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THE USE OF UAV AND GIS TECHNOLOGY FOR OBTAINING THE DIGITAL MAP OF UASVM CLUJ-NAPOCA CAMPUS

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Abstract

The purpose of this project is to build a digital map of the UASVM Cluj-Napoca's campus, in order to help students from the freshman and the visitors because it has a large area of about 23 ha and a number of 15 buildings. We made use of the UAV photogrammetric method, which has advantages such as very short mapping times and reduced costs compared to aerial photogrammetry, using the aircraft. Based on the cartographic data obtained by UAV photogrammetric methods, the necessary paper drawing elements were taken.. In the first phase, we obtained the map using ArcGIS Desktop. Using the data that we obtained from this program we published the ArcGIS Online map where pop-ups were added to each building in order to fit each and every building on the university's website so anyone with access to the Internet can access it from their smartphone.

Keywords*: ArcGIS Online, digital map, geodatabase, UA.V*

INTRODUCTION

With the development of the computing technique, the method of photogrammetric measurements has also evolved. Starting from the need for low implementation and maintenance costs, a more efficient technology has been developed not only economically but also from a quality stand point. The UAV can therefore be seen as a supplement or substitute for terrestrial photogrammetry and related fields such as topography or cadastre. Compared with other technologies, the UAV technology provides very large coverage (100 ha / hour) and with an average centimeter accuracy, depending on the product you need to be done.

UAV photogrammetry can be perceived as a new instrument or branch of classic photogrammetry. UAV opens up new insights into recordings made from small to medium distances, but also introduces new alternatives (https://www.ipartner.ro/media/files/pdf/ro_uav_uav.pdf).

Using photogrammetric measurements as support for classical topographical measurements in order to obtain the topographic plans for urban areas, ArcGIS Online provides the means to create maps and interactive applications that can be shared with specific groups or with all users. Users benefit from ready-to-use content, applications, and map templates. It does not matter if you use desktops, browsers, smartphones or tablets. ArcGIS Online includes a gallery of basic maps and tools that allow you to add data and make customized maps for different purposes (http://www.esri.ro/~/media/esri-Romania/Files/Pdfs/ONLINE%20%20151.pdf)

The pop-up windows contain descriptive information about the spatial objects in each thematic layer on the map. A pop-up contains a header and attribute information based on the columns and rows of your data. Pop-up windows are displayed when you click on a spatial object on the map. You can change how the information is displayed in the pop-up window by changing the title and specifying the fields to display.

MATERIALS AND METHODS

In order to obtain the orthophotomap, a Phantom 4 Pro drone (Figure 1) was used, incorporating a 20 MPcamera with a 1 inch sensor, Drone Deploy for the flight planning, two Trimble R10 GPS receivers, one of which was mounted on a base point previously determined using static methods. In order to achievemaps we used ArcGIS Desktop and ArcGIS Online.

Figure 1. Phantom 4 Pro D

RESULTS AND DISCUSSIONS

The technological process of obtaining digital orthophotomap consists of several stages. The first one consists on marking the ground control points (Figure 2), which is a practical method by which the position of the terminal in the aero-photographed area is visible on the photogrammetry image by fixing visible markings around the point terminal (Toderaș, 2007) and determining using the GPS the X, Y, Z coordinates of the control points determined using GNSS technology. The next stage is flight planning with the help ofDrone Deploy application. A frontal overlap of 75% and 65% lateral overlap was established and the average flight altitude was 100m. The launch of the drone was done in front of the ICHAT building, being the highest point. To prevent possible accidents we had to enable obstacle avoidance mode. The estimated flight time was 15min 15sec covering an area of 31 ha and an estimated number of 245 photograms (Figure 3).

