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GEODETIC BASIS WHEN PERFORMING MARINE HYDROGRAPHIC MEASUREMENTS

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ABSTRACT: *Geodetic network is the set of permanently stabilized points on the earth's surface, the position of which is determined in a single coordinate and altitude system (X, Y and H) accepted in a given country. When creating geodetic networks, the basic principle from the "general to the private" must be respected, i.e. one must go from the "big to the small".*

KEYWORDS: *Hydrographic measurements, Marine backbone network, Working geodesic network*

1. Introduction

Geodetic networks are determined by many factors that ultimately determine their diversity. A major factor is the accuracy they must satisfy when using them to solve various scientific and applied problems. An important factor is also the nature of the land surface in terms of the configuration of the terrain and the size of the area on which the geodetic networks are built.

In case of specific needs for the creation of topographic plans and maps for a given region, the state supporting geodetic networks in it are compressed with supporting geodetic networks with local purpose (GNLP) – their accuracy is less than that of the state networks.

Thus, compressed supporting geodesic networks are in most cases not sufficient to carry out detailed surveying. They are supplemented to the required density with an additional network of points that form a so-called working geodetic base (WGB). It is uniform for horizontal and vertical measurements, with certain coordinates and heights of its points. Depending on the object, the scale of the plan, the topographic conditions, the chosen method of shooting and a specific tool for work, its density, shape and accuracy are determined. The points of the supporting and working geodetic base form the photographic base from which a geodetic survey is carried out to create a plan, map or digital topographic model [2, 3, 5]. Thus graduated geodetic networks of the Republic of Bulgaria determine their division into:

- State Geodetic Network (State GPS Network);
- Geodetic Networks with Local Purpose (GNLP);
- Photographic (working) geodesic networks (WGN).

The main classical methods using which planned basic geodesic networks were established in the recent past are triangulation, polygonometry, trilateration and combinations between them, depending on the nature and coverage of the earth's surface. Today, GNSS measurements (comic triangulation) are widely used for laying basic geodetic networks.

Comic triangulation makes it possible to achieve sub-centimeter accuracy in applications with an extremely wide range – from building local networks to large-scale tasks such as the study of global geodynamic processes, surveying, tracing, etc. Measurements shall be made without visibility between points, under all weather conditions, time of day and season [2, 3, 5].

For surveying, high-precision relative phase GNSS measurements are of primary interest. They are performed simultaneously at two points – basic (reference) and determinable (mobile). Depending on the way measurements are carried out and their processing, the following methods are distinguished:

- static and kinematic;
- in real time and with subsequent data processing.

Common to all geodesic methods is the relative nature of the results – it is not the coordinates of the determinable points that are calculated with high accuracy, but the spatial vectors that connect them to the reference stations [5].

2. Exhibition

Marine Support Geodesic Network

For planning attachment of measurements in sea photos, the supporting geodetic network of the coastal and insular parts of a country is used. At sea, the coordinates of the points are determined by means of RGS (Radio Geodesic Systems), RNS (Radio Navigation Systems) and by the methods of precise navigation, and in recent years with GNSS (Global navigation satellite system) [2, 4].

Through accurate navigation, the location of the ship without a marine geodesic network can be determined. A marine photograph can also be carried out in an area, but this requires modern, high-precision and expensive navigation equipment. For this reason, a marine supporting geodetic network (MSGN) is created through the methods of marine geodesy. The points of this network are evenly located not only along the coast and islands, but also on the seabed.

Marine geodetic networks are needed to solve the following main tasks [2, 4]:

- general geodesic tasks – to determine coordinates of points, to provide marine topographic photographs, to study the surface of the geoid (quasigeoid), to determine the demarcation limit or other boundary lines;
- engineering and geodetic tasks – determining the location of facilities and communications on the seabed, geodetic provision of exploration and extraction of minerals, as well as provision of surface and underwater construction and other activities;
- scientific tasks – geodetic provision of geographical, geophysical and oceanographic studies, solving space problems, etc.

The requirements for the accuracy of the activities carried out at sea are not the same and additional studies are carried out to unequivocally justify the accuracy of the MSGN. In many cases, this accuracy is directly dependent on the accuracy of the technical means by which it is created. In perspective, through the development of technical means and research methods, the real accuracy of the MSGN points is expected to increase significantly.

Now the main geodetic activities at sea are solved using the supporting geodetic network created on the coast, on islands, on the water surface, and less often – under the water or on the seabed. Modern automated measurement complexes are needed for the creation of the MSGN, which include highly accurate Satellite Navigation Systems (SNS), RGS, Ground-based RNS,

hydroacoustic means and systems, GNSS receivers and electronic computing machines (ECM) on board the screen [2, 4, 5].

The MSGN transmits a unified system of coordinates to a large area of the World Ocean and provides with initial data research, photographic and other geodetic activities.

Depending on their purpose and technical means, MSGN are divided into:

- Planned MSGN that are necessary for the transmission of a unified coordinate system over large areas of the seabed and the World Ocean (Fig. 1);
- Chains or polygons of MSGN that connect local marine geodetic constructions with the unified coordinate system (Fig. 2);
- Local MSGN with several points, which are used to attach individual photographed sections near the coast to the supporting geodetic network on land.

