and evaluation. The Mining Industry has undergone several major transformations in the technological era. As we speak, miners are using new complex technologies in their exploitation area, in order to make better use of the Earth's resources. Although initially developed for military purpose, UAVs have benefited in the most recent years from a high-level trust from the civil segment. The derived products obtained from the acquired images-orthophoto, point cloud, digital elevation model-as well as the different sensors that can be installed on their platform, allow these devices to be used in various applications. The field of Mining, quickly embraced this technology that provides fast implementation, visibility for inaccessible or dangerous areas and smart solutions for balancing the demand and environmental protection.*

**Keywords:** mining, UAS/UAV platforms and sensors, 3D modelling, mission planning, primary data processing.

### **INTRODUCTION**

This paper is focused over a small surface pit in a village from Romania, called Mirsid. This location was chosen in order to demonstrate the proposed workflow over a compact area, thus the utility of using UAV technology in the mining field.

Mirsid is situated in the Salaj County, region of Transilvania, Romania. With a population of 2160 inhabitants from which 1500 are active in the work field, the economic segment in the area is highly represented by the extractive industry. The tuff extracted from the surface pit is a type of sedimentary rock, with a high degree of porosity, used on a large scale in the production of cement.



Figure 1. Site Location



Figure 2. Salaj County

## DATA ACQUISITION

The first step in this scientific research was the acquisition of the high-resolution aerial images of the surface pit using the eBee drone from SenseFly. This is one of the most used professional drones on the market because it is very easy to pilot and does not require special skills or technical certifications. Also, the eBee's autopilot continuously analyses data provided by the Inertial Measurement Unit and on board GPS allowing the user to see the image acquisition progress in real time, and also to intervene at any point in the flight plan. The device can further be equipped with other sensors to serve the purpose of the flight mission. For this case study, eBee was equipped with a RGB camera which captured 221 images in less than 40 minutes with an absolute horizontal/vertical accuracy of down to 3/5 cm.

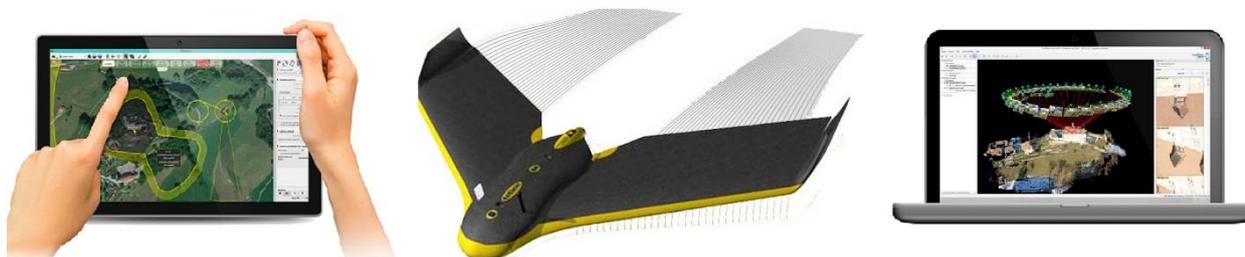


Figure 3. eBee drone

## DATA PROCESSING

EBees has a built-in Flight Data Manager that assists the user to pre-process, geotag and organize the flight's image. These files can be imported in professional photogrammetry software for further processing. In the case of the aerial images captured over the surface pit of Mirsid was used Esri's software Drone2Map. The 64 bit application is designed in collaboration with the producers of Pix4D, with which it shares similar options, allowing in the same time fast processing of the data and an easier interaction with the tools.

In this project – based application, the user can choose from 3 types of processing sessions, depending on the data available and the output expected. In the case of the Mirsid's pit, the images acquired in the field, were used in the the Mapping Project Template. This type of project reacquires aerial images with a high amount of overlap. As a result, it returns 2D products ready to use in ArcGIS. Below, see the orthophotomosaic and the Digital Surface Model obtained from the flight and used in the analysis.



Figure 4. Orthophoto

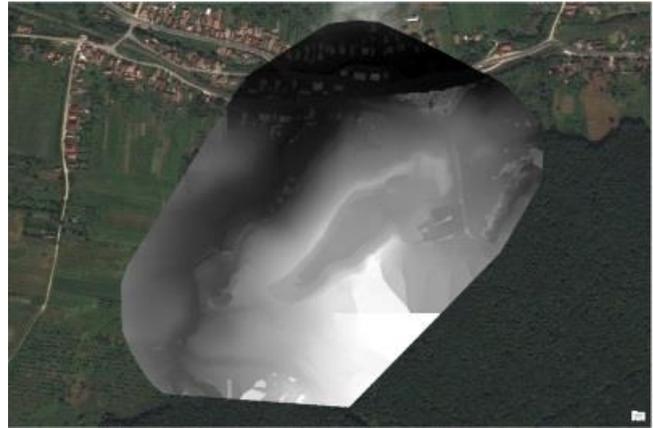


Figure 5. DSM

In addition to the 2D products, Drone2Map compiles the images into other formats that are ready to use in the ArcGIS Platform but do not resume only to it : LAS, .obj, .fbx, AutoCad .dxf, etc. Such a format is the 3D.pdf and .obj formats, which allow non GIS users to visualize and analyze the results of the UAV flight in programs that use other environments : Adobe Reader, CityEngine, Maya, 3D Max, SketcUP, etc. On the other hand, LAS which is a public format file for the interchange of 3-dimensional point cloud is addressed to professional GIS experts. Running specific tools on this file format reveals important information for the study area: building heights, building footprints, etc. A particular interest for this project is represented by the possibility of extracting the height of the trees and the size of their crowns. These two elements, can be combined in order to estimate the amount of wood available in the extraction area.