Figure 2. Ground control point

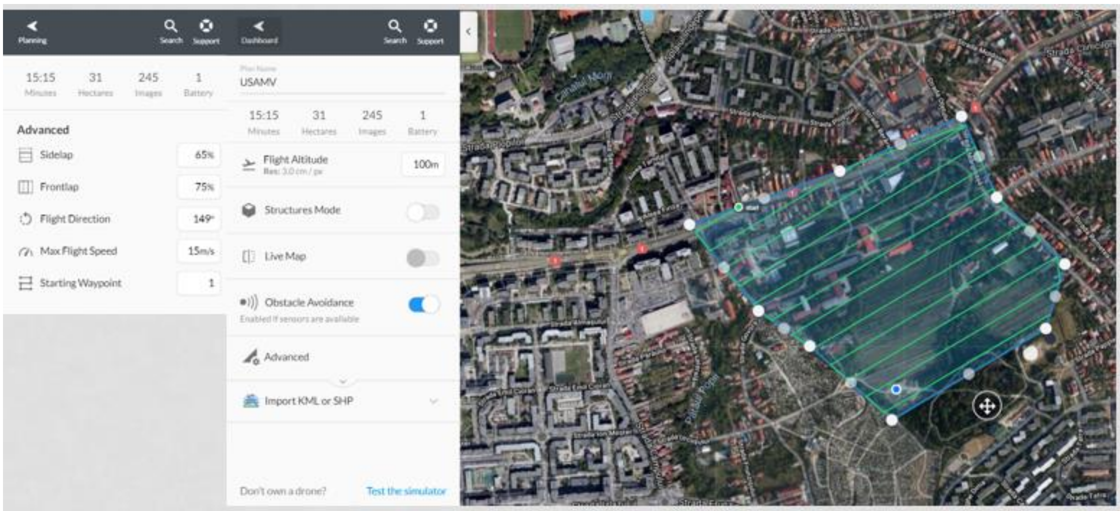

Figure 3. Flight plan

In the next step we used Agisoft PhotoScan, which is an advanced image-based 3D modelling solution aimed at creating professional quality 3D content from still images. Based on the latest multi-view 3D reconstruction technology, it operates with arbitrary images and is efficient in both controlled and uncontrolled conditions. Photos can be taken from any position, providing that the object to be reconstructed is visible on at least two photos. Both image alignment and 3D model reconstruction are fully automated. (https://www.agisoft.com/pdf/photoscan-pro_1_4_en.pdf)

In this program, the photogrames alignment was made in block. Then the checkpoints were marked on each photo. Next, we determined the compensation error as RMSE (Root Mean Square Error).

$$\sigma_0 = \pm\sqrt{\frac{[vv]}{r}}$$

r – redundancy of compensation

$$r = 3(n'_R + n'_L) - (7n_M + 3_{n_L})$$

Where:

n_M – number of Stereomodels from the block;

n_L – number of Link points;

n\`$_R$ - number of total appearances of reference points on n_M models;

n'$_L$ – number of points of view in the model

Root Mean Square Errors in landmark, link and control points are calculated as follows:

$$e = \pm\sqrt{\frac{v_{X_R}^2 + v_{Y_R}^2 + v_{Z_R}^2}{3n'_C}}$$

$$e = \pm\sqrt{\frac{v_{X_L}^2 + v_{Y_L}^2 + v_{Z_L}^2}{3n'_L}}$$

$$e = \pm\sqrt{\frac{v_{X_C}^2 + v_{Y_C}^2 + v_{Z_C}^2}{3n'_C}}$$

Table 1. Average square errors in landmarks

Label	XY error (m)	Z error (m)	Error (m)	Projections	Error (pix)
101	0.009	-0.004	0.010	11	0.549
102	0.005	-0.001	0.005	10	0.318
103	0.022	-0.006	0.023	6	0.269
104	0.013	-0.026	0.030	8	0.277
105	0.017	0.016	0.024	15	0.265
106	0.007	0.007	0.010	14	0.158
107	0.011	0.009	0.014	13	0.375
108	0.027	0.009	0.029	10	0.205
109	0.018	-0.020	0.027	4	0.273
110	0.024	0.008	0.025	7	0.204
111	0.018	-0.006	0.019	23	0.226
112	0.041	-0.013	0.043	14	0.223
113	0.013	-0.001	0.013	11	0.450
114	0.012	0.003	0.013	22	0.174
115	0.026	0.010	0.028	11	0.421
116	0.016	0.001	0.016	12	0.430
Total	**0.020**	**0.011**	**0.023**		**0.312**

Generating the digital elevation model is done based on dense points cloud (Figure 4). The digital elevation model. The altitude of the campus ranges between 341m and 427m (Figure 5).

