Krzysztof Zdanowicz*

Possibilities of Taking Measurement Photos with Camera from Board of Radio-Controlled Hang-Glider Model

1. Introduction

In geodesy and cartography there still exist many situations and requirements where the traditional and popular measuring techniques are insufficient and unprofitable. These are measurements of inaccessible and hard-to-access objects which will be cheap, fast and reliable. There are reasonable needs of acquiring the images and cartographic developments for grounds touched with disasters – fires, floods, earthquakes, grounds hard to access because of the measurement specification – swamps, sharp banks, embankments, glaciers, waters or grounds on which there is necessity of constant documentation of the changing space, e.g. archaeological excavation grounds [1–2].

Recently it has been possible to observe the increase of interest of the low-altitude aerial flights performed from the altitude which doesn't go beyond 200 m. The attempts of receiving the photos using balloons, radio-controlled mini helicopters, telescopic masts or kites are taken [3–4]. In this essay the possibility of using unmanned aerial vehicle (UAV) is suggested. The UAVs are amateur radio-controlled models (in this case it is a model of a hang-glider) equipped with photo cameras for taking photogrammetric photos from low altitude. The aim of this aerial flight is to gain specified geoinformation. According to the definition ratified by Polish Committee for Standardization, geoinformation is a knowledge concerning objects such as facts, events, things, processes, ideas, including a conception which in fixed context has got specified meaning and allows to specify the location of the relevant object on the surface of the Earth towards other objects [5].

In the study we used photos from low-altitude aerial flights which were made available thanks to Institute of Photogrametry and Remote Sensing – Faculty of

* Faculty of Mining Surveying and Environmental Engineering, AGH University of Science and Technology, Krakow

Environmental Engineering and Land Surveying – University of Agriculture in Krakow. The photos were taken from 70 m pitch by amateur photo camera Vivitar which was installed on the board of a model of radio-controlled hang-glider Skyflex. The study of the photos was the subject of Krzysztof Zdanowicz and Krzyszfof Stanowski's graduate work which was titled *Suitability of using low--altitue photogrammetic aerial flight from Unmanned Aerial Vehicles for the geoinformational need using Photogrammetic Digital Station 'Delta'*.

2. Photogrammetric Photos Study

To estimate the usefulness on the UAV aerial flight area, the studies had to been led in two stages:

1. Putting the traverse network and levelling network on the aerial flight area.
2. Photogrammetric photos study.

In the first stage the three-survey point closed traverse was established (Fig. 1). Next, using polar method, the constantly established points were used to appoint the coordinates X, Y of chosen photopoints visible in the photo. Next, using the method of direct (spirit) leveling, the points altitude of the sequence was appointed and using the method of leveling without changing place the pickets altitude (photopoints) was appointed (Fig. 2). The closing leveling sequence error equaled 0.001 m, whereas the maximum error of the point location in the traverse did not go beyond 0.01 m (point 9999).

The second stage consisted of establishing in sequence three orientations of photos: inner, relative and absolute orientation. The photos were elaborated on the photogrammetric digital station Delta with taking into account the photographic lens distortion which was earlier examined and thanks to which the photos were taken by.

The conducting of absolute orientation allowed to orient the spatial model on the basis of earlier measured photopoints which were:

- sewage well – points no 3, 6, 16, 17, 22, 24;
- curb corner – points no 7, 15, 18, 19;
- corner of cellar window entrance – point no 9.

Absolute orientation report – gained from the station Delta – shows with what errors the coordinates of points were appointed as a result of photogrammetric photos study towards the coordinates of the same points received in the way of classical geodesy measurement. Beneath there is a fragment of this report (Fig. 3):

