Analysis of the quality of measurements of permanent base stations (UZPOS) in the territory of Samarkand

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\textbf{Abstract.} The article analyses the quality of GNSS measurements linked to permanent base stations (UZPOS) in the Samarkand region. For full-fledged, high-quality work and analysis of observations, existing state geodetic points were used. To carry out high-quality geodetic work, recommendations, instructions, and guidance materials describing the most modern geodetic methods and technologies must be drawn up. Existing state geodetic triangulation points were selected in such a way that one of them was as close as possible and, conversely, one as far away as possible from the permanent base stations located in the Samarkand region.

\section{1 Introduction}

The world practice has accumulated considerable experience in the creation and implementation of modern high-precision continuously operating base stations (CORS). The UZPOS satellite network has been established in the Republic of Uzbekistan relatively recently, using modern methods, the accuracy of which is also significantly higher than traditional ones.

The use of CORS system can be economically favourable compared to purchasing and maintaining own geodetic instruments. Users can access high quality geodetic data on demand, thus reducing the cost of equipment and its updating.

Overall, the CORS system offers the advantages of high data accuracy, availability, versatility of application, network integration, standardisation and cost-effectiveness, making it a popular choice for professionals in surveying and related fields.

CORS stations and their associated geodetic infrastructure are important tools for research in geodesy, geophysics, geology and other disciplines. They provide data for studying land surface changes, plate motions, climatic phenomena and other geodynamic processes.

CORS system provides valuable data for planning and development of infrastructure projects such as roads, bridges, tunnels, airports and other facilities. It helps improve the accuracy of design, construction and quality control in these projects.

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These benefits make CORS an attractive choice for professionals in surveying, engineering, geoinformatics and other industries that require accurate and accessible geodetic data for a variety of applications.

The Uzbekistan POsitioning System (UZPOS) is a national network of 50 GNSS base stations. Three UZPOS stations in Samarkand continuously send data to the control centre in Tashkent. The collected data are archived, published and used for post-processing of field measurements and various scientific studies [1].

The quality of the received GNSS measurements at UzPOS points was assessed using the BKG Ntrip Client (BNC) programme, which uses the algorithms of another well-known TEQC Unavco programme. The input data for the BNC programme for each of the points was a measurement file for a certain date. The daily assessment of measurement quality is a rather labour-intensive task and hardly makes sense, since the changes in the parameters of multipath, cycle disruption and signal-to-noise ratio at a station are unlikely to change rapidly over several days [1].

The BNC programme allows the following graphs to be plotted from the source files in RINEX format (in our case, these are daily files with 30-second measurement intervals) and to obtain the final data:

- Projection of multipath data onto the celestial sphere.
- Projection of signal-to-noise ratio data onto the celestial sphere.

In addition, using this programme, it is possible to obtain the percentage ratio of GNSS measurements made to potential measurements. The IGS KITG (Kitab) station equipped with a rather modern GNSS receiver was chosen as a comparison station.

![Signal to noise ratio Station AKTD (Aktash) UzPOS.](image1)

**Fig. 1.** Signal to noise ratio Station AKTD (Aktash) UzPOS.

![Multipath for station AKTD (Aktash) UzPOS.](image2)

**Fig. 2.** Multipath for station AKTD (Aktash) UzPOS.
After analyzing the data, it can be claimed that UzPOS points correspond to the best stations of the IGS network in terms of observation quality (multipath parameter, signal-to-noise ratio, percentage of measurements completed), and that they can definitely be used to build the Republic of Uzbekistan's new high-precision reference coordinate system.

Once a satellite infrastructure project is implemented, most positioning-related work can be done in real-time. This means that in a few seconds, each consumer of the system data directly at the work site can determine the coordinates of an object with the accuracy he requires [4].

2 Analysis of the experience of developed countries in establishing reference systems

In world practice, there are examples of the creation of state, departmental, and private networks of base stations. Along with them, there are networks formed as a result of cooperation between various research organizations’ to solve educational, scientific, and applied problems [2].

The global network of permanently operating base stations is the IGS network of the International GNSS Service. Currently, it consists of 362 stations, mostly owned by research institutions. There is also a European network of permanent stations, the EPN (EUREF Permanent Network), the status of which is equal to that of the IGS network. However, measurements carried out at 200 permanently operating stations of this network in Europe, are aimed at implementing and clarifying the European reference coordinate system, designed to solve scientific and industrial problems in the European Union. A network of permanently operating CORS (Continuously Operating Reference Stations) base stations ensures the security of the US government coordinate base. The network includes about 1274 stations, maintained by the US National Geodetic Survey (NGS), and about 200 stations maintained by other government and non-government organizations. Measurement data at permanently operating stations of the CORS network are available on the Internet. In Japan, out of 130 thousand geodetic points that implement the state reference system, more than a thousand are permanent base stations [5].

Russia has adopted a new system for constructing a state network, according to which some of the points of the FAGS (Fundamentally Astronomical and Geodetic Network) are permanently operating base stations. Currently, the state geodetic network is under construction [4].

