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DETERMINATION OF GEODETIC NETWORK COORDINATES FOR AREA OF MINING FACILITIES WITH GNSS TECHNOLOGY MEASUREMENTS

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ABSTRACT

Insufficient availability of geodetic networks with known coordinates around mining facilities has a significant impact on mining facilities, conducting geodetic measurements and geodetic surveys, improving the quality of work and testing measuring instruments.

With this in mind, the information on the determination of geodetic network in the Zarmitan and Muruntau mining is provided by the Leica GS10 GNSS satellite receivers of navigation systems. The influence of the external environment on the accuracy of the planned and height coordinates obtained from the observations and the duration of the navigational measurements have taken into account and the analysis was carried out. Planning and height precision indicators (HDOP, VDOP, PDOP, TDOP) are detailed. The graphs of coordinates change depending on several cycles of GNSS measurements are also given.

It is recommended that you perform repeated GNSS measurements at different points of the year, with long intervals at established checkpoints.

Keywords: DOP, GNSS, coordinates accuracy, geodetic network.

INTRODUCTION

In order to carry out this research, we have a 2-band Leica GS10 GNSS 2-frequency GS-10 satellite receiver designed for the use of high-precision geodetic measurements at the Samarkand Aero Geodesy Corporation under the State Committee of Land Resources, Geodesy, Cartography and Cadastre. Mobile navigators and computer technologies and software (Leica Geo Office, Credo GNSS). GNSS technology enables you to quickly and efficiently identify geodetic reference point's coordinates and set up, update, calculate and equalize geodetic networks.

However, there are no guidelines, instructions or programs for the use of these systems for scientific and methodological and educational purposes. Only in 1998, the State Committee for Land Resources, Geodesy, Cartography and State Cadastre of the Republic of Uzbekistan developed guidance on the use of satellite receivers in the creation and reconstruction of geodetic networks, and in 2014 at the Tashkent Institute of Irrigation and Agricultural Mechanization Engineers. Conducted the first training sessions on using GNSS for teachers.

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In 2017, a manual version of the electronic taximeter application was developed. In addition, no manuals on the use of modern geodetic instruments have developed to address problems encountered in the field of geodesy and cartography. Consequently, the lack of well-known geodetic points around the mining facilities, improving the quality of work performed at field facilities, conducting geodetic measurements and geodetic surveys, field testing and field research activities, and testing of measuring instruments. Have a significant impact on the performance of their work.

Given the above, there should be reference points (geodesic points) in the Zarmitan and Muruntau mining sites. These checkpoints and geodetic points have used to link theodolite or tachometric paths and leveler nets, which are put into geodetic measurements by workers (miners, markers, geodesists).

MATERIALS AND METHODS

In the Zarmitan gold deposit, 3 ground rappers were installed and upgraded from such geodetic base stations. It should be noted that for the GNSS receiver, most of the selected area was mountainous, with no known obstacles (tall buildings and trees) encountered and allowed 100% signal reception from satellites. The effects of external factors were rare in the study, that is, in open areas with no barriers to signal reception. Such land may serve as the foot of the Muruntau mountain range, where the Muruntau gold mine is located, and since 1927 employees of the Navoi Mining and Metallurgy Company (field surveyors and geologists working at the Muruntau gold mine) have been conducting field and field research.

Every year, month and day, Navoi Mining and Metallurgy Company employees conduct field geodetic measurements at the Muruntau gold mine located in the Muruntau range of Tomdi district in Navoi region. The object area is located between Besapan, Murunduyuk villages and Muruntau mountain range (Figure 1).

Figure 1. Muruntau mining area

In accordance with the geodetic work program, taking into account the physical and geographical conditions of the area, all angular and linear measurements should be connected to points of plan and height networks. Absence of appropriate geodetic points or disappearance of such points creates certain difficulties in binding and equipping of theodolite or total station paths and leveler grids near the site of the object, as well as the conditional basis of polygonometry.