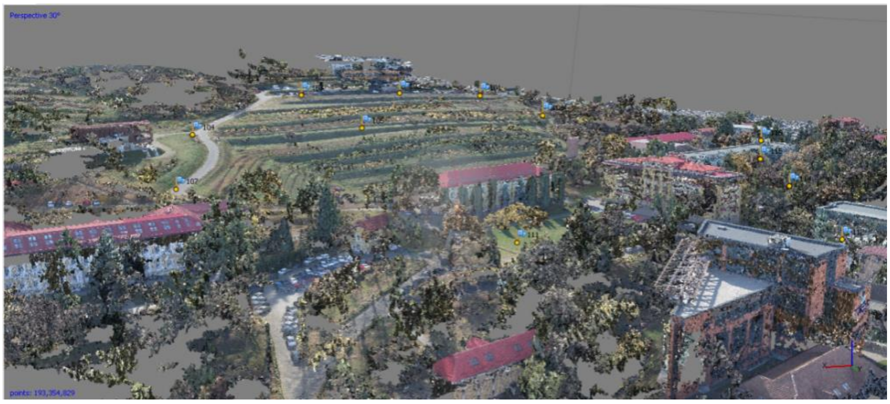

Figure 4. Point cloud

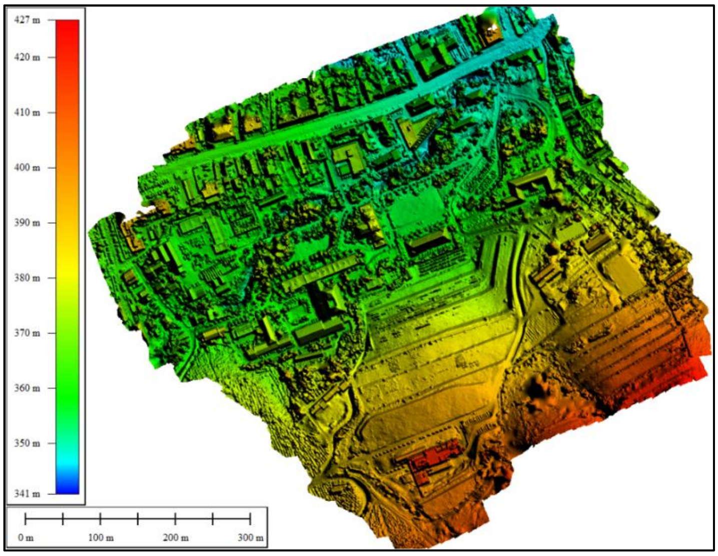

Figure 5. Digital elevation model

From the Emergency Department, we came in possession of the buildings' analogue plans. Buildings are located in the UASMV's campus in Cluj-Napoca. These planes were verified by measurements using a Leica Disto. We found them compliant, we vectorized them and took the names of each room (Figure 6).

