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GEODETIC MEASUREMENTS ON THE YEGHVARD RESERVOIR

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In this article we present two different methods of geodetic measurement on Yeghvard reservoir. The comparison of results obtained by both traditional geodetic measurements and UAV show that surveying performed by drone is more efficient in terms of accuracy and time consumption. The method is especially efficient during geodetic measurements in inaccessible places.

Background

Negotiations were conducted with Japan International Cooperation Agency (JICA) for financing the re-construction of the reservoir. According to the information of RA Water State Committee the technical investigations will be finalized in 2016.

In order to understand the present status and the significance of the reservoir full topographic survey has been conducted in the site, which includes:

1. Plane survey for Yegvhard reservoir topographic drawings by 1/2,000 scale contour at 0.50m 1540 ha,
2. Plane survey for feeding canal 1 topographic drawing by 1/2,000 scale contour at 0.50m 51ha,
3. Plane survey for feeding canal 2 topographic drawings by 1/2,000 scale contour at 0.50m 73ha,
4. Plane survey for feeding canal 3 topographic drawings by 1/2,000 scale contour at 0.50m 92ha,
5. Reporting

The latest geodetic equipment and software packages were used for the survey.

1.Description of the survey area

The survey area is characterized by complex relief and structures. The reservoir area constitutes mainly arable lands. Only in the northwest part some perennial houses are in place.

All along the northern reach of the reservoir the Arzni-Shamiram Irrigation Canal passes, which is the main water supply source of Yeghvard reservoir. The reservoir has two dams, which are located in the southeast and west.

Several options were discussed for feeding and diversion systems and topographic survey works were carried out for these options. The feeding canal is foreseen to start in the Arzni-Shamiram and Arzni branch intersection. Two options were considered for diversion canal. In the first option the canal is running through a gulch in Nor Erznka, while in the second it is running along the northern fringe. Both are illustrated in the Figure 3 below.

In view of the above mentioned peculiarities the procedure and time schedule of survey works have been developed, as well as the relevant equipment have been selected.

All the reservoir area, the northern areas for diversion and feeding canals have been surveyed with the latest technologies, i.e. with unmanned aerial vehicle and respective set of software. While the other option for the diversion canal has been surveyed with total stations and GPS system based on the peculiarities of the area.

2.Comprehensive Aerial Photography With Unmanned Aerial Vehicle

The technology of aerial photography based on drones consists of the following stages:

Preparatory works

Aerial photography of the area is a set of works with different stages including digital photography of the ground surface with a flying machine in order to produce digital photos and afterwards elaborate photo maps and orthophoto plans of the target area.

Preparatory works including:

- data collection and systematization - maps or photographic materials, lists of benchmark coordinates from National Benchmark Grid or boundary network etc.
- calculation of the parameters for transition from WGS-84 coordinate system into the coordinate system which we need.
- analysis of the physical and geographical characteristics of the target area – forests, mountains, water, average temperature, etc.
- elaboration of technical design and maps (schemes) showing the boundary of the target sites and implementation schedule;
- calculation and data loading into the ground control station: the height of the photo shooting, the longitudinal and lateral overlap, borders of the photo shooting, position of starting point with respect to the most high-rise buildings, selection of landing site;
- selection of points for horizontal and vertical provision of images (benchmarks and control points), as well as selection of method for determining the coordinates of these points;
- obtaining permission for the flight;
- technical inspection and preparation of instruments and equipment for work;
- inspection and charging of batteries.

Field works

Using unmanned aerial vehicle with an installed photographic equipment allows to produce high-resolution aerial photographs of the area at a given height in a certain place and time. At first during field works we are choosing base map, highlighting coverage area as a rectangle or polygon, we are setting desired Ground Sampling Distance (i.e. 5 cm (2 in) / pixel). Flight altitude defined automatically as a result of given pixel (e.g. 5 cm/pixel = 162 m altitude). This altitude determines maximum single-flight coverage possible, automatic definition of flight lines & image capture points, set image overlap, necessary for stereo coverage, define safe landing zone inspection and establishment of points for horizontal and vertical provision of images (at least 5 points in the target area), as well as their measurement.

