

# PHOTOGRAMMETRIC RESEARCH CONDUCTED AT THE ANTARCTIC STATION "ACADEMICIAN VERNADSKYY"

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## ABSTRACT

For three recent years the Ukrainian photogrammetrists from the Lviv Polytechnic National University have been doing wide-ranging complex photogrammetric research at the Antarctic Station "Academician Vernadskyy". The station is located on one of the islands in Argentine Archipelago. The main aim of our experts is to fulfill the following tasks: to get a digital map with the scale of 1:1 000 which is to serve as a basis for GIS of the archipelago with the following indication of biologic, radiometric, magnetometric, geophysics and other data; to monitor the coastline and to find out the dependence of the changes on the natural factors; to research the DTM structure of the coastal glaciers, to determine the cinematic parameters (displacement) and glaciologic data. To accomplish these tasks we have elaborated and put into practice the mathematic model of photogrammetry of cinematic processes and complex technology of conducting digital terrestrial survey from a firm point and from a moving boat. In the course of the expedition period 2002 - 2004 the researchers made about 1000 digital photographs that were stereoscopically processed on the digital photogrammetric station DELTA-2. The analysis of the digital maps and DTM proves effectiveness of technology, and accurate presentation of the changes of spatial objects. The paper includes the photos of Galindez Island and some cartographic material got in the course of research.

## THE MONITORING OF THE COASTLINE

A wide range of researches and experiments has been done at the Ukrainian Antarctic Station "Academician Vernadskyy". Extensive information collected on this region needs systematizing. This natural requirement pushed forward the idea of making GIS of the Argentine Islands and adjacent coast of Antarctic peninsula.

The topographic map with the scale of 1:1000 were chosen a basis for making GIS because such map is very convenient to indicate in details all the information like biologic areas, colonies of birds, location of various sensors (radiometric, magnetometric, meteorological and the like).

To make the topographic maps we used the methods of terrestrial phototheodolite digital survey [1].

The survey included field and cameral work. The field work aims to obtain photographic (digital) information (a stereogram) about the locality and data defining the elements of the absolute orientation.

The field work provided the geodetic base on the territory under survey. The work started with surveying Marina Point from the boat equipped with the tripod to fix camera.

However the complicated glacier situation in the year 2002 kept us from completing the whole amount of work planned according to the technology. So the decision was to survey the island from the adjacent territories: Winter Island, Grotto Island, Corner Island, Skua Island. To provide a complete mapping, the survey was done in two ways: normal and with equal deviation of the optical axis of the camera depending on basis. After the field and cameral photogrammetry work was completed on Winter Island, the expedition proceeded with survey on Grotto Island, intermediate islands and Corner Islands.

The expedition of the year 2003 finished the survey of Galindez and Winter Island.

Some "dead" areas were found in the process of digital phototheodolite survey of the island coastline. This necessitated topographic photographing which was done with the use of GPS. Owing to peculiarities of the relief it was necessary to use GPS in topographic survey of the western part of Galindez Island. Still the planned work was not accomplished, as it appeared impossible to get directly to the object under research. Then digital phototheodolite survey was done on Penguin and Penjuin Points. To mark and to determine the control points, the researches landed from the boat. The digital phototheodolite survey (normal and with equal deviation of the optical axis of the camera) was done from two bases fixed on the main altitudes.

The technology of mapping the coastline from the boat was used to survey the western part of the island with the preliminary determination over all area under survey.

Thus digital phototheodolite survey done from the boat or from the basic points, or with the use of GPS was applied to collect data on the whole territory of the island. The collected data were used in subsequent cameral photogrammetry work aiming at creating topographic map with the scale 1:1000 which will make a basis for GIS.

The cameral work consisted in processing of the terrestrial photographs on photogrammetric station "Delta" [3].

## THE RESEARCH OF COASTAL GLACIERS.

The project of geoinformatic system "Antarctic" suggests researching the glaciers located on the Argentine Islands.

The use of the above-mentioned terrestrial digital phototheodolite survey defines the following parameters of the glaciers:

- Space location of the glacier in a certain period of time;
- Data on morphometric characteristics of the glaciers;
- From the results of several cycles it is possible to derive space change of the glaciers, the change of their shape and size, the change of the volume of the ice;

The data on the characteristics of the glaciers give a ground for the conclusions about the local and global changes of climate.

A prior estimate how precisely the space coordinates of object points were determined is highly important stage of any geodetic or photogrammetric work.

To get errors  $m_x$ ,  $m_y$ ,  $m_z$  of space coordinates (see Table) it was used a well known formulas of estimating the precision of the phototheodolite survey with the basic data ( $m_x$ ,  $m_z$ ,  $m_p$  – average square-law error of defining coordinates and parallaxes by photographs;  $m_B$  – average square-law error of measuring the photography base) for digital theodolite, made on the base of digital camera DC-260 and theodolite 2T2 with  $x_j=40$  mm;  $z_j=25$  mm;  $m_B=5$  mm;  $m_p=m_x=m_z=0.005$  mm.

