ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ
АКАДЕМИЯСЫ» РҚБ

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»

N E W S

OF THE NATIONAL ACADEMY
OF SCIENCES OF THE REPUBLIC
OF KAZAKHSTAN

SERIES

OF GEOLOGY AND TECHNICAL SCIENCES

2 (470)

MARCH – APRIL 2025

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

«ҚР ҰҒА» РҚБ Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).
Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.
Тақырыптық бағыты: *Геология, гидрогеология, география, тау-кен ісі, мұнай, газ және металдардың химиялық технологиялары*
Мерзімділігі: жылына 6 рет.
http://www.geolog-technical.kz/index.php/en/

«Известия РОО «НАН РК». Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).
Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.
Тематическая направленность: *геология, гидрогеология, география, горное дело и химические технологии нефти, газа и металлов*
Периодичность: 6 раз в год.
http://www.geolog-technical.kz/index.php/en/

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *geology, hydrogeology, geography, mining and chemical technologies of oil, gas and metals*
Periodicity: 6 times a year.
http://www.geolog-technical.kz/index.php/en/

NEWS of the National Academy of Sciences of the Republic of Kazakhstan
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224–5278
Volume 2. Number 470 (2025), 152–165

https://doi.org/10.32014/2025.2518-170X.497

UDC 528.236:528.48

O. Kurmanbayev*[1], A. Koishygarin[1], G. Jangulova[1], G. Madimarova[2], Z. Sarsembekova[1], 2025.
[1]Al-Farabi Kazakh National University, Almaty, Republic of Kazakhstan;
[2]Kazakh National Technical University named after K.I. Satpayev, Almaty, Kazakhstan.
E-mail: olzhas_ak@list.ru

CONCEPT OF STATIC MEASUREMENT PROCESSING AT THE FABRICHNY BASE STATION

O. Kurmanbayev – PhD, Associate Professor of Al-Farabi Kazakh National University, Almaty, Kazakhstan, E-mail: olzhas_ak@list.ru, ORCID: ID 0000-0002-4867-6910;
A. Koishygarin – PhD student, Senior lecturer of Al- Farabi Kazakh National University, Almaty, aibek19891117@gmail.com, https://orcid.org/0009-0009-3437-8865;
G. Jangulova – Candidate of Technical Sciences, Professor Al Farabi Kazakh National University, Almaty, Kazakhstan, E-mail: gulnarzan@gmail.com, https://orcid.org/ 0000-0002-7866-1031;
G. Madimarova – Candidate of Technical Sciences, Professor, Kazakh National Research Technical University named after K.I. Satpayev, Almaty, Kazakhstan, E-mail: madimarovagulmira69@gmail.com, https://orcid.org/0000-0002-9155-633;
Z. Sarsembekova – PhD student, Senior lecturer of Al Farabi Kazakh National University, Almaty, Kazakhstan, E-mail: sarsemberova zeynep @gmail.com. https://orcid.org/0000-0002-8083-9513.

Abstract. Article provides detailed information and results regarding a modern, high-precision, and stable communication system designed for signal processing at the Fabrichny base station. One of the key challenges in the design and operation of base stations is the processing of static measurements - a critical process that ensures communication quality, signal stability, and reliability of data transmission. Article highlights the primary methods for processing static measurements, using the Fabrichny base station as an example, and explains their significance in maintaining the seamless operation of communication networks.

Results. Methodology of the automated control system has been enhanced to enable real-time monitoring of station operations, data collection on signal quality, and automated analysis. The findings from this study were applied in the project «Development of innovative methods for forecasting and assessing the condition of engineering structures to prevent technogenic emergencies» and were also integrated into the educational process.

Scientific novelty. As a result of conducted research, the following were developed and implemented in production:

- method for determining point coordinates with high accuracy;
- a large number of satellite observations, allowing residual measurement errors to be calculated with sufficient accuracy;
- evaluation process for the quality of initial points and the identification and elimination of gross measurement errors.

The novelty of coordinate determination method is validated by Certificates of the Republic of Kazakhstan for a work of science.

Practical value. The obtained results can be applied to the processing of static measurements to enhance the efficiency of base stations and optimize the development of network infrastructure. Precise and timely measurements play a crucial role in preventing potential equipment failures, maintaining high communication quality, and ensuring a stable connection for users.