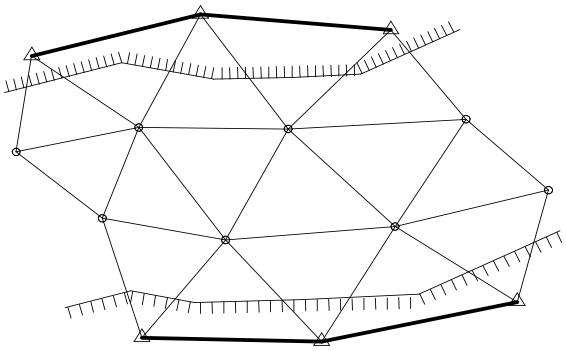

Fig. 1

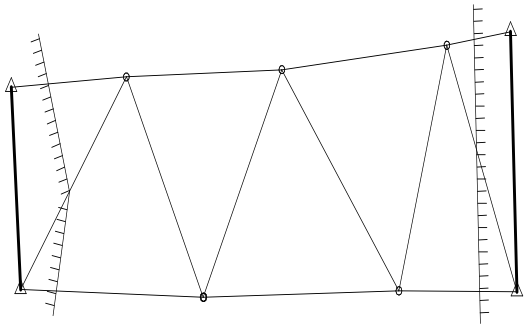

Fig. 2

The most commonly used figures in the MSGN are the equilateral triangle, square and central system. In deep-sea areas, hydroacoustic devices, usually a transponder, are anchored at marine support geodesic points. The absolute coordinates of the points are determined from surface vessels by synchronous measurements performed with hydroacoustic and integral systems.

The main methods for determining the coordinates of MSGN points are spatial trilateration, linear – angular method and measurement of distances and directions to bottom points by hydroacoustic systems. Active or passive acoustic means can be placed at these points. The principle of creating a MSGN is from the general to the private. First of all, the fundamental points of islands, along the coast, on special stationary platforms, fixed at the bottom, are created. The distance between these points is from 100 to 1000 km, and the accuracy in their position is no more than 0.5 m. These points shall be compressed by sea support points with a distance between them from 2 to 30 km and an accuracy of not

more than 1 – 2 m. To increase accuracy, it is necessary to measure two acoustic bases with a common sea support point [2, 3, 4, 5].

The establishment of the MSGN is divided into the following stages:

- Preparation of a technical design;
- Bringing the MSGN into working order;
- Performance and processing of measurements.

The technical design specifies the number of starting and newly defined points, the measured quantities by type and accuracy, a preliminary a priori assessment of the accuracy of the designed points, the limit values of the distances and radii of operation of the measuring equipment are checked. In addition, the expected conditions for stabilizing the new points and bringing them into working condition are analyzed. In many class creation of the marine supporting geodetic network, the possibilities for network compression are justified. Also, the algorithms for processing measurements and determining the X, Y, Z coordinates of the grid points are specified and the costeffectiveness of the project is justified.

Bringing MSGN into working condition is a process in which the structure of the seabed, depth, acoustic properties of the aquatic environment, etc. are studied. factors in the area of each newly designated point.

The performance and processing of measurements are stages in which the measurements provided for in the technical design by type and accuracy are realized as fully as possible and mathematical processing of the measurements according to the current instructions is carried out. The equalization of the measurements is by the method of least squares.

The MSGN points are stabilized depending on their location – underwater by concrete slabs or blocks, and above water by stationary platforms.

Signaling of marine reference geodetic points is carried out by means of special signals (buoys). Fixing the signal is done with a special anchor. Signals can be passive or active.

Passive signals are placed for unambiguous recognition of the point. The reflected acoustic signal from such a point is stronger and clearer than the reflected acoustic signals from the near vicinity of the point.

Active acoustic signals (transponders) emit pulses according to a set program when pulses with certain characteristics are sent to them from the ship. The big problem with acoustic signals is the duration and reliability of their action. It depends on the power supply, power consumption, operating

conditions. The duration of operation of transponders is between 10 and 20 years [2].

Marine working geodetic base

The working geodetic datum is a set of points on land for which planar coordinates x, y and altitude H are known. This datum is used for coastal photographs in the area of optical visibility from the coast. When reference geodetic points along the coast are at long distances, a working (photographic) geodetic base is developed, included in the reference network. The mean square error in the position of the points of the working geodetic base relative to the points of the reference grid should be higher than 0.2 mm at the scale of the plan or map.

The working geodetic base is created by triangulation, polygonometry, chains of triangles, quadrilaterals, geodetic angular and linear-angular sections with increased accuracy and others. Polygon and polygon runs can be included, closed, and meshed with node points. Depending on the configuration of the coast in the area of the photo, the type of geodesic construction is also determined. The choice of the locations of the points from the work base is taken into account with the tools and methods that will be used in the photograph.

In a photo using optical technical means, the points are selected so that next to them there is geometric visibility to a larger part of the photo area. In this case, the distances between the points of the working base are shorter and comply with the distances between the gauges. When the photograph will be carried out by radiogeodetic methods, the distances can be 2 – 3 km and more. The working geodetic base is connected to the shore reference geodetic base [2, 3, 4].

In the organization and planning of a seabed photograph, various objective and subjective factors such as bottom relief dynamics in the area, survey objectives, qualitative and quantitative measurements, goals and priorities of the contractor must be considered [1].

The elevation grid of land near the area of the photograph is used as an elevational reference for coastal photographs. The altitudes of the points from the working base are determined by geometric and trigonometric leveling. The mean square error of the heights of the points should be less than 0.02 m, and the mean square error of the mutual position of two adjacent points of the working base should be less than 0.05 m.

It should be added that when creating the support and working geodetic base on the coast, the instructions given in the relevant instructions are followed [2].

3. Conclusion

At the current stage of the development of marine geodesy, when taking coastal marine photographs, mostly local marine reference geodetic networks are created, included in the reference geodetic network on land. Establishing a marine reference geodetic network is too expensive and no country has yet fully established such networks.

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