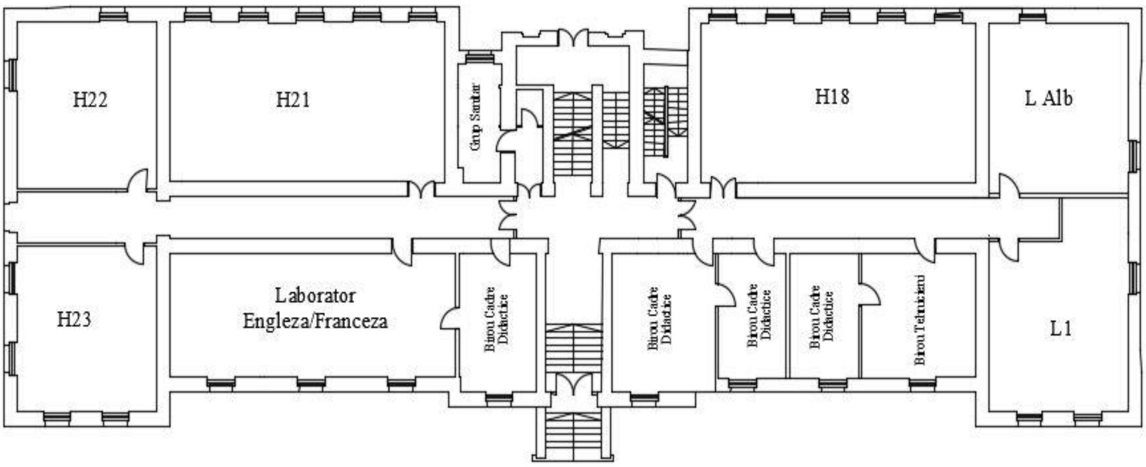

Figure 6. Analogue plan

The UASVM campus digital database is made in ArcCatalog (Figure 7) using the geodatabase vector format and the Stereographic 1970 coordinate system. The related data set contains thematic layers of the campus's focal points, namely: buildings, amphitheaters, parking spaces and sports areas.

