Creation and development of continuously operating networks in the Russian Federation. Yesterday, today, tomorrow.

Aleksei LAPSHIN and Sergey STAROVEROV, Russian Federation

Key words: Global Navigation Satellite System (GNSS), GPS, Reference systems

SUMMARY

The last few years have seen significant changes in the development of Global Navigation Satellite System (GNSS) infrastructure in the Russian Federation. Over the previous two years, Rosreestr created 45 points of the Fundamental Astronomical and Geodetic Network (FAGN). Their total number amounted to 99. A hardware and software complex of the Federal Geodetic Stations Network (FGSN) has been developed, which makes it possible to collect, analyze, and process satellite observations made at GNSS stations in order to control the stability of their operation and ensure that they can be used in solving the tasks of determining the location of objects in real time mode. Thus, it was possible to integrate more than 2000 of these stations. An information system has been created that allows to:

- use a range of international and domestic sources of additional data;
- function in conditions of limited accessibility by providing autonomous determination of additional parameters (ephemeris and clock corrections, ionospheric and tropospheric parameters, inter-channel delays of GLONASS (Global Navigation Satellite System in Russia) and GPS satellite signals);
- perform retrospective processing of data incoming with delay;
- perform joint equation of the results of a given set of daily solutions of the FGSN network;
- estimate the speeds of movement of FGSN points in the ITRF;
- to perform delayed processing of data from individual stations or a set of several stations and then insert them into the general equation;
- to perform joint network equation with a final common solution for the entire IGS network stations implementing ITRF;
- to perform remote verification of satellite equipment.

SUMMARY (in Russian)

В последние несколько лет в РФ произошли значительные изменения в развитии ГНСС-инфраструктуры. За два года созданы 45 пунктов фундаментальной астрономо-геодезической сети (ФАГС), доведя общее количество до 99. Разработан аппаратно-программный комплекс федеральной сети геодезических станций (ФСГС), позволяющий выполнять сбор, анализ и обработку спутниковых наблюдений, выполненных на ГНСС-

станций, в целях контроля стабильности их работы и обеспечения возможности использования при решении задач определения местоположения объектов в режиме реального времени. Таким образом, удалось обеспечить интеграцию более 2000 станций. Была создана информационная система, позволяющая:

- использовать совокупность международных и отечественных источников дополнительных данных;
- функционировать в условиях ограничения доступности за счёт обеспечения автономного определения дополнительных параметров (уточненных эфемерид и поправок бортовых часов, параметров ионосферы и тропосферы, межканальных задержек сигналов спутников ГЛОНАСС и GPS);
- выполнять ретроспективную обработку, поступающих с задержкой;
- выполнять совместное уравнивание результатов заданного набора суточных решений сети ФСГС;
- оценивать скорости движения пунктов ФСГС в ITRF;
- выполнять отложенную обработку данных с отдельных станций или набора нескольких станций с последующей вставкой их в общее уравнивание;
- выполнять совместное уравнивание сети с окончательным общим решением для всей сети станций IGS, реализующих ITRF;
- проводить удаленную поверку спутниковой аппаратуры.

Creation and development of continuously operating networks in the Russian Federation. Yesterday, today, tomorrow.

Aleksei LAPSHIN and Sergey STAROVEROV, Russian Federation

With the development of Global Navigation Satellite System (hereinafter referred to as GNSS), new opportunities are emerging for the development of the geodesy and cartography industry, which makes it possible to significantly improve the quality and increase accuracy of geodetic and cartographic works on the territory of the Russian Federation.

As part of the development of the Russian geodetic infrastructure, the network of continuously operating networks points of the Fundamental Astronomical and Geodetic Network (hereinafter referred to as FAGN) is being intensively expanded.

By increasing the number of FAGS points, the density and uniformity of coverage of the country's territory, the quality of services provided by the owners of Differential Geodetic Stations (hereinafter referred to as DGS) is monitored, the uniformity of measurements and dissemination of the state coordinate system throughout the territory of the Russian Federation is ensured, as well as technological conditions are created to comply with legal requirements when performing geodetic works in the state reference frame using GNSS equipment.

As of January 1, 2022, the total number of FAGN points was 54.

During 2022, 45 new points were put into operation, thereby adding to the network up to 99, with 12 of them with double work centers. In 2023, 2 more points were put into operation, so the total number of FAGN points by the end of 2023 reached 101.

Nevertheless, the analysis of geodetic space and the needs for spatiotemporal information indicates the possibility and necessity of further development of this network. Taking into account the changing requirements for the accuracy and reliability of location detection, as well as the need for denser coverage within some regions, the FAGN requires further development in the direction of increasing the number of stations.

In addition, DGS networks are being created and expanded with the help of GNSS technologies to solve a complex of the most important applied and scientific problems in geodesy and cartography.

DGS networks are being created in order to provide the territory of the Russian Federation with high-quality economic operating activities, introduce the Russian GLONASS space navigation system, reduce the cost of cadastral works, increase the efficiency of navigation, cargo transportation, climate change, and reduce the costs during survey and construction work.