Key words: static measurements, base station, data processing, coordinate systems, measurement alignment methods.

Acknowledgment, funding: work was carried out according to GF AP23489372 on the topic: "Study of the geotechnical state of a rock massif and development of a methodology for geomechanical complex monitoring for forecasting deformation processes during subsoil development."

©О. Құрманбаев*[1], А. Койшыгарин[1], Г. Джангулова[1], Г. Мадимарова, З. Сарсембекова[1], 2025.

[1]Әл-Фараби атындағы Қазақ Ұлттық университеті, Алматы, Қазақстан;
[2]Қ.И. Сәтбаев атындағы Қазақ ұлттық техникалық зерттеу университеті, Алматы, Қазақстан.
E-mail: olzhas_ak@list.ru

ФАБРИЧНЫЙ БАЗАЛЫҚ СТАНЦИЯСЫНДА СТАТИКА ӘДІСІМЕН ОРЫНДАЛҒАН ӨЛШЕМДЕРДІ ӨҢДЕУ КОНЦЕПЦИЯСЫ

О. Құрманбаев – PhD, әл-Фараби атындағы Казақ ұлттық университетінің қауымдастырылған профессоры, Алматы, Қазақстан, olzhas_ak@list.ru, ORCID: ID 0000-0002-4867-6910;
А. Койшыгарин – PhD докторанты, әл-Фараби атындағы Казақ ұлттық университеті, Алматы, Қазақстан, aibek19891117@gmail.com, https://orcid.org/0009-0009-3437-8865;
Г. Джангулова – техника ғылымдарының кандидаты, әл-Фараби атындағы Казақ ұлттық университетінің қауымдастырылған профессоры, Алматы, Қазақстан, E-mail: gulnarzan@gmail.com, https://orcid.org/ 0000-0002-7866-1031;
Г. Мадимарова – техника ғылымдарының кандидаты, Қ.И. Сәтбаев атындағы Қазақ ұлттық техникалық зерттеу университетінің профессоры, Алматы, Қазақстан, E-mail: madimarovagulmira69@gmail.com, https://orcid.org/0000-0002-9155-6332;
З. Сарсембекова – PhD докторанты, әл-Фараби атындағы Казақ ұлттық университетінің аға оқытушысы, Алматы, Қазақстан, E-mail: sarsemberova zeynep @gmail.com, https://orcid.org/0000-0002-8083-9513.

Аннотация. Мақалада Фабричный базалық станциясында сигналдарды өңдеуге арналған жоғары дәлдік пен тұрақтылық жүйесі туралы мәліметтер мен нәтижелер келтірілген. Базалық станцияларды жобалау мен пайдалану кезінде басты міндеттердің бірі статикалық өлшеулерді өңдеу болып табылады, бұл байланыс сапасын, сигналдың тұрақтылығын және деректердің сенімді берілуін қамтамасыз ететін маңызды процесс. Базалық станция мысалында статикалық өлшеулерді өңдеудің негізгі әдістері келтіріліп, олардың байланыс желілерінің үздіксіз жұмысын қамтамасыз етудегі маңызы түсіндіріледі.

Нәтижелері. Автоматтандырылған басқару жүйесінің әдістемесі, станцияның жұмысын нақты уақытта мониторингтеу, сигнал сапасы туралы деректерді жинау және автоматты талдау жүргізу үшін жетілдірілген. Зерттеудің нәтижелері «Техногендік сипаттағы төтенше жағдайлардың алдын алу үшін инженерлік құрылыстардың жай-күйін болжау мен бағалаудың инновациялық әдістерін әзірлеу» жобасын орындау кезінде енгізілді, сондай-ақ оқу процесінде пайдаланылды.

Ғылыми жаңалығы. Жүргізілген ғылыми зерттеу жұмыстарының нәтижесінде:

-жоғары дәлдікпен нүктелердің координаттарын анықтау әдісі жасалды;

-өлшеулердің жеткілікті дәлдікпен қалдық қателіктерін есептеуге мүмкіндік беретін көп мөлшерде жүргізілген ғарыштық бақылаулардың нәтижелері талқыланды;

-бастапқы нүктелердің сапасы бағаланып, өлшеулердегі қателіктер жойылатын әдіс анықталды.

Әзірленген тірек торабы мен пункт конструкциясының жаңалығы ғылым туындысына ҚР куәлігімен расталды.

