Comparative Study on Executing Topographic Plans Using UAVs

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ABSTRACT

The present paper aims to carry out a comparative study on how the digital model can be obtained using the images taken with a camera mounted on a UAV, in two cases: The case where there are control points determined on the ground. The case where there are no control points determined on the ground. To verify the consistency of the digital model, field verification points were determined using GNSS receivers. Basically, on the same area of interest were carried out GNSS RTK measurements and two flights with two different types of UAVs: SenseFlyeBee X and DroneZone XF8-CT. The flight was carried out at the same height and with medium resolution cameras (Sony A7R 35 mm 36 Mpix and SenseFlyAeria X 24 MPix).The GNSS receivers were different. Thus, for the DroneZone XF8-CT a GNSS receiver of the u-Blox NEO8M type was used and for SenseFlyeBee X a GNSS RTK receiver of the TRIMBLE BD 93 type and a SenseFly GeoBase base. To establish the consistency of the data, 28 verification points were measured on the ground with GNSS technology. The measurements for determining the position of the control points were performed on different days, using a Leica GS08 Plus GNSS system, connected to the National Network of Permanent GNSS Stations (RN-SGP) through the ROMPOS system. The flight made with DroneZone XF8-CT, 6 control points were determined. The flight made with SenseFlyeBee X, only the data taken by the RTK system from the SenseFlyeBee X UAV were used. The data were processed and a Digital Terrain Model was created for each flight. Finally, a comparison was made between the two Digital Terrain Models, in order to determine the differences between them, but also the differences as against the RTK verification measurements made with the Leica GS08 Plus GNSS system.

Keywords: UAV; Control point; Camera; Topographic plan; Digital terrain model

METHODOLOGY

Making the first variant of the digital terrain model

The area where the study was conducted is the commune of Schitu, Giurgiu County, Romania. In the area there have been works for the introduction of the systematic cadastre, respectively the measurement of each property. For this, a DroneZone XF8-CT flight was equipped with a u-Blox NEO8M GNSS receiver and a Sony A7R 35 mm 36 Mpixcamera. Also, the property limits were determined with a total station Leica TS06 type and Leica GS08 Plus GNSS receivers. To georeferencing (scaling) the images taken with the UAV system, 6 control points have been determined, pre-signaled on the ground, before he flight [1-3].

When designing the flight, we took into account the following considerations:

Depending on the products to be obtained, the longitudinal and transverse covers between the images are determined, as well as the height and the speed of flight;

Establishing the orientation of the flight strips;

Determining the best days and times for carrying up the photogrammetric flight;

Analysis of the weather; information is collected from weather stations near the area of interest;

Establishing the final flight route that is handed over to the pilot or operator of the photogrammetric camera.

The longitudinal coverage was of 80% and the transverse coverage of 50% to obtain in the end a trueortophoto. The strips were established according to Figure 1.

Figure 1: Flight strips.

The pre-signaling was marked on the ground either with paint or single-use plates, as in Figure 2.

Figure 2: Pre-signaling the control points on the ground.

At the time of flight the flight conditions were optimal: clear sky, temperature over 5°C, wind speed below 2 m/s.

Following the data processing with the Agisoft software, a cloud of points was obtained. In order to obtain the Digital Terrain Model (DTM), we have performed the unsupervised (automatic) classification and then the supervised (manual) classification of the cloud of points in order to establish the points that belong to the ground class [4-6].

By triangulating the points in the ground class, we obtained a solid model known as the Digital Terrain Model (DTM) (Figure 3).
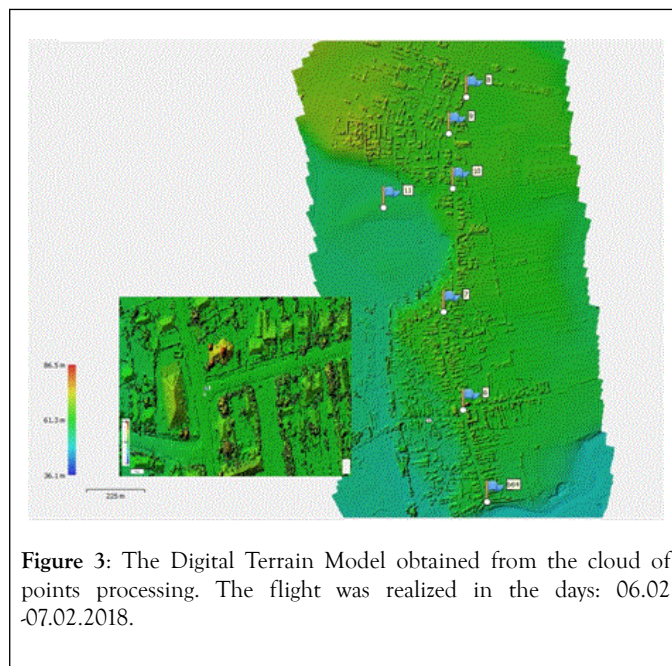

Figure 3: The Digital Terrain Model obtained from the cloud of points processing. The flight was realized in the days: 06.02 -07.02.2018.