Currently, in order to create a single high-precision coordinate base on the territory of the Russian Federation and transfer the entire user sector to work in a single reference frame, a Federal Geodetic Stations Network (hereinafter referred to as FGSN) has been created and is being actively developing.

The prerequisites for the FGSN creation are:

- a significant increase in the number of geodetic stations owned by legal entities and individuals due to the widespread use of satellite methods for determining the coordinates of terrain objects in geodetic activities;
- the lack of a modern digital system to provide consumers with information about the quality of services delivered using geodetic stations;
- the lack of statutory and technical regulation corresponding to the level of technology development in terms of the application, the use and operation of geodetic stations of various operators as part of an integrated federal network;
- low density of permanent points of the Fundamental Astronomical and Geodetic Network, which limits the uniform distribution of the state reference frame on the territory of the Russian Federation;
- the availability of networks of geodetic stations similar to FGSN;
- registry errors due to incorrect determination of the coordinates of stations of disparate DGS operators.

FGSN is a set of differential geodetic stations, forming a single three-dimensional spatial structure, which is the most important reason for uniting disparate private and public networks of geodetic stations into a single system for the purpose of joint processing of measurement information and obtaining spatial coordinates in the state reference frame..

An important achievement in the field of GNSS infrastructure development is the creation of the hardware and software complex of the Federal Geodetic Stations Network (hereinafter referred to as the FGSN HSC).

As a result, the following functionality has been implemented in the FSGN HSC:

- collection of satellite data from DGS operators;
- control of observation files quality;
- formation and maintenance of an integrated observation database;
- long-term reliable storage of measurement data;
- protection of stored information from unauthorized access;
- processing of satellite data from disparate operators by a single tool;
- joint equalization of processing results in a single state reference frame;
- provision of information to consumers and DGS operators.

The result of FGSN HSC processing are daily coordinate solutions of FGSN points in the state geodetic reference frame of 2011 with the accuracy (RMS error) of determining the coordinates of FGSN points relative to FAGS points from 2 to 3 cm.

Accuracy (RMS error) of determining the mutual position of FGSN points is ranging from 0.5 to 1 cm.

The FGSN HSC development resulted in the FGSN Information System (FGSN IS), in which the following capabilities were realized:

- Using a combination of international and domestic sources of additional data, taking into account their accessibility;
- stable operation of the System under conditions of limited availability due to autonomous determination of additional parameters (ephemeris and clock corrections, ionosphere and troposphere parameters, inter-channel delays of GLONASS and GPS satellite signals);
- performing retrospective processing of data incoming with delays;
- joint equalization of the results of a given set of daily solutions of the FGSN network;
- possibility of estimating FGSN points movement speed in ITRFxxxxx;
- delayed processing of data from individual stations or a set of several stations and their subsequent insertion into the general equalization;
- joint equalization of the FGSN stations network with a final common solution for the entire network of IGS stations implementing ITRFxxxxx;
- an automated tool for remote verification of DGS has been developed within the framework of the FGSN IS.

The owners of DGSs belonging to the FGSN improve the accuracy of coordinates of their base stations through integration with the state geodetic network (FAGN) and, as a result, increase the quality of services provided.

Consumers can choose the appropriate DGS station network owner for the works in the works producing area, resulting in:

- elimination of errors during periodic installation of geodetic receivers at a temporary base station;

- significant reduction in the time required to determine high-precision coordinates;

- increase in labor productivity when performing work in real time mode (RTK);

- improvement of the quality of cadastral and land surveying works;

- exclusion of accumulation of new registry errors in the Unified State Register of Real Property.

To ensure the production of accurate measurements on the territory of the Russian Federation, it is necessary to expand the geographical coverage of the FGSN. This will improve the accuracy of coordinates and heights of observation points in remote and poorly explored regions.

To provide the reliability and stability of measurements, it is necessary to carry out regular inspection and maintenance of observation points. This includes control of movement and deformation of the points, as well as updating their coordinates and heights.

Further development of the FGSN IS is planned to be aimed at creating a service for automated processing of satellite observation data obtained during geodetic, cartographic, land surveying, town-planning and cadastral works in the area of FGSN points coverage.

It is also necessary to keep up-to-date the mathematical apparatus for processing and equating the points included in the FGSN, taking into account the world trends in the development of scientific class software.

CONTACTS

Aleksei LAPSHIN
Public Law Company ‘Roskadastr’
10, building 1, Orlikov lane
Moscow
RUSSIAN FEDERATION
Tel. +7 (495) 587-80-80
Email: federal@kadastr.ru
Web site: https://kadastr.ru/

Sergey STAROVEROV
Public Law Company ‘Roskadastr’
10, building 1, Orlikov lane
Moscow
RUSSIAN FEDERATION
Tel. +7 (495) 587-80-80
Email: federal@kadastr.ru
Web site: https://kadastr.ru/