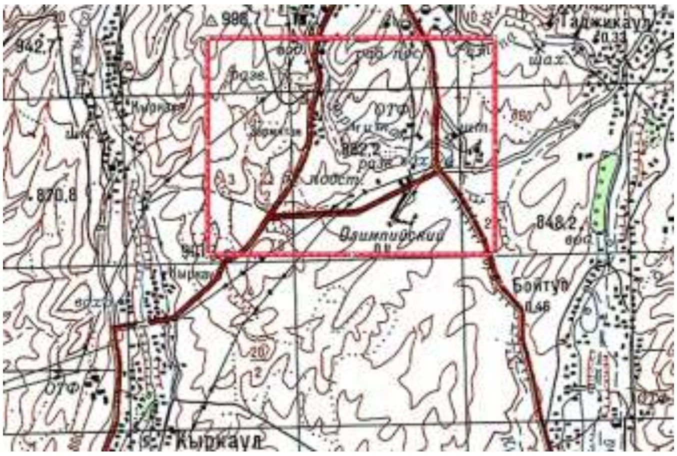


Figure 2. Zarmitan mining area

The mathematical basis of geodetic measurements is still the Gauss-Kruger projection used in topographic - geodetic and geophysical research. All of this work also uses modern GNSS navigation systems based on engineering research WGS84 and UTM. Lack of modern digital maps presents certain difficulties in designing and constructing objects. In order to solve the above problems it is necessary to develop a method of change of coordinates between two systems (SK42, WGS84) and to introduce modern geo-information technologies that meet national economic needs. Much work has been devoted to the change of the classical and modern coordinate system, but this problem remains open and requires the right solution.

Regardless of which coordinate system is used for topographic surveying and navigation, it is necessary to have a starting point with clear rectangular and geodetic coordinates.

Therefore, the purpose of this work is to coordinate geodesic surveying and geodetic and geological survey networks located in the Zarmitan gold mine area (Zarmitan village and Koshrabot mountain range, Kushrabad district of Samarkand region, Figure 2) and near the Muruntau mountain range (Muruntau gold mine) to identify GNSS observations.

Initial coordinates of 3 geodetic networks installed in the Zarmitan area were determined using the Leica GS10 GNSS satellite receiver. Due to the lack of tall buildings and trees in all the three locations, and no open space, there were no direct signals from the satellites that could have a direct impact on the accuracy of the signal (DOP) (Figure 3, Table 1).

The GNSS DOP positioning indices play an important role in describing the geometric position of the satellite relative to the receiver, as well as in finalizing the coordinates of the detected points. In the future, the coordinates of these points will be determined and checkpoints will be established for theodolite, total station and leveler roads.[3]

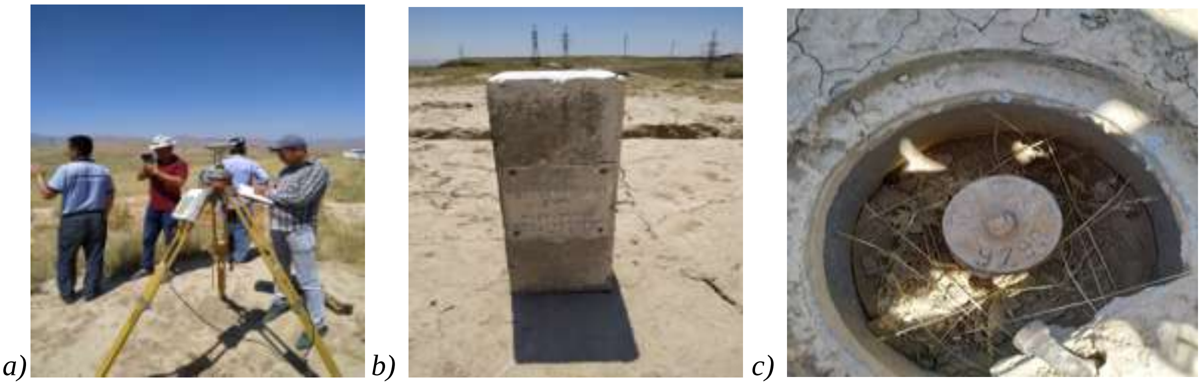

a) b) c)

Figure 3. Second geodetic network in Zarmitan area: a- determination of coordinates geodetic network; b- the sign placed on the geodetic network; s-ground repertoire.