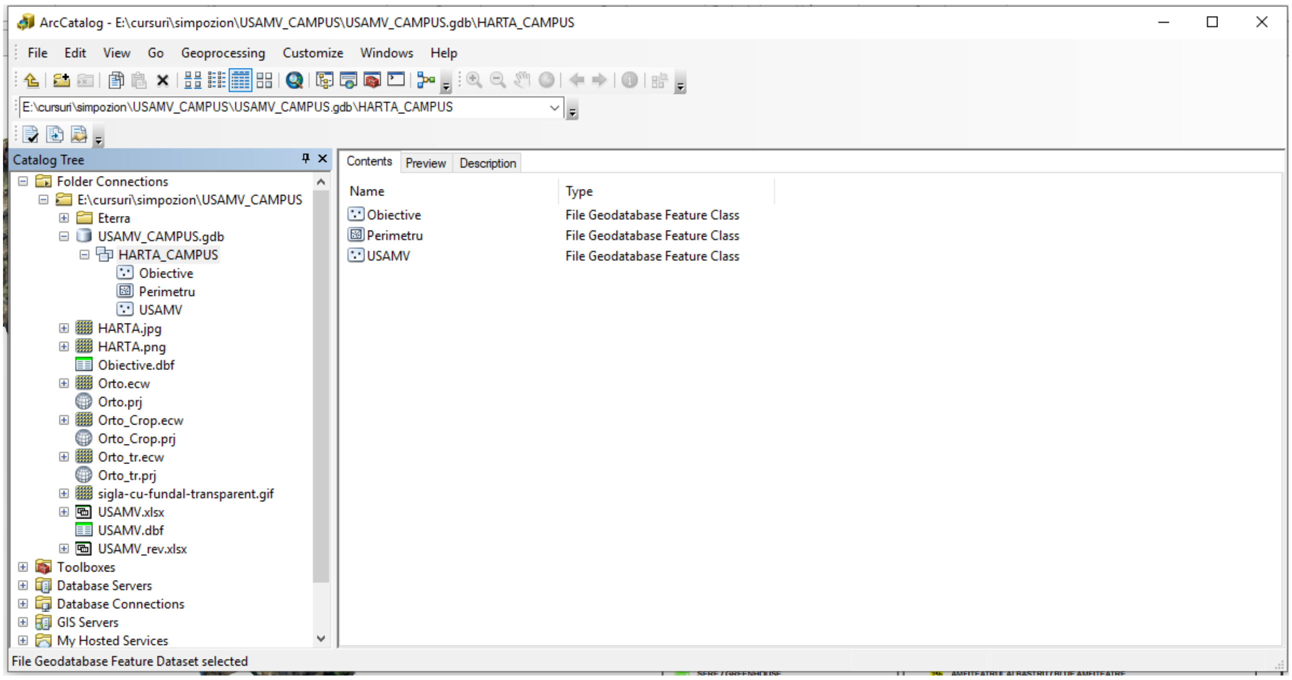

Figure 7. ArcCatalog Database

The vectorization of this map was made in ArcMap on the basis of the obtained orthophotoplan, with a resolution of 4.86 cm / pixel. The map digitization has been made of polygon and point type to create pop-ups. Thematic layers contain symbols representative of each objective (Figure 8).

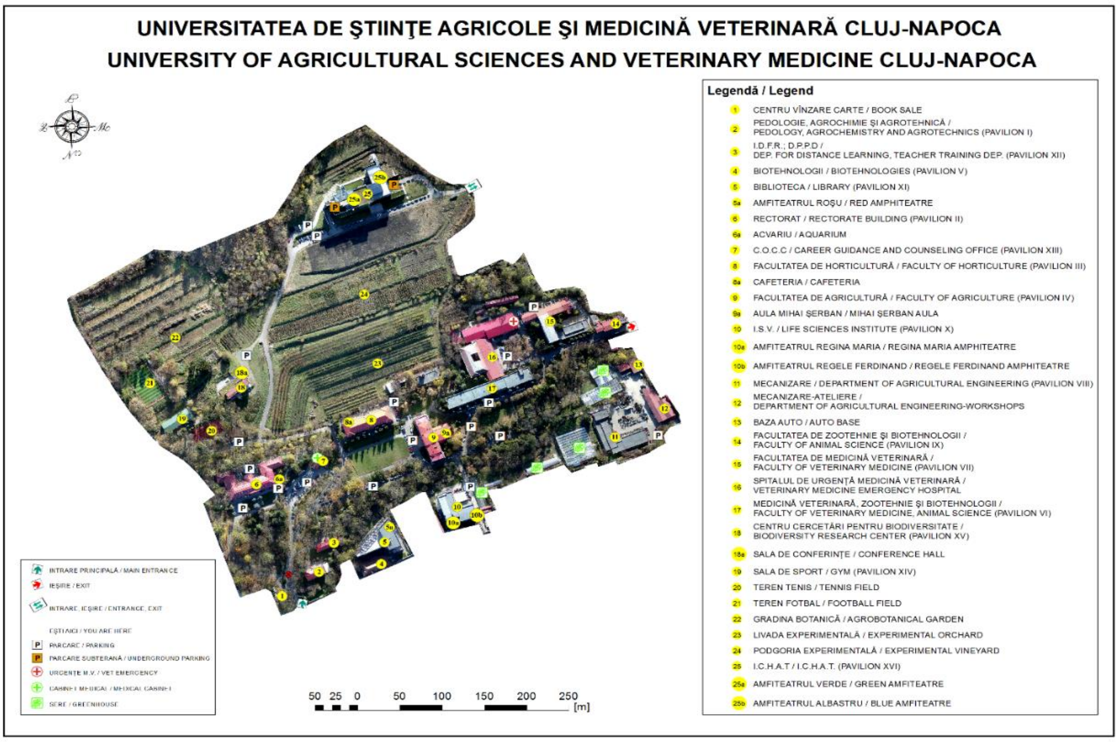

Figure 8. UASVM Campus Digital Map

In ArcGIS Online an interactive map will be made available to a broad audience that includes the UASVM campus digital database, based on the UAV-based campus image, there will be thematic layers for students/visitors, and pop-ups with information allowing students to view lecture/laboratories hierarchies and also parking spaces, amphitheaters where conferences and events take place, and sports areas. Pop-up windows give life to the attributes associated with each thematic layer of spatial objects on the map. Each spatial object on the map corresponds to a pop-up window that contains a list of attributes and values that contain information about its structure, presentation image, and the corresponding floor reports as well as links to each image (Figure 9).