Практикалық құндылық. Алынған нәтижелер статикалық өлшеулерді өңдеуде қолданылып, базалық станциялардың жұмыс тиімділігін арттыруға және желілік инфрақұрылымның дамуын оңтайландыруға мүмкіндік береді. Дәл және уақытылы өлшеулер жабдықтардың мүмкін болатын қателіктерін болдырмауға, байланыс сапасын жоғары деңгейде ұстауға және пайдаланушыларға Ғаламдық радионавигациялық ғарыштық жүйенің тұрақты басқару блогімен қосылуын қамтамасыз етуге мүмкіндік береді.

Түйін сөздер: статикалық өлшемдер, базалық станция, деректерді өңдеу, координаттық жүйелер, өлшемдерді жинақтау әдістері.

©О. Курманбаев*[1], А. Койшыгарин[1], Г. Джангулова[1], Г. Мадимарова[2], З. Сарсембекова[1], 2025.

[1]Казахский национальный университет им. аль-Фараби, Алматы, Казахстан;
[2]Казахский национальный исследовательский технический университет имени К.И. Сатпаева, Алматы, Казахстан.
E-mail: marzhsn-nurpeisova@rambler.ru

КОНЦЕПЦИЯ ОБРАБОТКИ ИЗМЕРЕНИЙ СТАТИЧЕСКИМ МЕТОДОМ НА БАЗОВОЙ СТАНЦИИ ФАБРИЧНЫЙ

О. Курманбаев – PhD, ассоциированный профессор Казахского национального университета им. аль-Фараби, Алматы, Казахстан, E-mail: olzhas_ak@list.ru, ORCID: ID 0000-0002-4867-6910;

А. Койшыгарин – PhD докторант, старший преподаватель Казахского национального университета им. аль-Фараби, Алматы, Казахстан, E-mail: aibek19891117@gmail.com, https://orcid.org/0009-0009-3437-8865;

Г. Джангулова – Кандидат технических наук, ассоциированный профессор Казахского национального университета им. аль-Фараби, Алматы, Казахстан, E-mail: gulnarzan@gmail.com, https://orcid.org/ 0000-0002-7866-1031;

Г.С. Мадимарова – кандидат технических наук, профессор Казахского национального исследовательского технического университета имени К.И. Сатпаева, Алматы, Казахстан, E-mail: madimarovagulmira69@gmail.com, https://orcid.org/0000-0002-9155-6332;

З. Сарсембекова – PhD докторант, старший преподаватель Казахского национального университета им. аль-Фараби, Алматы, Казахстан, E-mail: sarsemberova zeynep@gmail.com, https://orcid.org/0000-0002-8083-9513.

Аннотация. В статье приведены сведения и результаты современной системы связи высокой точности и стабильности для обработки сигналов на базовой станции Фабричный. Одной из основных задач при проектировании и эксплуатации базовых станций является обработка статических измерений, это важный процесс, обеспечивающий качество связи, стабильность сигнала и надежность передачи данных. Приведены основные методы обработки статических измерений на примере базовой станции и объясним их значение в обеспечении бесперебойной работы сетей связи.

Результаты. Усовершенствована методика автоматизированной системы управления, для осуществления мониторинга работы станции в режиме реального времени, сбора данных о качестве сигнала и проведения автоматического анализа. Результаты исследовании внедрены при выполнении проекта «Разработка инновационных методов прогнозирования и оценки состояния инженерных сооружений для предупреждения чрезвычайных ситуаций техногенного характера». а также использованы в учебном процессе.

Научная новизна. В результате проведенных научно-исследовательских работ созданы и внедрены в производство:

- метод определения координат точек с высокой точностью;
- большое количество спутниковых наблюдений, позволяющие с достаточной точностью вычислять остаточные погрешности измерений;

- оценены качество исходных точек и исключающие грубые погрешности измерений.

Новизна метода определения координат подтверждена Свидетельствам РК на произведение науки.

Практическая ценность. Полученные результаты могут быть использованы при обработке статических измерений позволяющие повысить эффективность работы базовых станций и оптимизировать развитие сетевой инфраструктуры. Точные и своевременные измерения позволяют предотвратить возможные сбои оборудования, поддерживать высокий уровень качества связи и обеспечивать пользователей стабильным соединением с центром управления глобальной радионавигационной системы.