Four geodetic networks were established around the Muruntau carriage. GNSS checkpoint measurements were performed on 10 cycles to check and configure classical geodetic instruments (Figure 4). In the Gauss-Kruger projection, the quadratic coordinates and the mean squared error of the measured values of this point are calculated on the basis of $\chi 2$. The next step is to study the lands and geodesic points near the foot of the Muruntau ridge.[1,3]

Unfortunately, no geodetic networks were found near the landfill and near its geodetic networks, and the area where the geodetic base station was established in the 1980s was left beneath the ore dump.

The choice of this landfill is due to the complexity of the terrain, which can perform triangulation, polygon metric and general station work, as well as satellite geodetic measurements.

Figure 4. Geodetic network in Muruntau Mountain.

Taking into consideration all the requirements of geodetic operations and the terms of the interconnection between the points in the future, it was decided to establish a checkpoint in the center of the landfill and the rest of the landfill.

This point was made by the expedition members (aeronautical personnel) in accordance with the instructions for the use of satellite receivers in the creation and reconstruction of geodetic networks and the installation of points as described in Class I-IV geodetic points guidance. To this checkpoint, concrete was mounted on the ground and 4 cycles of GNSS measurement were performed on the top and middle of this pile (Figure 5).[4,5,6]

In addition, this element is used as a starting point for all geodetic and satellite measurements performed by geodesists.

Figure 5. Measurement of the checkpoint at the landfill using GNSS.

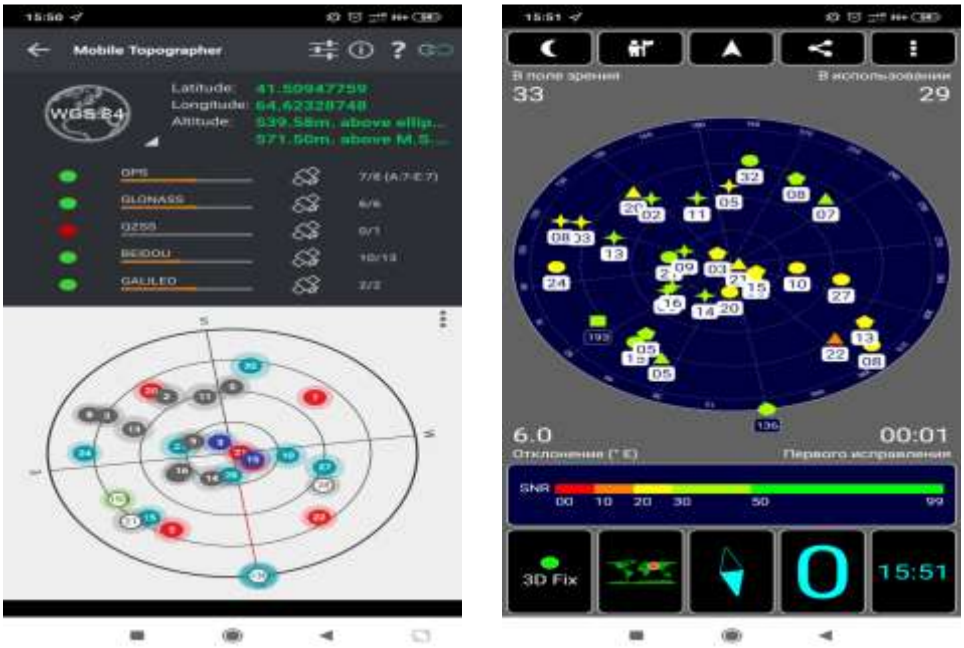
RESULTS

Analysis. In the analysis of the GNSS measurements, the main focus is on the accuracy of external factors to determine the coordinates, as well as the effect of satellite configuration during the session.

As for satellite configuration, it depends on the altitude and azimuth of the satellite trajectory.