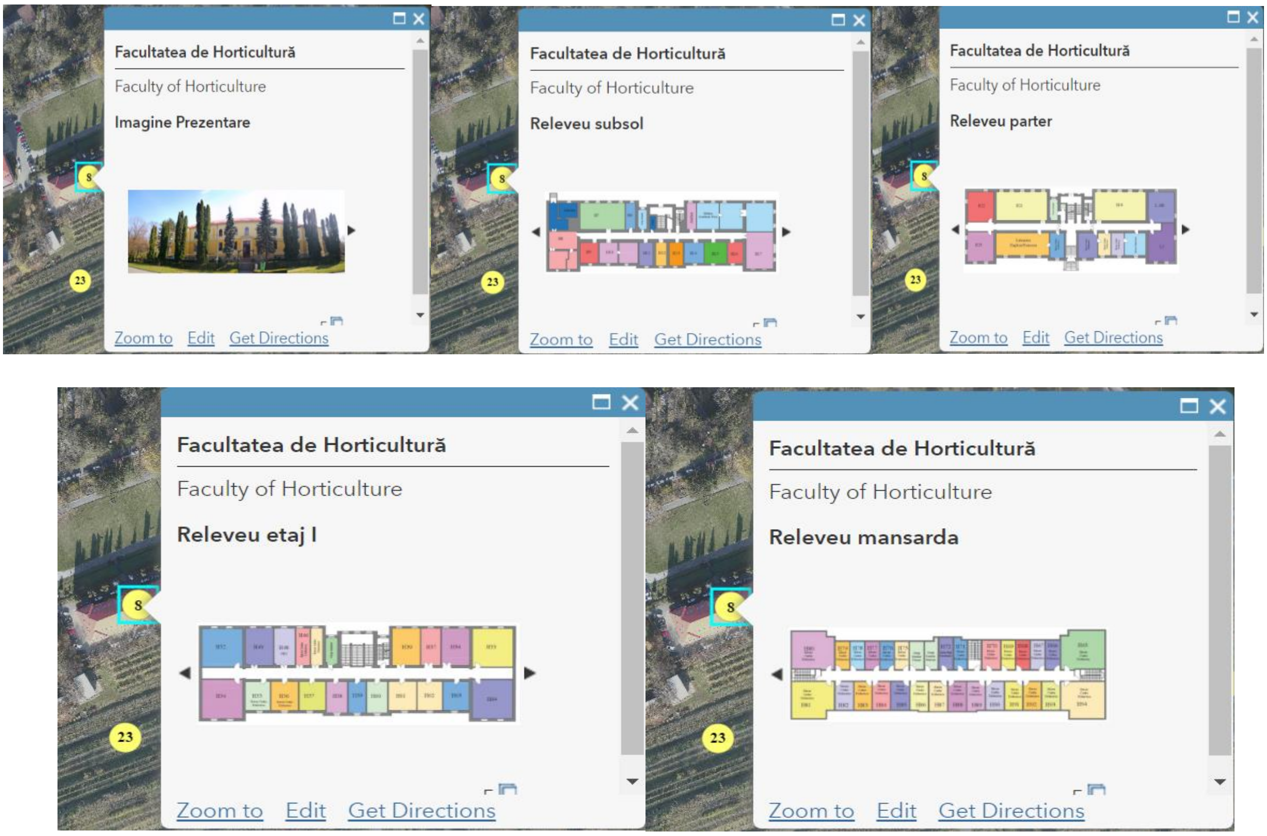

Figure 9. Pop-up windows

CONCLUSIONS

The main advantage of the photogrammetric method is the very short reception time and low cost. Also, a very large volume of data (points cloud, orthophotomap, digital elevation model) is obtained. The GIS Online application has the advantage that the digital map can easily be accessed through a link by any interested person.

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