Ключевые слова: статические измерения, базовая станция, обработка данных, системы координат, методы выравнивания измерений.

Introduction. Satellite data collection plays a crucial role in modern science and technology. Data obtained from satellites is extensively applied in fields such as geodesy, cartography, climate research, and space exploration. Satellite systems like GNSS (Global Navigation Satellite System) enable highly accurate determination of object coordinates.

Modern communication systems demand exceptional accuracy and stability in signal processing. One of the primary challenges in the design and operation of base stations is the processing of static measurements. This process is vital for ensuring communication quality, signal stability, and the reliability of data transmission.

This article explores the key methods for processing static measurements, using a base station as an example, and highlights their significance in maintaining the smooth operation of communication networks (Mikhailov, 2011; Khabarova, et al., 2018; Sizov, et al., 2018).

Static data refer to information collected when an object remains stationary over extended period. Such data are typically gathered at local geodetic stations or research points and are crucial for studying phenomena like crustal movements, tectonic shifts, and climate change. Static measurements involve coordinates that remain constant over time, enabling precise tracking of data variations and facilitating long-term observations (Smirnov, 2005).

Static measurements refer to data collected under conditions where system or equipment parameters remain unchanged over time (Kashkin, et al., 2001;). In the context of a base station, these parameters may include:

Signal strength level.

Interference and noise metrics.

Antenna coordinates and orientation.

Temperature and climatic conditions affecting equipment performance.

This data is gathered in a static mode, where the object (base station) remains unaffected by significant external environmental changes or movements. 5

Object of the study is Kargaly (known as Fabrichny until 2007), a village in

the Zhambyl district of the Almaty region, Republic of Kazakhstan. It serves as the administrative center of the Kargaly rural district and is the only settlement within its boundaries. The village is located approximately 11 km southeast of Uzyn-Agach village, 50 km west of Almaty, at the foothills of the Ile-Alatau range (see Figure 1).

Geological structure. Geological and lithological structure of the site includes alluvial-proluvial deposits of the Middle Quaternary age (QII), represented from the surface by soil and vegetation layer, subsidence loam, non-subsidence loam and 2 (two) engineering-geological elements (EGE) have been identified.

EGE-1 - Subsidence loam, light brown in color, hard consistency, loess-like, macroporous, with veins and salt spots, vertical fracturing is observed, exposed thickness 17, 40 m.

EGE-1 - Non-subsidence loam, light brown in color, with a consistency ranging from hard to soft-plastic. It is loess-like in nature and has an exposed thickness of 4, 50 m.

Fig. 1. Base station «Fabrichny»: installation area boundary of base station is highlighted in red.

Engineering and seismic conditions. According to SP RK 2.03-30-2017 «Construction in seismic zones of the Republic of Kazakhstan» and based on the General Seismic Zoning -2_{475} map, the initial seismicity of the area is assessed at 9 points. Engineering and geological surveys indicate that the site is covered by clayey soils with a porosity coefficient exceeding 0,9, classifying the soil category as III (third) in terms of seismic properties (Nurpeisova, et al., 2019; Madimarova, et al.2020).

Consequently, the updated seismicity for the work site is determined to be 10 points. The estimated horizontal acceleration (αg) is 0.563g, and the estimated vertical acceleration (αg) is 0.499g.