Field works including:

- clarify the location of the launch pad to start the unmanned aerial vehicle;
- measurement of wind speed and direction - with wind speeds above 10 m / s the flight must be postponed to more favorable weather;
- fixing catapult so that drone can fly against the wind;
- assembling drones;
- deploying ground control station (GCT);
- checking connections and operation of mobile elements of the plane;
- loading route program into the drone;
- loading the coordinates of return of the drone;
- start the drone from a starting device or elastic catapult;
- implementation of aerial photography in the automatic mode;
- monitor the implementation of the rout program, speed of the drone, wind speed, voltage in batteries, as well as control over the remaining time of the flight;
- landing the drone in automatic mode;
- copy of telemetry data and digital aerial photographs produced by the drone;
- preliminary analysis of digital images of the area to identify disruption and non-triple overlap
- analysis and examination of UAV, packing in a carrying case;
- folding of ground control station.

Cameral works

The resulting high quality photos have the required overlap and photographing centers linked with a GPS surveying equipment can process the materials with the help of special software as quick and as accurate as possible. The output of the processing of the images will be presented as photo maps, photo plans or orthophoto plans. The accuracy of the results depends on the height of the photo shoot, weather conditions and the resolution of the applied photo equipment. At the moment, the accuracy of orthophoto plans meets the requirements of geodesy, topography and cadaster, and the produced 3D models of the area allow to quickly assess the quantity and site of construction works, mining, etc.

Cameral works including:

- Copying the resulting data - photos, telemetry, field data from ground-based GPS-receivers - in the photogrammetric station;
- Processing of data from the GPS receivers: receiving point coordinates of horizontal and vertical provision of images, centers photography;
- visual assessment of the quality of photos and sorting of images;
- download images and telemetry into special software;
- formation of routes and division into blocks;
- installation of benchmarks;
- photogrammetric processing;
- digital elevation modelling (height matrix);
- production of digital orthophoto plan;
- marking on the maps;
- interpretation and digitization of the facilities in the area;
- filling the semantic information of facilities;
- production of digital electronic map.

The completely new mapping solution Trimble® UX5 sets new standard for fast and secure data collection offering fully complete system based on the most powerful and advanced technologies, such as reverse and automatic systems of control and safety. (http://uas.trimble.com/ux5).

3.**Performed research**

Before starting any survey work it was necessary to study the nearby points in the national benchmark grid. After studying the arrangements of the geodetic points in the reservoir area it was decided to obtain coordinated of 3 geodetic points which are kept in Center of Geodesy and Cartography SNCO.

It should be noted that in the Republic of Armenia a real time functioning grid is in place which facilitated our work since the GPS equipment are working within the same coordinate reference system. The survey team also conducted field visits to inspect each geodetic point and to measure them with our equipment in order to make sure that the coordinates measured by our team are within the same reference system. The monitoring results are given below.

Table 1.

The measured coordinates of geodetic points.

Name	X	Y	H
Hoxatumb	4461685.923	452858.364	1320.379
Arapar	4462282.13	450652.861	1383.07
Eghvard	4467280.733	457180.435	1384.965

Table 2.

The difference between the given and measured coordinates of geodetic points.

Name	ΔX	ΔY	ΔH
Hoxatumb	-0.007	-0.017	-0.007
Arapar	-0.015	0.002	0.007
Eghvard	-0.103	-0.105	0.511

The analysis of the received results showed that our GPS coordinates differ from the coordinates of Center of geodesy and cartography for a few millimeters, which is completely acceptable since we had been working with RTK method.

Only Yeghvard geodetic point was problematic since the difference exceeded the acceptable margin. Our studies and surveys revealed that the coordinates of Yeghvard geodetic point was defective.