3 The purpose of the study

It is aimed at studying the requirements for points of the permanent operating satellite State geodetic network (PSGGS), that is, the relative location of points to ensure the accuracy of points. Analysis of the possibilities and prospects for improving the technique of accurate differential positioning and identification of factors affecting the efficiency of determining coordinates and experimental verification of the validity of proposals to improve the technique of accurate differential positioning [2-3]

To achieve this goal, the authors of the study directly selected points of the state network, triangulation points 2 - class Ziyadin, Karatepa, and Khishrav. One of the points is located as close as possible to one of the UZPOS stations, and also one of them is as far away as possible in the Samarkand region of the Republic of Uzbekistan. The location of the three triangulation points is shown in Figure 3 [5].
require solutions with fixed ambiguities [4]. Measurement methods such as “fast statics”, “Stop and go” and “kinematics” necessarily work can be carried out taking into account the highest requirements currently placed on produce remarkably accurate spatial coordinates for network points.

30 minutes with an open horizon. All three points of vibrant triangulation are without obstacles.

An analysis of the quality of GNSS measurements collected over two sessions at UzPOS points demonstrated their very high quality, not inferior to the quality of the best stations of the international IGS network. Utilizing Credo GNSS Software with contemporary third-party geodetic software to process GNSS measurements at UzPOS points has shown to produce remarkably accurate spatial coordinates for network points.

Their undoubted suitability for solving problems of geodesy and land cadastre, for constructing high-precision GIS, for use in engineering, geodetic, and survey work. All this work can be carried out taking into account the highest requirements currently placed on them [1].

The given solution sequence applies to conventional static baseline solutions. Measurement methods such as “fast statics”, “Stop and go” and “kinematics” necessarily require solutions with fixed ambiguities [4].
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The international IGS network. Utilizing Credo GNSS Software with contemporary third-points demonstrated their very high quality, not inferior to the quality of the best stations of An analysis of the quality of GNSS measurements collected over two sessions at UzPOS 5 Research results

obstacles.

30 minutes with an open horizon. All three points of vibrant triangulation are without UZPOS base stations was more than 30 km, the duration of measurements was at least 20-

antenna (receiver) was mounted on a tripod with a fixed height (usually 1.2-1.5 meters) and carried out at points in the RTK measurement mode with an average of 3-5 minutes [6]. The “static” method for at least 40 fixing in a horizontal position with a bipod or tripod. When the distance from the operating

points on the territory of the Samarkand region.

Fig. 3. Location diagram of the studied permanent operating satellite networks and triangulation [0x0], 02020 (2024)

Graph of errors detected by the static method.

Fig. 4. Graph of errors detected by the static method.

Table 1. Research from UZPOS base stations and observation was performed in two sessions, using the static method and the GNSS device South.

<table>
<thead>
<tr>
<th>No.</th>
<th>Vector</th>
<th>Vector length 1-session, m</th>
<th>SKO</th>
<th>Error in plan</th>
<th>Height error</th>
<th>Vector length 2-session</th>
<th>SKO</th>
<th>Error in plan</th>
<th>Height error</th>
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<td>0.018</td>
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<td>0.003</td>
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<tr>
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<td>9</td>
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</table>

Table 2. Research from UZPOS base stations and observation performed in two sessions, using the RTK method and GNSS device South.

<table>
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<tr>
<th>No.</th>
<th>Vector</th>
<th>Vector length 1-session, m</th>
<th>SKO</th>
<th>Error in plan</th>
<th>Height error</th>
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<td>6</td>
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<td>904.462</td>
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</table>
The analysis of the results of the above research shows that as a result of increasing the distance in GNSS measurements, an increase in the mean square error, plan error, and height error results was observed in the "STATIKA" and "RTK" methods.

6 Conclusion

The research conducted in this article proves that distance has a significant impact on the results of the coordinate determination method. In most cases, the accuracy of geodetic measurements lies in the fact that the distance between base stations is chosen incorrectly. In the area of field research, 3 points of the class 2 triangulation network, the state geodetic network, were selected to study the accuracy of measurements. The error of these definitions is that they do not take into account the time and geometric factors of satellite communication [5].

Due to the assessment of accuracy, there is an opportunity to solve issues of technical and economic importance:

- To study the laws of measuring errors affecting the transfer of point coordinates and distances in geodetic grids of different forms.
- To determine the most rational option for establishing a network with various measurements of points, azimuths, and base sides located on it, based on the assessment of accuracy by modelling with the help of computer programmes and by observing Earth satellites.
- Checking that the nearest network element has been determined with the required accuracy using measuring methods during network construction.

Creating a network of reference stations in the Republic of Uzbekistan is a timely task and requires further expansion to cover the entire territory of the country. In the future, it is planned to unite single base stations located in the regional centres of Uzbekistan into a single network. This will serve to create a unified geodetic basis[6]

References

1. 8_Rukovodyashhij_tehnicheskij_material_po_prime
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   content/uploads/2021/04/8_Rukovodyashhij_tehnicheskij_material_po_prime
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