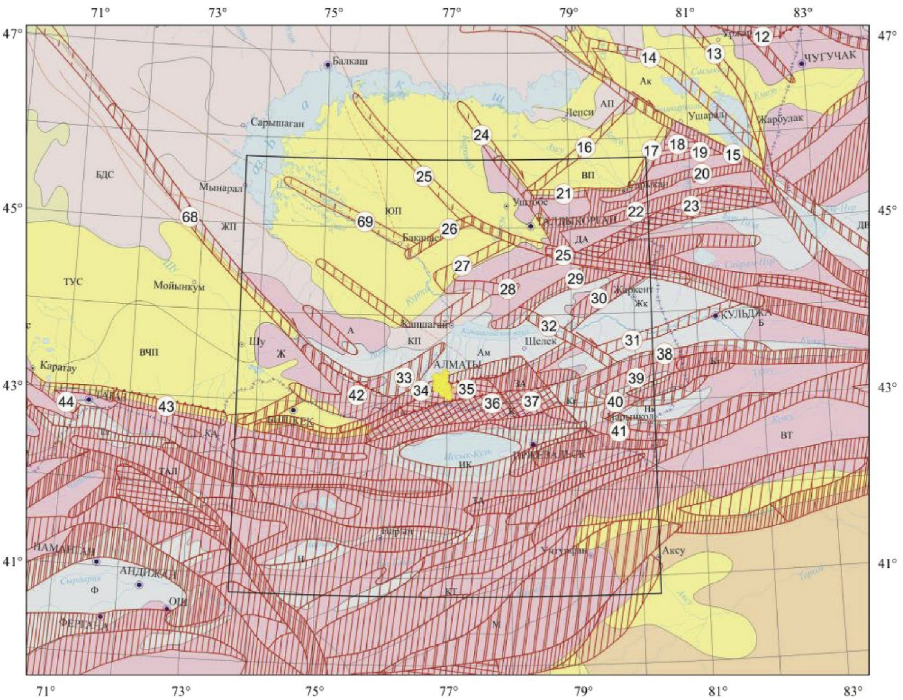


Fig. 2. - Seismogenerating (seismotectonic model) zones of the Almaty region

Relief and soils. The central and southern parts of the territory are high-mountainous, with absolute altitude of up to 4760 m (3636) in the Zailiyskiy Alatau and Kyushgey-Ala-Too ridges and their spurs. The ridge crests are narrow, rocky, and characterized by pointed peaks. At altitudes of 3800 m and above, the ridges are typically covered with perennial snow and glaciers. Ridge slopes are steep (35–40°), rocky in places, and dissected by gorges and narrow valleys. The spurs feature dome-shaped tops and gentler slopes.

The northern part of the territory consists of a foothill hilly plain, heavily incised by deep sais (dry channels) and rivers, which complicate off-road vehicle

movement. The soils in the central and southern regions are rocky and stony, while the northern soils are predominantly sandy loam.

Groundwater in the region is generally fresh. In the northern part and hollows, it is found at depths of around 7 m, often surfacing as springs. However, in areas near saline marshes, the groundwater is saline or bitter-salty and located at depths of up to 25 m.

The area lies in a seismically active zone, where earthquakes with a strength of 8-9 points have been recorded. The soil composition includes clay, loam, saline soils, sand, and sandy loam.

The region experiences a moderate continental climate, characterized by dry conditions on the plains and increased humidity in the foothills and mountainous areas. Winter (December-February on the plain, November-March in the mountains) is cold, mostly with cloudy weather. The prevailing daytime air temperature on the plain is 0, -3°C, nighttime -5, -18°C (minimum -35°C), thaws over 16°C are frequent, in the mountains respectively -7, -15°C and -39, -37°C (minimum -48°C), thaws are rare.

Hydrography. The Chon-Kemin River has a predominant width of 20-40 m, with depths ranging from 0,8 to 1,5 meters, and exhibits a flow rate between 1,8 and 3,0 meters per second. The riverbed is rocky, featuring small low outcrops, while its banks are steep and occasionally precipitous.

The Kaskelen River measures up to 12 meters in width and approximately 0,5 meters in depth. In its mountainous sections, the flow rate reaches about 1,5 meters per second, decreasing to 0,8-0,9 meters per second on the plains.

Steel rivers in the area are relatively small, with widths up to 10 meters and depths up to 0.5 meters. Many of these rivers are regulated by earthen or, less frequently, concrete dams, resulting in the formation of small reservoirs upstream.

The Big Almaty Canal is 10-16 m wide, 3-4 m deep, and has concrete slopes. The remaining canals (aryks) are small.

Regime. Rivers and canals freeze in December, there is usually no continuous ice cover on them, they break up in early March. Flood on the rivers is from April to July, low water sets in in August.

Road network. The main Almaty-Bishkek highway has two asphalt concrete carriageways, 8 m wide each, for the first 50 km. Highways with improved asphalt pavement have a carriageway width of 7-9 m, and a roadbed of 9-16 m. The remaining unpaved highways have a profiled roadbed 5-8 m wide, most often without reinforcing additives; in wet weather, along with dirt roads, they become very soggy and difficult to pass for vehicles. Bridges on the roads are reinforced concrete, some are metal and wooden, the load-bearing capacity of bridges on paved highways is from 30-40 to 100 tons, on other roads - up to 25 tons. Overcoming the Zailiyskiye Alatau and Kyungey-Ala-Too ridges is possible by pack transport along trails from June to September. The rest of the time, the passes are covered with snow. Movement of pack vehicles outside of trails is only possible along river valleys in dry weather.