After studying the National benchmark grid points our working group started examining the target area and selecting suitable locations for the new benchmark grid. The experts of the working team decided to install 6 geodetic points in compliance with the following requirements:

1. Benchmarks installed below the freezing zone with depth of 1-1.2 m.
2. DN 100 mm steel pipes were used as working material which were afterwards painted red and numbered with white paint.
3. GPS monitoring was conducted for each point and the coordinates as well as the absolute elevations were established.
4. Topographic survey at Yeghvard reservoir with unmanned vehicle

The equipment described in the chapter above was used for the survey of Yeghvard reservoir. Since the reservoir area is about 1540 ha it was impossible to complete the survey with a single flight. Therefore, the area was split into 12 sections, Figure 2

Figure 1. The arrangement of survey sections

The selection of sections was made based on the peculiarities of the given relief. For each section a safe takeoff and landing place was chosen (Figure 3).

Figure 2. Establishing takeoff and landing points by means of special software

From the very beginning it was intended to carry out all survey works within RA reference system so that later on no problem arises with regards to land alienation and that all the results can be connected to the cadastral map.

In order to meet this requirement land benchmarks of 1.3*1.3 m were installed along the fringe and in the center of each section and the coordinates of those benchmarks were established via Trimble R7 GPS system before starting the flights.

Five or six similar benchmarks were selected for each section. Their coordinates were transferred to Trimble Business Center and with special instructions the photos were transferred to WGS-84 coordinate system used in Armenia. It should also be noted, that in Armenia the system of Baltic Sea is used as basis for elevations. The survey works were also implemented within this system.

More than 150 GB information was collected through aerial survey which was processed with special licensed software packages. These packages were used for the following important actions:

1. Transferring survey photos and flight file of .jxl format to Trimble Business Center software system;
2. Adjustment and scaling of adjacent photos;
3. Loading the coordinates of land benchmarks into the system which, as described earlier, are produced by measuring the centers of black and white benchmarks by means of GPS.
4. Each benchmark is visible in more than ten photos. By choosing the benchmark and showing its location adjustment is being done bringing all photos to the required coordinate and elevation system;

5. After absolute adjustment the point cloud is created which is used for getting the surface and contour lining;
6. After creating the required form of contour lines the file is transferred to CAD system and processed.

After final processing the contour lines of all sections were merged resulting in one complete unit for surface area of 1,540 ha.

Survey works in the feeding and diversion canals were implemented following the same principle except 3rd canal which was measured with GPS and total stations.