Carrying out the second digital terrain model

A new UAV model has launched on the market, SenseFlyeBee X, equipped with a TRIMBLE BD93 type GNSS RTK receiver, a SenseFly GeoBase base and a SenseFlyAeria X 24MPix camera. From the description that the seller made, it turned out that there was no need for control points (landmarks) for georeferencing [7-9].

We decided to do a comparative study, to convince ourselves that the newly developed system has the performances described by the seller [10].

Thus, we redo the flight we had made with the first type of UAV, on the same area, but without determining control points on the ground. The flight was made during the 27 November 2018period. The data were processed with the same type of program and we obtained a new digital terrain model, for the same area [11].

Verification of results

During the systematic cadastral work, we performed measurements with the total station and GNSS receivers to determine the property limits.To do this, we created a topographic network of densification, determined with the Leica GS08 Plus GNSS receivers connected to the National Network of Permanent GNSS Stations (RN-SGP) through the ROMPOS system. The network was made of wooden stakes.

From this network were selected a number of 31 points spread over the entire area over which the flight was made and the digital terrain model was obtained (Figure 4).The accuracy of determining these control points is ± 3 centimeters. The points were named: B01, B02, B03, B04, B05, B06, B07, B08, B09, B10, B11, B12, B15, B16, B19, B21, B23, B38, B43, B50, B54, B55, B65, B68, 5, 6, 7, 8, 9 10 and B64.
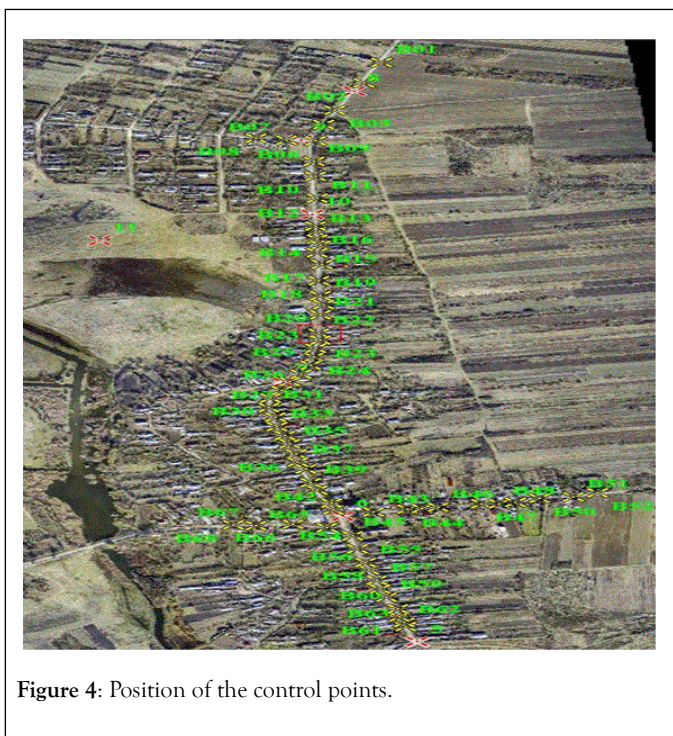
Figure 4: Position of the control points.

The altitudes of these points were noted in a (Table 1), together with the name of each. The first digital model was loaded in the

Agisoft program and, based on the planimetric position of each of the 28 points it was extracted from the digital terrain model, the altitude of each point and was noted in the table.

Similarly, the altitude of each of the 31 points of the second digital terrain model was determined and noted in the table, in the respective column.

RESULTS AND DISCUSSION

Following the results obtained in Table 1 was made, in which we have:

In the column marked with 1, the altitudes of the 31 control points determined on the ground with GNSS technology.

In the column marked with 2, the altitudes of the 31 control points extracted from the digital terrain model obtained with the UAVDroneZone XF8-CT.

