Applying of unmanned aerial vehicle in the Extreme North condition for the purpose of land survey

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1. Introduction

The use of modern equipment such as unmanned aerial vehicle (UAV) allows surveying and carrying out office analysis of received data in minimum time, which significantly increases work productivity.

Research objective is thinking of high efficiency of the UAV in the Extreme North where there is a very short favorable season for surveying. For this purpose it was done a comparative analysis of timeline and results of land surveys and aerial photography.

One of the limiting factors of the implementation of UAVs particular in Sakha Republic is the lack of experience of organizations and the lack of theory-based recommendations on the choice of survey instruments for UAV and parameters using aerial photography.

2. Test area

The test area is located in Ust-Mil village situated in Ust-Maisky district of Sakha Republic (Russia). This place is included to region of Extreme North. Extreme North – part of the territory located mostly in the north of Arctic Circle. The territory of the Extreme North is an arctic zone, tundra, forest tundra and northern taiga. Harsh climatic conditions don't allow working for long time.

The climate of Ust-Mil is subarctic, with a long and cold winter (October - April) and short summer. Snow covers test area from 30 September and lasts 210 days. Every year in the test area there are an average 60 foggy days, 10 rainy days, 12 days with snowstorms.

The main transport artery is the Aldan River which ice drift begins in May and the ice-formation – in the beginning of October. There are only winter roads in test area from November to April. In summer there are only water roads [4].

Based on the above considering the short season of surveying (about 100 days) and difficult transport situation it is necessary to use the latest technologies for the Extreme North. Thus, the "traditional" methods of instrumental survey using tachymeter often take a long time and associated with significant costs. Particularly instrumental survey disadvantages can be observed in impassable large areas, when the task is to quickly get the topographical plans of scale 1: 500, 1: 1000, 1: 2000 [5].

3. Traditional land survey

There are topographic maps of Ust-Mil of 1:25000 scale and smaller. State geodetic network presented by 2nd class triangulation points and 2nd category polygonometric points.

Topographic survey was produced by tacheometric methods, vertical and horizontal survey in 1:1000 scale with contour interval 0,5 meters. Office analysis of geodetic measurements was made in software "CREDO". Surveying was made in the Local 3-degree coordinate system 1988 and Baltic vertical datum 1977.

Following types and amounts of works were carried out in the process of engineering and geodetic surveys:

– horizontal survey of built-up area, M 1:1000 - 90 hectares;
– vertical survey of built-up area, M 1: 1000 - 90 hectares;
– tacheometric survey, M 1: 1000 - 90 hectares;
– office analysis and technical statement.

Survey control was created by a field traverse system from triangulation point Kuranakh, point 0057. The distance and angles were measured by tachymeter NIKON NPL-352. Angles divergences do not exceed 22″. Height control was created by tachymeter traverse levelling.

Tacheometric land survey is performed also by tachymeter NIKON NPL-352. Table 1 shows us the main characteristics of this instrument. Survey of relief and situation was carried out from the points of survey control by polar method. Field works were combined with the office analysis.

Table 1 – Main characteristics of tachymeter NIKON NPL-352

Angle accuracy	5”
Telescope magnification	26x
Precision	3mm + 2mm/km (reflected) 5mm + 2mm/km (unreflected)
Measurement range	300 m (unreflected) 5 000 m (1 prism)
Battery pack	15 hours (at +20°C)
Main unit	168 mm W x 173 mm D x 347 mm H
Weight	5,3 kg

Composed plan was verified by visual checking and revision survey and measurements. The discrepancies do not exceed 0,3 mm in a plan scale.

4. Aerial photography

Aerial survey was carried out with the use of complex "Ptero" developed by joint stock company "AFM-Servers". Its main characteristics are shown in the Table 2.

Surveying consisted of several stages:

– preparatory works;
– flight operations;
– processing of the received data.

Preparatory work includes the creation and coordination of the ground identification points in survey area. Identification mark has a simple, cross-shaped construction and the size depends on the UAV flight altitude. The color and size of the mark is calculated in advance in order to be of bright tones on a dark surface. We used a conventional board. Identification marks were placed regularly all the way around. Coordinate measuring of marks was produced using GNSS receivers by relative method of satellite positioning. The base station was installed in a close proximity to work site (about 2 km).