Figure 6. 3D Point Cloud

## DATA ANALYSIS

The 2D data products obtained by processing the images in Drone2Map, can be further analyze using specific tools in the ArcGIS platform. We used the desktop component, in particular ArcGIS PRO and the Surface tool set, in order to qualify and visualize the terrain land form.

Starting with the raster elevation as input, we used several instruments and gained information by producing a new dataset that identifies a specific pattern within an original dataset. Certain patterns that were not readily apparent in the original surface were derived, such as the angle of slope, steepest downslope direction (Aspect) and shaded relief (Hillshade). Each surface tool provides insight into a surface that can be used as an end in itself or as input into additional analysis.

The “Aspect” tool derives aspect from a raster surface, in this particular case, from DSM. Using this tool, we identified the downslope direction of the maximum rate of change in value from each cell to its neighbors. Aspect can be thought of as the slope direction. It is measured clockwise in degrees from 0 (due north) to 360 (due north). Flat areas with no downslope direction are given a value of -1. Having to know this information is very useful because it leads to the identification of portions to be exploited in the future. Also, after the exploitation, the area must enter a process of redevelopment. Knowing the solar illumination for a location in a region can be used to determine the diversity of plants that can be grown there, or the possibility of installing a photovoltaic park.

For each cell, the Slope tool calculates the maximum rate of change in value from that cell to its neighbors. Basically, the maximum change in elevation over the distance between the cell and its height neighbors identifies the steepest downhill descent from the cell.

The Hillshade tool obtains the hypothetical illumination of a surface by determining illumination values for each cell in a raster. It does this by setting a position for a hypothetical light source and calculating the illumination values of each cell in relation to neighboring cells. It can greatly enhance the visualization of a surface for analysis or graphical display, especially when using transparency. By default, shadow and light are shades of gray associated with integers from 0 to 255 (increasing from black to white). By modeling shade, we can calculate the local illumination and whether the cell falls in a shadow or not and identify each cell that will be in the shadow of another cell at a particular time of day.