Typically, the minimum satellite altitude should be 100-150, then the VDOP is considered to be good (Fig. 6), and, on the other hand, if the satellites are close together, the geometry of the satellites means "weak".[1,2,3]

This is true, and vice versa, if the satellites are much longer than one another, then the geometry of the satellites can be considered "strong" and the DOP value is below average. Characteristics of HDOP, VDOP, PDOP, TDOP are quality indicators of location and time spatial inequality on horizontal, vertical surfaces. These descriptions are functions of a covariance matrix composed of parts of a global and local coordinate system. During the GNSS observation period, the DOP ranged from 0.112 to 0.204. The results of the two measuring cycles significantly deviated from the mean. After detailed analysis of the results of the GNSS measurements, the results of 3 cycles were excluded from processing.[3]



Latitude: 41.50947759
Longitude: 64.62328748
Altitude: 539.58m, above ellip...
571.50m, above M.S...

Figure 6. Satellite location configuration.

The resulting coordinate values may not be finalized, can be used as initial results, and will need to be refined in longer follow-up sessions.

Based on the theory of mathematical processing of geodetic measurements with large-scale measurements carried out under the same conditions, the value of coordinate's accuracy corresponds to a normal Gaussian distribution law.

Since GNSS measurements are conducted with limited time intervals and with some noise, it may be difficult to obtain the possible coordinate value.

Calculation of the accuracy of GNSS measurements plays an important role in the final determination of coordinates.

Statistical analysis of GNSS measurements and the processing of access programs according to the standard program are important factors for generalizing the navigation measurements.

Typically, the measure of accuracy is the average squared error (σx). Many mistakenly think that error and measurement accuracy are the squared error of the arithmetic mean (σ) of the whole array.

This assumption represents the average of the entire array. According to the law of random error normal distribution: the higher the accuracy of the measurements, the errors were combined around the zero value. This law operates as a measure of the accuracy of measurements by a single parameter - a quadratic error.

If GPS is not predominant among the random measures that make up the measurement error, we can assume that these errors correspond to the normal distribution law commonly used to estimate the accuracy of measurements in geodesy. Estimation of the coordinates of the checkpoints (geodetic networks) obtained at the Zarmitan deposit was calculated using the Gaussian formula and all the coordinates were obtained under the same conditions, that is, measured with equal precision. Figure 7 below shows a graph of the change of coordinates over time, including the filtering.

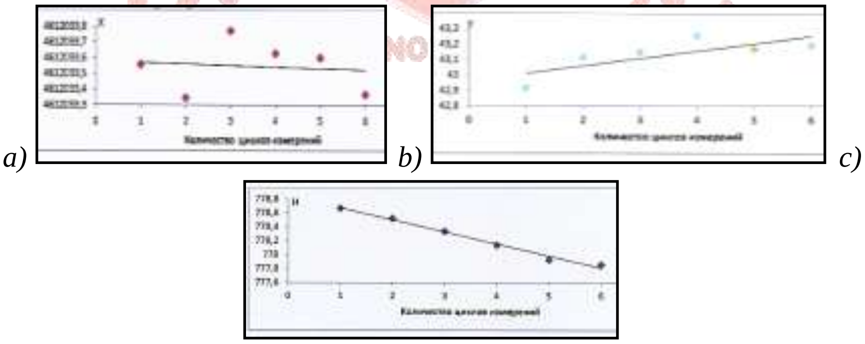
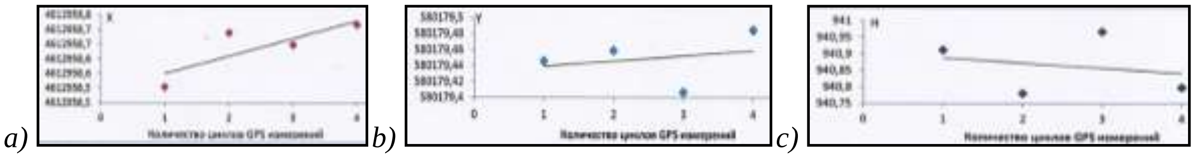


Figure 7. The graph of changes in the coordinates of the network obtained in the Zarmitan deposit: a, b-along the horizontal component; c - is the vertical component.