The name of glacier	Y <sub>φ</sub> (M)	B (M)	f (MM)	Normal case of survey			Parallel case of survey φ = 15°		
				m <sub>x</sub> (M)	m <sub>y</sub> (M)	m <sub>z</sub> (M)	m <sub>x</sub> (M)	m <sub>y</sub> (M)	m <sub>z</sub> (M)
Galindez	200	40	92	0.028	0.054	0.020	0.029	0.056	0.020
			280	0.006	0.018	0.004	0.006	0.018	0.004

The analysis of these data proves that the precision of the coordinates defined with the above-proposed method is equal to the precision of the volumes defined with the method of the vertical grid [2].

The field work included the following stages:

- To reconnoitre the territory and to make the working project of survey;
- To fix the control and base points and to define their geodetic coordinates;
- To make a long-term centers of survey;
- Photographing [3].

The long-term centers of survey were made of the thick-walled tubes.

The complex monitoring consisted in the following. The devise and the mark are fixed on the left and right points of the base. The digital phototheodolite fixed on the left point and an sighting mark on the right one. The centering was done in a usual for geodetic devices way. After the digital phototheodolite and the mark have been fixed, the altitude of the tool  $i$  is being measured.

Photographing was done in the following order:

1. To set the reading on the orientation device (theodolite 2T2) so that it suits the survey;
2. To loose the fixing nut and to turn the theodolite so that a sighting mark is seen trough the telescope of the orientation device. Then, after the nut has been fixed again to superpose the bisector of the telescope and the center of the a sighting mark;
3. To check the reading precision and the level position; if necessary to correct the position of levels and to do once more the mark sighting;
4. To switch on the camera; to fix the operating exposure; to choose the way of survey;
5. To shift the digital phototheodolite to the right point and the sighting mark to the left. To do the survey in the same order.

The survey was done with different focal lengths of the camera (Kodak-260C, Olympus E20p) which were determined by the angles of object coverage. The next step according to the technology was to find out the coordinates of the points of survey by means of GPS in static condition to raise the precision of finding the location of centers. In this way zero cycles of the glacier survey were completed. The surveys done in different time resulted in 12 stereograms, both, normal and with equal deviation of the camera optical axis to the right and to the left (15°) with the focal length of the camera 92 mm and 280 mm (Fig. 1).

The cameral processing of the materials was done on the digital



Fig.1. General view of the Galindez Glacier.

photogrammetric station (DPS) "Delta". Still due to the high steepness of slopes under survey it appeared a problem to sketch the relief of the glacier outcrop in horizontals. Therefore it was decided to present the relief in verticals as the projection of the lines with equal altitude on the vertical plane. Fig.2 shows the glaciers on Galindez Island presented in verticals.

The processing (like in previous cases) was done on the digital photogrammetric station (DPS) "Delta".

But the main task of the research of the glaciers is to find out the change of glaciers volumes. The repeated survey of this part of Galindez Island was conducted in the expedition of the year 2003.

The volume of the glacier was learned from the results of processing the stereograms by means of vertical grid [2]. It is determined that the surface volume of the glacier diminished in 3220 m<sup>3</sup>, which is caused by considerable temperatures drop in summer period of 2002 and 2003.

The materials of the expedition of the year 2004 are still being processed and the results will definitely bring new facts about dynamic processes in the region of the Arctic station "Academician Vernadsky".

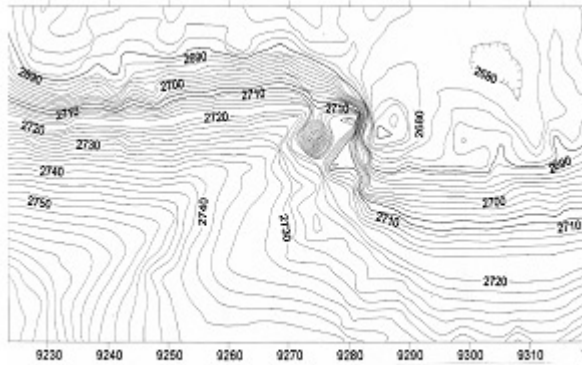


Fig.2. The fragment of the glacier presented in verticals.  
Relief section in 2 m.

## CONCLUSIONS

1. The use of the digital photogrammetric methods enabled to automatize the process of making topographic maps and plans.
2. The experimental-research work proved it possible to survey, process and make big-scale maps by means of digital phototheodolite.
3. The technology of processing digital terrestrial photographs on DPS "Delta" was developed .
4. It was created the topographic map of Galindez Island with the scale 1:1000.
5. The experiments proved it possible to use digital terrestrial photographic survey for mapping and determining the glaciers.
6. It is worthwhile to present the relief of the glacier outcrop as verticals.
7. Digital photographs of glaciers received by means of the digital phototheodolite are advisable to be processed on DPS "Delta"

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