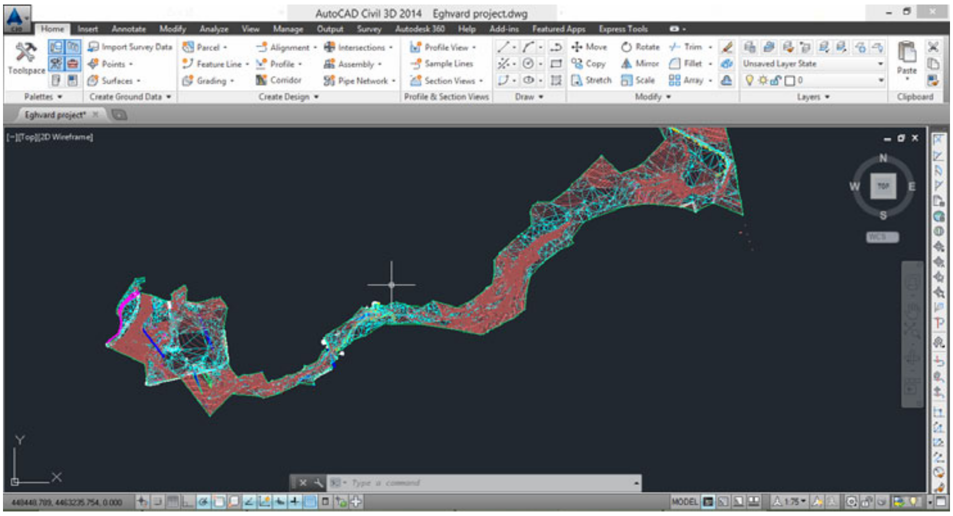

Figure 3. Conventional survey of the conveyance system alignment

This alignment is characterized by complex relief and built-up area. Before starting the survey works a survey grid was created on the site. Afterwards the relief was surveyed by means of total station. More than 3,900 points were surveyed which were later processed by AutoCAD program.

Arzni-Shamiram irrigation canal was also surveyed with the abovementioned method. The contours of the canal are presented with absolute accuracy.

Conclusion

Based on the measure results and the spent time we have compared traditional geodetic measurements and the cartographic works with the UAV shown in the 3th table.

Table 3.

The difference of traditional geodetic measurements and the cartographic works with UAV

	UAV	GNSS	Comments
Area	1.5 km^2	1.5 km^2	
Marking and measuring earth study points	1 ¼ hours	---	Study points are not necessary for all tasks
Time settings	15 min	15 min (in day)	
Time measuring	45 min	30 ½ hours (4 days)	
Time folding	15 min	15 min (in day)	
Time treatment	4 hours (2.80 GHz Intel Core i7, 16 GB RAM)	---	The data can be processed at night
Overall time	6 hours 30 min	32 hours 30 min	5time faster than GNSS
Density measuring	4 centimeters (with altitude 120 meters)	15 meters	Maximum density 2.4 centimeters
In terms of accuracy	2 centimeters	1 centimeters	
Height accuracy	4 centimeters	2 centimeters	

We have compared the works on the area 1.5 km^2. Cartographic works with GNSS will take 4 days. Cartographic works with the UAV for the same area take 40 min. Data processing time for both measurements is the same but our measurements data were processed automatically. After comparing it became evident that the measurement method used and offered by us in term of time consumption is 5 times productive than any traditional measurement method.

After this analysis, for big areas and with difficult terrain (if scaling factor is equal or bigger to 1:1000), we recommend to do cartographic works by the aero photogrammetric method.

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Գրախոսող՝ Հ. Բաբայան

ԵՂՎԱՐԴԻ ՋՐԱՄԲԱՐԻ ԳԵՈԴԵԶԻԱԿԱՆ ՉԱՓԱԳՐՄԱՆ ԱՇԽԱՏԱՆՔՆԵՐԸ

Ս. Վ. Թովմասյան, Ն. Խ. Գյուրջյան, Ա. Ա. Մարգարյան, Ա. Լ. Վասիլյան

Ամփոփում

Հոդվածում ներկայացված են Եղվարդի ջրամբարում իրականացված գեոդեզիական չափագրման արդյունքները, որոնք կատարվել են երկու տարբեր եղանակներով: Ստացված արդյունքների համեմատությունը ցույց տվեց, որ անօդաչու թռչող սարքի կիրառումը առավել արդյունավետ է ինչպես չափագրման ճշտության տեսանկյունից, այնպես էլ պահանջվող ժամանակից: Վերջինիս կիրառումը հատկապես արդյունավետ է դժվար հասանելի վայրերում հանույթ իրականացնելիս:

ГЕОДЕЗИЧЕСКИЕ РАБОТЫ НА ВОДОХРАНИЛИЩЕ ЕГХВАРД

С. В. Товмасян, Н. Х. Гюрджян, А. А. Маргарян, А. Л. Василян

Резюме

В статье представлены геодезические измерения, выполненные на Егвардском водохранилище с использованием двух различных методов. Сравнение результатов измерений показало, что геодезические работы с применением дрона более эффективны, как с точки зрения точности измерений, так и требуемого времени. Применение дрона особенно эффективно для геодезических измерений в труднодоступных местах.