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SELECTION OF APPROPRIATE GEODETIC EQUIPMENT FOR RECEPTION OF GNSS SIGNALS WHEN CONDUCTING HIGH-PRECISION MEASUREMENTS

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ABSTRACT: *The subject of the research is to make the right choice of GNSS receiver and related equipment, which will allow to achieve the required accuracy and high productivity with minimal material costs when conducting high-precision geodetic measurements.*

KEYWORDS: *geodetic equipment, receiver, GNSS measurments.*

1. Introduction

The first task in conducting high-precision geodetic GNSS measurements is to select a suitable receiver. Receivers can use five types of signals to determine coordinates: C/A code, P(Y) code of two frequencies and carrier phase of two frequencies. Millimeter accuracy can only be ensured by measurements of the carrier phase, code measurements can provide accuracy up to a meter [3]. The main disadvantage of single-frequency measurements is the inability to accurately read the ionospheric delay. However, for baselines with a moderate length of up to about 20 km, single-frequency receivers give almost the same results as dual-frequency receivers, as ionospheric refraction is (mainly) excluded when subtracting phase measurements between base points. Base lengths reduce during periods of high activity of the solar flares. Observations at two frequencies significantly weaken the influence of the ionosphere and provide faster (about 1.5-2 times) and reliable results.

2. Requirements to be must respond an receivers for conducting high-precision geodetic GNSS measurements

- **Type of signals received and method of phase measurement.**

The most common geodetic receivers on the market are multi-channel code correlation receivers that track the entire wave phase of the carrier frequencies. Accurate phase measurements at full wavelength frequencies L1 and L2 can be combined to form a different combination with a wavelength of 86 cm. The whole ambiguity of such a combination is solved much easier than for a carrier phase with a wavelength of 19 cm [1, 2]. Receivers that use other signal processing methods may be used if the results obtained from their certification confirm the required level of accuracy.

- **Number of channels in the receiver.**

To track all visible satellites ("all-in-view" concept), a high-precision geodetic receiver that only works on GPS must have at least 12 channels. If the receiver operates on two satellite systems, then there must be at least 20 channels. This leads to increased accuracy, reliability and speed of results. In order to obtain satisfactory results when observing only 5 satellites, the receiver must operate at a point for about an hour, while for 10 satellites a few minutes and sometimes seconds are sufficient. A large number of satellites (over 9) are especially useful for real-time kinematics [3].

- **Receiver sensitivity.**

It is considered that the receiver should be tracking the signals to a level of 20 dB/Hz. With this sensitivity, it will be able to track signals even through the leaves, which significantly weakens their strength.

- **Attenuation of the multipath effect by signal processing.**

The error due to multipath in the carrier phase must be less than 1 mm at a distance between the antenna and the reflecting surface of more than 30 m. The error due to multiplicity in the code must not exceed 1 m for the same distance. Multi-path degrades the accuracy, reliability and speed of signal reception.

- **Interference suppression**.

In order for harmonics of signals from other sources not to interfere with the operation of the receiver when they enter the frequency band, the GNSS receiver must suppress interference, at least in the range of 50 dB.

- **Type of antenna and its characteristics.**

The higher the measurement accuracy, the higher the requirements for the receiving antenna. For a geodetic receiver, it is important that the phase center of the antenna has a symmetry of better than 2 mm. This requirement is explained by the fact that, the position actually calculated by the satellites refers to the phase center of the antenna. It is then brought to the reference point of the ARP antenna and then to the point marking through the measured antenna height. If the center moves according to the orientation of the antenna, this will result in an error in the calculated position. In order for the antenna to have this characteristic, it must have a four-pole power circuit. The antenna of the surveying receiver must be able to be oriented towards the sides of the horizon.

Equally important is the antenna's ability to take multi-way signals: the presence of a reflecting plane (ground plane) or throttle rings (throttle ring), the use of technologies such as *Stealth*. The antennas with throttle rings are quite large in size. The ability of the antenna to receive only a circularly polarized signal with right polarization also prevents multiplicity, as once a reflected signal reverses the polarization. Conical antennas, unlike flat ones, provide good protection from birds, which is especially important for base stations.

The antennas in the receiver can be internal or external. In some receivers, both types of antennas are allowed, then when an external antenna is connected, the internal antenna is turned off.

- **External signals.**

The receiver must have an output of 1 pulse per second (signal with a frequency of 1 Hz), synchronized with the SRNS time. This is necessary for such tasks as timing, aerial photography and more. The receiver must have a recording accuracy of not less than 25 ns. The receiver must have a stable frequency input of 5, 10 or 20 MHz from an external generator required for long monitoring sessions.

- **The presence of an automatic weather station.**

Meteorological data obtained during the measurement may be required to process the observations. The results of temperature, pressure and humidity measurements at an automatic meteorological station may be recorded in the observation file at the point. Similar information is especially important when performing work in which the requirements for accuracy in determining the height are high. This applies in particular to work areas with significant differences in height between points (50 - 100 m or more), including aerial photography with GNSS.

- **The amount of internal memory.**

The satellite receiver has a memory for recording results and a memory for configuring the receiver. The memory in the receiver can be located on removable technical media of different types (PCCMA cards type I, II, flash memory, etc.). The requirements for the memory of the receiver, necessary for recording the results of the measurements, depend on the type of work performed, the modes and parameters of the measurement and the type of the receiver. For continuous satellite measurements performed by dual-frequency, multi-system satellite receivers via daily sessions with a recording interval of 30 seconds, the receiver's memory must be at least 64 MB, as the file size of daily measurements, depending on the type of equipment, may be 1.9 MB or more.

- **Power supply and batteries.**

The receiver and antenna must have low power consumption with several options. The system can be light but high in power consumption, forcing heavy batteries to be carried in the field. Batteries with different technologies have different weights and prices. Lithium batteries without recharging are light but very expensive. Lead acid is much cheaper, but also heavier. Low power consumption extends the life of electronics. It is convenient to use a receiver with battery attachments without cable connections, although this is insignificant for many types of measurements.

- **Environment.**

Normally, the equipment must operate at an ambient temperature of -20 to +50 C. The system must also operate in rainy weather.

- **Physical characteristics.**

The entire system of receiver, antenna, display, batteries, chargers, tripod and computer for post-processing must be small. The receiver must be strong, light and portable.

- **Accuracy.**

If the parameters of the equipment are chosen correctly, the accuracy of the measurements will depend only on how the surveyor will work with the system. For example, errors will be greater if a long line is observed and the session duration is short, or when the geometric factors of loss of DOP accuracy are large.

- **Receiver compatibility.**

In one project you can use receivers from different models or manufacturers. However, their compatibility and synchronization of observations must be checked (this is one of the tasks of metrological certification). Subsequently, problems may arise due to different number of channels, different signal processing techniques and different connections to time standards.

3. Conclusion

A number of publications are devoted to the problem of choosing equipment for conducting various types of geodetic GNSS measurements. The right choice of receiver and related equipment allows to achieve the required accuracy and high performance with minimal material costs as well as to provide protection from unexpected problems.

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