In accordance with the requirements of Guidance of industry [2], it is necessary the photo base with the resolution 15 pixel/cm and the positioning error no more than 60 cm to obtain topographical plan 1:1000 scale. On the UAV "Ptero" it was installed Canon EOS 5D Mark II camera, matrix 36x24 mm, focal distance 50 mm and infinity focused.

Table 2 – **Main characteristics of UAV "Ptero-E4"**

Weight, kg	9,5
Maximum take-off weight, kg	20
Wing span, m	3,03
Engine type	Ac electronic motor
Maximal flying distance, km	130
Operating ceiling, m	2000
Time of flight, h	1,5
Speed, kmh	85-115 (course speed), 180 (maximum)

Aerial survey was carried out on assigned routes with a photo overlap 60 and 40%; relative flying height was 200 meters. Enhanced value of longitudinal and transverse overlaps is determined to eliminate possible discontinuities in photogrammetric triangulation block associated with instability of the vehicle. Digital camera was subjected to the photogrammetric calibration and as a result of which the data of inner orientation of photogrammetric camera and lens distortion parameters have been defined. The images were obtained in RAW and JPEG format size 4592 Ч 3056 pixels. According to the results of development of photogrammetric triangulation network it may be concluded that the stability of keeping flight parameters was kept during the aerial survey.

Accuracy evaluation of photogrammetric triangulation network was realized by discrepancies of coordinates and wing points height located in areas of images with triple overlap and overlap between routes and inconsistencies of topographic point coordinates and heights. Root-mean-square errors of determining X, Y coordinates and Z heights of wing points are 0,11 m, 0,11 m and 0,20 m respectively. Root-mean-square errors of determining X, Y coordinates and Z heights calculated by discrepancies on topographic points are 0,21 m, 0,25 m and 0,8 m.

5. Results

The total number of days of land survey is 33 days, and aerial photography using UAV "Ptero-E4" is 17 days. Thus, survey with UAV twice as fast in comparison with the land survey. The comparison of the performance time is shown in the Table 3.

Table 3 – **Comparison of the periods of work execution**

Work stages	Performance time		Report documents
	Land survey	Aerial photography	
Development of work production program	2 days	2 days	Work production program
Acquisition of information from Yakut Regional Surveying and Mapping Management	Customer provides	Customer provides	Project area background data, coordinates and heights of main base stations, coordinate system and heights information, materials of previous surveying
Ground observation	2 days	2 days	–
Horizontal and vertical survey network	5 days	5 days	–
Survey	14 days	3 days	–
Creating of topographic plan	10 days	5 days	Digital topographic plan of 1:1 000 scale

When survey area is a large enough, as a rule, hundreds of hectares, the solution of these tasks with the help of unmanned aerial vehicle are more effective than the ground topographic works, which are very demanding and time-consuming. In particular this advantage gives to UAV over land survey when choosing the type of survey in condition of Extreme North, namely in the Republic of Sakha (Yakutia), where there are vast space to work with poorly developed transport infrastructure. Another important advantage of the use of UAV is that the digital cartographic materials produced by this technology are relevant at the time of the survey and are not out of date information, as usual with traditional techniques.

As a matter of course it has been clearly shown the efficiency of the use of modern equipment in this case, unmanned aerial vehicles, in the Extreme North. In our case, the use of UAV cut the time of land surveys thrice, office processing - twice.

References:

1. Obiralov A.I. Photogrammetry and remote sensing. – M.: Kolos, 2006. – 335 p.
2. Instruction for photogrammetric works for creation of digital topographic maps and plans. GKINP (GNTA)-02-036-02. – M.: CNIIGAiK, 2002. – 49 p.

3. Instructions for topographic survey in 1:5000; 1:2000; 1:1000; 1:500 scales. – M.: Nedra, 1985. – 98 p.
4. Official portal of the Republic of Sakha (Yakutia) // URL: http://old.sakha.gov.ru/ustmil
5. Creation of orthophotos // Geoscan. URL: https://www.geoscan.aero/ru/application/geodesia/