In the column marked with 3, the altitudes of the 31 control points extracted from the digital terrain model obtained with UAVSenseFlyeBee X.

The following columns are the differences between the altitudes of the control points determined in the 3 variants.

Table 1: Measurement results.

Point	Measured ROMPOS GNSS [m]	Measured with DEM Drone Zone [m]	Measuredwith DEM Pix4D eBee RTK [m]	Δ 12 [m]	Δ 13 [m]	Δ 23 [m]
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
			Measurements07.17.2018			
B01	64.190	64.252	64.596	-0.062	-0.406	-0.344
B02	63.910	63.942	64.292	-0.032	-0.382	-0.350
B03	63.930	63.930	64.252	0.000	-0.322	-0.322
B04	63.860	63.870	64.079	-0.010	-0.219	-0.209
B05	63.750	63.798	64.038	-0.048	-0.288	-0.240
B06	63.450	63.503	63.826	-0.053	-0.376	-0.323
B07	63.350	63.466	63.665	-0.116	-0.315	-0.199
B08	63.190	63.283	63.511	-0.093	-0.321	-0.228
			Measurements 07. 26.2018			
B09	63.23	63.337	63.575	-0.107	-0.345	-0.238
B10	62.8	62.91	63.076	-0.110	-0.276	-0.166
B11	62.290	62.367	62.631	-0.077	-0.341	-0.264

|						
B12	62.590	62.698	62.950	-0.108	-0.360	-0.252
B15	63.140	63.249	63.457	-0.109	-0.317	-0.208
Measurements 07. 27.2018						
B16	63.24	63.365	63.586	-0.125	-0.346	-0.221
B19	62.58	62.67	62.927	-0.09	-0.347	-0.257
B21	62.38	62.486	62.754	-0.106	-0.374	-0.268
B23	63.77	63.91	64.148	-0.14	-0.378	-0.238
B38	63.560	63.625	63.969	-0.065	-0.409	-0.344
B43	63.640	63.736	63.969	-0.096	-0.329	-0.233
Measurements 08. 29.2018						
B50	63.100	63.150	63.444	-0.050	-0.344	-0.294
B54	63.190	63.115	63.318	0.075	-0.128	-0.203
B55	62.590	62.487	62.776	0.103	-0.186	-0.289
Measurements 09. 04.2018						
B65	62.430	62.497	62.850	-0.067	-0.420	-0.353
B68	59.650	59.735	59.981	-0.085	-0.331	-0.246
Measuremens 11. 27.2018 Leica GS8						
5	61.850	61.947	62.078	-0.097	-0.228	-0.131
6	63.788	63.846	64.095	-0.058	-0.307	-0.249
7	63.625	63.676	63.947	-0.051	-0.322	-0.271
8	63.947	63.920	64.276	0.027	-0.329	-0.356
9	63.541	63.522	63.829	0.019	-0.288	-0.307
10	62.192	62.188	62.418	0.004	-0.226	-0.230
B64	61.874	61.972	62.129	-0.098	-0.255	-0.157
-	-	-	-	Δ Minimum	-0.140	-0.420	-0.356
-	-	-	-	Δ Mean	-0.059	-0.317	-0.258
-	-	-	-	Δ Maximum	0.103	-0.128	-0.131

Thus, column 4 represents the difference between the altitudes obtained from GNSS measurements and the digital model obtained with the UAVDroneZone XF8-CT. Column 5 represents the difference between the altitudesobtained from GNSS measurements and the digital model obtained with UAVSenseFlyeBee X. Column 6 represents the difference between the altitudes obtained from the digital model obtained with the UAV DroneZone XF8-CT and the digital model obtained with the UAV SenseFlyeBee X in Figure 5.

Figure 5: Placement of the control points B.23 and B.55.

A graph of the altitude differences obtained in the 3 variants was made (Graph 1).
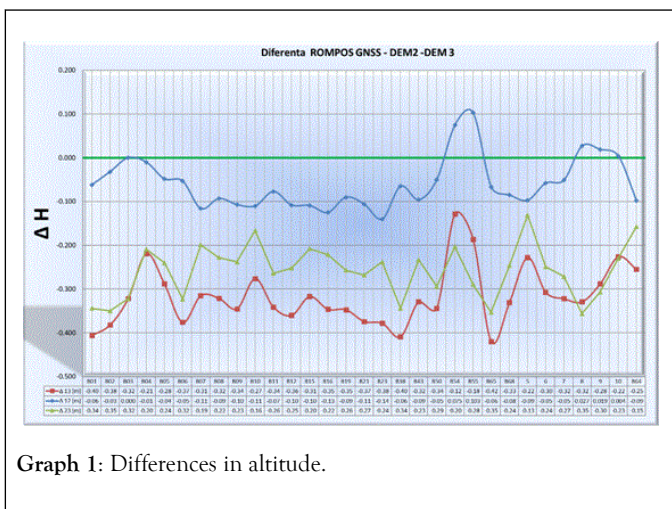
Graph 1: Differences in altitude.