After the removal of coarse measurements, the accuracy of the network coordinates was significantly increased and the deviation of the mean of each measurement session was proportional to the normal distribution law.

As for determining the coordinates of geodetic networks measured around the Muruntau mining site, there were no barriers to receiving signals from satellites. At the control site, navigation measurements were made with less cycles and shorter intervals. As a result, the accuracy and dispersion of the coordinate were satisfactory without filtering.

Figure 7-8 shows the differences in the values of the geodetic base point coordinates measured in Zarmitan and Muruntau due to detailed filtering and detailed evaluation.



a) b) c)

Figure 8. Graph of changes in coordinates of polygon network: a, b - along the horizontal component, c - vertical component height

As a result of processing the GNSS array of checkpoint measurements, the mean values of the rectangular coordinates, the altitudes, and their errors are summarized in Table 1.

Table 1. WGS84 coordinates (φ, λ), geodetic height (H) and mid-square errors

Name of the item	*WGS84 coordinates*		
	φ	*λ*	*H*
Kanavniy	41°30'18.34773"N	64°32'16.85551"E	561.1424
Solnichni	41°30'34.03740"N	64°37'23.75033"E	550.1194
Murin zap	41°31'58.21513"N	64°33'19.97628"E	779.8565
AERO	41°28'51.27307"N	64°37'33.78397"E	430.3816

Reference point	*Rover*	*Attachments*			*Standard errors*		
		Δx	*Δy*	*Δz*	*x*	*y*	*z*
Murin zap	solnichni	-4440.8487	3825.3577	-2096.8802	0.0002	0.0003	0.0002
kanavniy	solnichni	-6569.9310	2758.0166	355.2122	0.0002	0.0003	0.0003
solnichni	1AERO	651.5280	1916.7526	-2454.1663	0.0002	0.0002	0.0002
Murin zap	AERO	-3789.3215	5742.1106	-4551.0465	0.0002	0.0003	0.0003
kanavniy	AERO	-5918.4028	4674.7702	-2098.9540	0.0002	0.0004	0.0003
kanavniy	Murin zap	-2129.0818	-1067.3403	2452.0923	0.0001	0.0002	0.0002

Reference point	*Rover*	*Medium quadratic error*			*Vectors*	*Vectors error*
		x, y	*z*	*x, y, z*		

Murin zap	solnichni	0.0002	0.0003	0.0004	6225.062	0.0001
kanavniy	solnichni	0.0002	0.0004	0.0005	7134.201	0.0001
solnichni	1AERO	0.0002	0.0003	0.0004	3181.408	0.0001
Murin zap	AERO	0.0002	0.0004	0.0005	8248.806	0.0002
kanavniy	AERO	0.0003	0.0004	0.0005	7828.574	0.0002
kanavniy	Murin zap	0.0001	0.0002	0.0003	3418.327	0.0001

CONCLUSION

Based on the geodetic measurements performed, the locations of the geodetic networks selected during the inspection and their coordinates were determined using the GNSS receiver.

A graphical and analytical analysis of changes in the coordinates of the points, depending on the duration of the observation cycle and the impact of buildings and structures on the accuracy of measurements were performed. The geodetic heights were obtained with respect to the coordinate system WGS84 and the Krasovsky ellipsoid.

It can be used to determine the coordinates and heights of the WGS84 geodetic networks, the coordinates of the checkpoints and the intermediate networks of the total station path and the junction net, as well as the subsequent geodetic networks. They can be used as basic information for conducting surveying-geodetic and geological surveys, geo informatics and geodetic research.

In the future, it is planned to install geodetic signs, signals and pyramids around the established points for optimization of geodetic points, longitudinal and transverse movement and identification of centrifugal corrections.

Repeat GNSS measurements should be performed to clarify coordinates and to determine the rate of deformation of coordinates of these points over time.

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