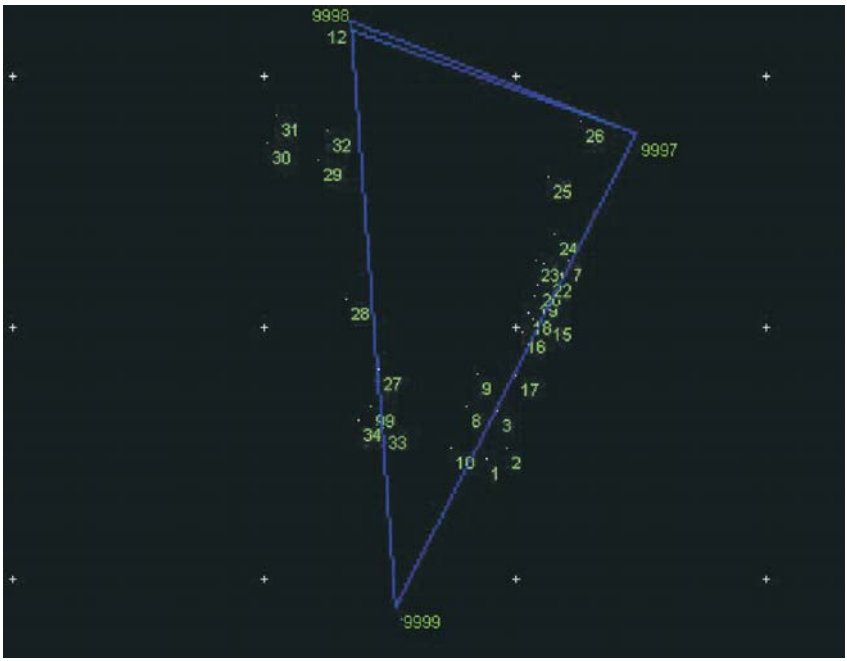

Fig. 1. The draft of traverse with points measured in positional and altitude way – the Geonet program

Fig. 2. The fragment of the photo with the photopoints location

Absolute orientation results

ID	X, m	Y, m	Z, m	DX, m	DY, m	DZ(m)	Stat
15	5407501.760	4549056.620	1.024	-0.013	0.000	-0.034	On
17	5407490.490	4549050.160	0.995	0.049	0.009	0.055	On
16	5407499.400	4549051.420	1.090	-0.007	-0.030	-0.012	On
6	5407501.620	4549053.440	1.078	-0.051	0.026	0.052	On
3	5407483.610	4549046.440	1.040	-0.029	-0.009	-0.037	On
24	5407518.770	4549057.900	1.187	-0.062	-0.057	0.082	Off
22	5407510.420	4549056.600	1.197	-0.028	-0.025	0.001	On
19	5407506.230	4549053.730	1.155	0.040	-0.009	-0.015	On
18	5407503.050	4549052.730	1.133	0.038	0.036	-0.010	On
7	5407513.320	4549060.530	1.228	-0.045	-0.070	-0.031	Off
9	5407491.050	4549042.600	1.410	0.062	0.063	-0.156	Off
	Root mean square			0.035	0.022	0.033	
	Average deviation			-0.004	-0.006	-0.010	

Fig. 3. Fragment of the absolute orientation report

The content of the report shows that root mean square for coordinates *X*, *Y*, *Z* equals adequately 0.032 m, 0.022 m and 0.033 m, while the average deviation of coordinates: $X = -0.004$ m, $Y = -0.006$ m, $Z = -0.010$ m. It displays with what precision the photogrammetric land details were measured with the photos study taken from low altitude on the photogrammetric digital station Delta. It must be emphasized that because of small amount of available photopoints, all of them were included in the absolute orientation process. As a result, the exact statistics which were received does not have fully objective character and in the consequence the real accuracy of the block can be lower.

The points no: 24 (sewage well), 7 (curb corner), 9 (corner of the cellar window entrance) were excluded from the report because of the difficulties with their unambiguous localization in the photo.

3. Summary

The comparison of the exact criterion of the details measurement given in the Technical instruction G-4 (§ 15 Act 1 [6]) and the received errors, shows that further studies in this directions are fully reasoned

The low-altitude photogrammetric aerial flights from UAV are very economical against the traditional geodesy measurements in the case of necessity fast data gaining or gaining the data from hard-to-access or dangerous areas. Because of the

low cost of using the unmanned aerial vehicles and developing low speeds, what has got untrivial influence on the quality of taken photos (small smudging of the photos), and the fact that while using the low-altitude aerial flights you do not have to be afraid of the influence of obfuscation or atmosphere refraction (on the contrary to high altitude aerial flights), this method can also find its usefulness in geodesy as a source of supplemental measurements. The method shows promise what justifies the purposefulness of undertaking more detailed research for establishing the range, possibility and terms of using this technology.

References

[1] Zapaśnik B.: *Przeszłość z lotu ptaka.* Wiedza i Życie, nr 10, 1996.
[2] http://www.muzarp.poznan.pl/, 04.2007.
[3] Petrie G.: *Ground-Based Aerial Photography*. Geoinformatics, no. 6, 2006, pp. 16–23.
[4] Aber J.S., Aber S.W.: *Unmanned Small-Format AerialPhotography from Kites for Acquiring Large Scale, High resolution, Multiview-Angle Imagery.* 2002, [on-line:] http://www.isprs.org/, 04.2007.
[5] http://www.geoinformacja.pl/ 05.2007.
[6] Instrukcja techniczna G-4: *Pomiary sytuacyjne i wysokościowe.* Warszawa 1983.