CONCLUSIONS

We start from the hypothesis that the correct altitudes are those determined directly on the ground, with the GNSS technology, using the permanent stations of the National Agency for Cadastre and Real Estate Advertising. From the presented values, the altitudes extracted from the model made with DroneZone XF8-CT are very close to those determined on the ground.This is because 6 ground control points were used, which fixed the digital model. The altitude values determined with SenseFlyeBee X are about 31 centimeters higher on average.

Between the GNSS measurements and the digital model obtained from the DroneZone XF8-CT flight, the largest negative difference is -14 centimeters and the largest positive is +10 centimeters. These differences are due to the fact that points B23 and B55 are located in grassy areas, where the altitude given by the drone is not very correct because it stops at grass level and not at ground level. From Figure 3 it can be seen that the two points are not located on a flat area, such as an asphalt road, a concrete platform, etc. The mean difference

between the two altitudes is -5.9 centimeters and falls within the accuracy of the GNSS determined point network, of ± 3 centimeters.

The digital model made from the DroneZone XF8-CT flight is different on average against the topographic network with -31.7 centimeters. It is clear that the relatively constant difference comes from the fact that on this flight we had no control point, so that the digital model is higher than the real model, determined by measurements referring to a system of verified altitudes. The conclusion is that even if we use a UAV that has a powerful GNSS receiver, a few control points are however needed in order to have the absolute altitude of the digital model as close to the reality on the ground.

SIGNIFICANCE OF THE WORK

Currently, the UAV technology for the realization of topographic plans is increasingly used. UAVs are equipped with GNSS receivers that give the position of the points with very high accuracy. Often users prefer not to determine control points anymore, considering that the results obtained are correct.

The present paper demonstrates that, in order to have a correct topographic plan, close to the reality on ground, at a UAV flight, control points measured on the ground are required.

REFERENCES

1. Păunescu C, Nache F, Păunescu V. Reliable 2D crowdsourced cadastral surveys: case studies from Greece and Romania. Inter J Geo Info. 2019;9(2):89.

2. Paunescu C, Dimitriu GS, Mocanu V. Position determination using GNSS. Inter J Geo Info. 2013;16(7):205.

3. Torhonen M, Salzmann M, Kasperavicius R, Sas E, Hokkanen J. Sustainabl governance of european cadastre and land registry agencies. Proc World Bank Conf. 2015;11:23-27.

4. Potsiou C, Volakakis M, Doublidis P. Hellenic cadastre: State of the art experience, proposals and future strategies. Comput Environ Urban Syst. 2001;25:445-476.

5. Amhar F, Jansa J, Ries C. The generation of the true orthophotos using a 3d building model in conjunction with a conventional DTM. Int Arch Photogramm Remote Sens. 1998;32:16-22.

6. Ambani S, Kalinga J, Lemmen C. Handheld land administration mapping methods: Institution of surveyors of kenya demonstrates alternative approaches. GIM Int. 2017;31:25-27.

7. Lengoiboni M, Lemmen C, Zevenbergen J. Innovative tools for tenure recordation: Documentation of overlapping and secondary land rights. GIM Int. 2017;31:41-43.

8. Williamson I, Rajabifard A, Kalantari M, Wallace J. A land information: Accurate, assured and authoritative. Proc FIG Reg Conf. 2012;8:26-29.

9. Basiouka S, Potsiou C. The volunteered geographic information in cadastre: Perspectives and citizens' motivations over potential participation in mapping. Geo J. 2014;79:343-355.

10. Basiouka S, Potsiou C. A proposed crowdsourcing cadastral model: Taking advantage of previousexperience and innovative techniques. Surv Rev. 2016;12:419-433.

11. Mourafetis G, Apostolopoulos K, Potsiou C, Ioannidis C. Enhancing cadastral surveys by facilitating theparticipation of owners. Surv Rev. 2015;47:316-324.