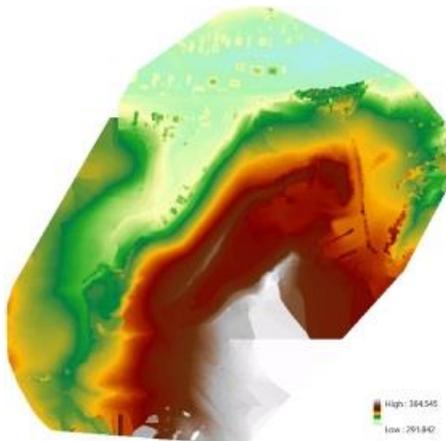


Figure 7. DSM

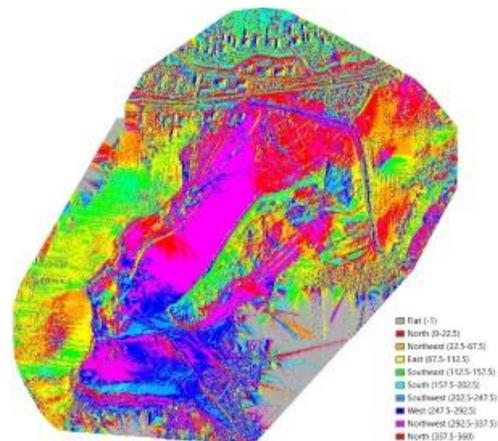


Figure 8. Slope Direction

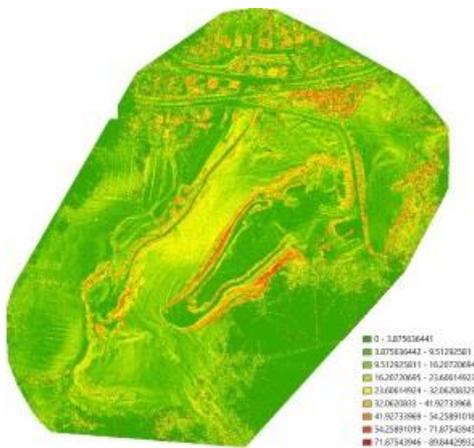


Figure 9. Slope



Figure 10. Hillshade

### 3D Modelling

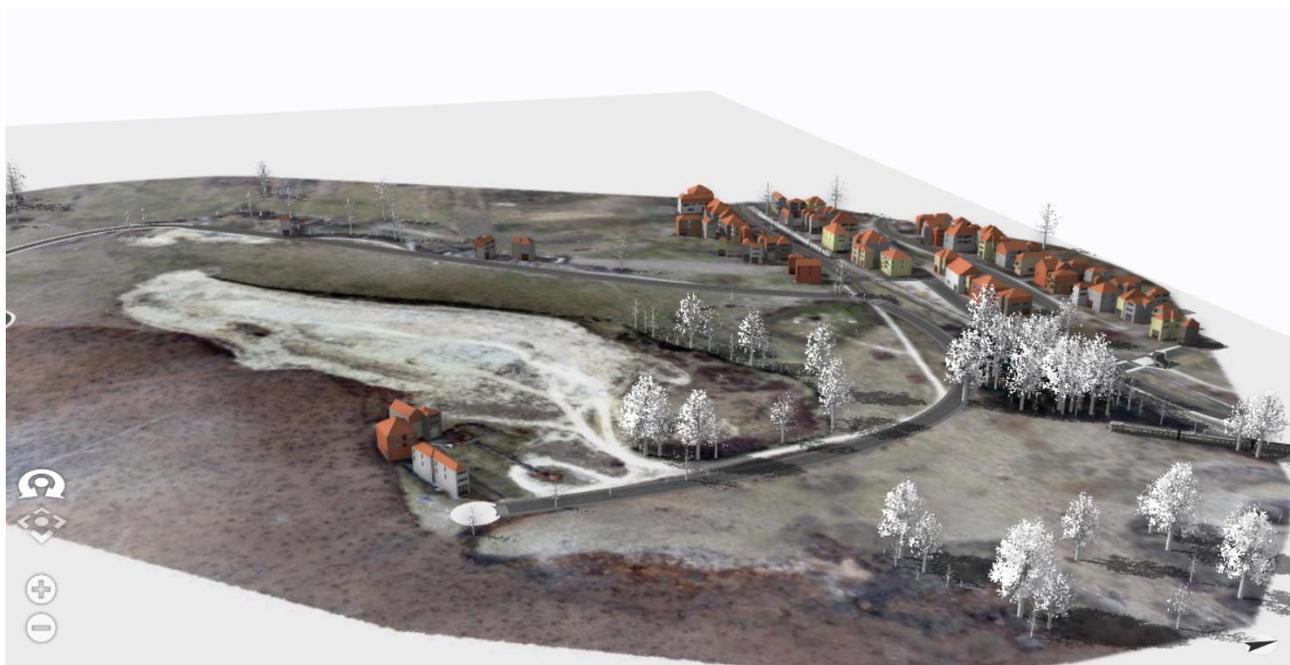
In the past 20 years, Geographic Information Systems have evolved into sophisticated complex systems for the management of spatial data. From classical maps to digital cartography, the evolution was dynamic, and the obvious next step is the upgrade to the future format generation of data - 3D. Until now, it was considered that Geographic Information Systems were able to process large data sets in 2D, but there were limitations in terms of data processing and visualization in 3D. Today, the software segment is highly competitive, and new technologies with complex capabilities and fast processing options have emerged. An example is the software City Engine, which makes possible the transition from 2D to 3D data. CityEngine enables compiling, using and managing geographic information in native formats like ArcMap or .shp and .Gdb and GIS mapping specific operations, data compilation, publishing and viewing online. Basically, it uses classic 2D data, attributes and sets the rules for 3D modeling, which means that data holders can create their own urban scenes starting with the support information they already have.

As input data, we used the building footprints, tree points and their attributes for height extracted from the LAS dataset in ArcGIS. For the roads and railroad, we created separate vectors with information with the width of the road, material and traffic.

The classical method for 3D modelling is a long term process and requires patience, attention, and a great focus on the details. With development of CGA (Computer Generated Architecture) language, 3D modeling has become procedural, which means a minimum of operator intervention and more important, processing of large data sets in a short time.

Computer Generated Architecture (CGA) is a programming language, developed exclusively for CityEngine. It can generate 3D models based on rules written in this language, and then assigned them to classical 2D GIS data sets. The modeling procedure underlying the CityEngine concept is focused on user interaction, which is allowed to intervene on objects and instantly see the effects of his actions.

With the CityEngine 2014.0 version, a library of rules for generating 3D models became available for download on [www.arcgis.com](http://www.arcgis.com). Users who do not have programming knowledge or are not familiar with CGA can use this library rules for generating 3D models of buildings, streets, roofs and building facades. They also contain a set of textures and objects that can be appealed from rules, without the need for the operator to purchase them separately or to create other custom applications. They also can be easily integrated in other rules.



*Figure 11. 3D Web Scene*

## CONCLUSIONS

UAV technology has improved a lot in the last years. We now have access to unmanned devices that can be equipped with sensors in order to acquire data from above the ground. By further processing this data, and analyzing with the help of specialized tool, we are able to find solutions to the daily problems of our society. The Mirsid project is a clear example of how an integrated workflow for UAV technology in the mining field works. Moreover, the fact that the results of the analysis are presented in the form of 3D web scenes brings the extractive industry at the round table for discussions. This is an important step in involving the civil society in the decision making process and also, opens a subject for the future: Smart Cities.

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