Methodology. The work uses a comprehensive approach, including: measurements at the base station equipped with built-in sensors that record the signal level, temperature, humidity and other parameters, monitoring at a certain frequency for further analysis, data collection using remote devices for more accurate measurements at the base station using spectrum analyzers and directional antennas.

Main content. In high-accuracy satellite data processing, two software packages with distinct properties and applications stand out: BERNESE and SGO. Both are primary tools for processing GNSS (Global Navigation Satellite System) data, and numerous significant scientific studies have utilized these programs in various research applications.

Bernese GNSS Software is a scientific, high-precision package designed for processing data from multi-satellite Global Navigation Satellite Systems. Developed at the Astronomical Institute of the University of Bern (AIUB) since the 1980s, it has long been a cornerstone in geodetic research and operational applications. Widely adopted in European and international networks—such as EUREF and IGS—it efficiently handles a variety of satellite signals (including GPS, GLONASS, and Galileo). One of its key strengths is its capacity to support and drive research into new processing methods and the precise evaluation of GNSS orbits, ensuring that it continuously evolves to meet the demands of modern satellite geodesy.

SGO (South Geomatics Office) is software package designed for a wide range of geodetic, cartographic, and geoinformation services. It supports land exploration, data collection and processing, map creation and updating, and geodetic monitoring. For over two decades, SGO has integrated the Bernese GNSS Software into its research, contributing significantly to scientific studies in satellite data processing. In particular, SGO specializes in accurately determining geodetic coordinates, calculating station velocities, and estimating atmospheric parameters (Author's, 2024; Nurpeisova, et al., 2024).

Once the GNSS receiver is connected, the dedicated equipment for collecting static measurements in RINEX format is activated. The necessary static observations are then acquired for further processing. Initially, these static measurements are recorded on the server, and subsequent daily measurement sessions are conducted. The collected RINEX data is later processed to generate updated geodetic solutions.

Various methods and equipment are used to collect static measurements:

Measuring instruments at the base station. Modern stations are equipped with built-in sensors that record signal level, temperature, humidity and other parameters. This data is collected at a certain frequency and recorded for further analysis.

Data collection using remote devices. For more accurate measurements, external devices such as spectrum analyzers and directional antennas are used at the base station. These devices help evaluate the signal propagation and its quality in different parts of the coverage area (Kim, et al. 2019; Alessandro, et al. 2021).

Automated monitoring systems. Such systems allow real-time monitoring of the station's operation, collecting data on signal quality and conducting automatic analysis.

To receive signals from GNSS satellites with a Choke Ring type device, the South CR3-G3 (3rd generation) uhg GNSS antenna was used. It is designed for use with a permanently operating GNSS base station (CORS).

- South CR-3 UHG provides stable phase center shift with an accuracy of less than 1 mm.
- The antenna design with a 2D Choke Ring helps to achieve high performance of multipath signal suppression.
- High gain antenna for low orbit satellites.
- Possibility of connecting a cable longer than 100 m without signal loss.
- Fully sealed main components, protection from dust and moisture. The antenna is designed for continuous operation in adverse environmental conditions.

All numerical values are obtained through the South CR-G3 antenna (shown in Figure 3).

Fig. 3. - South CR-3

Daily static data from stations BUCU, DRAG, GLSV, KIT3, POL2, TASH, and ZECK were processed relative to the world base station. Geographic coordinates were then determined in the ITRF2014 reference frame (which corresponds to the WGS84/GRS80 ellipsoid) at the Fabrichny base station. The processed results are summarized in Table 1.

Table 1 - Data processing indicators

Station	Latitude GMS	Longitude GMS	Height (m)	Geoid height (m) EGM2008
FABR	$43^0 10'$ 46.54600	$76^0 23'$ 40.26002	909.637	952.855

GNSS receivers first analyze the satellite signals received during measurements and then process these data with specialized software. For instance, BERNESE GPS Software (version 5.2) and the South Geomatics Office (SGO) tool- advanced geographic information system for spatial data-are used to correct coordinates and reduce measurement errors. The processed coordinate results are provided in several formats: Table 2 lists rectangular coordinates based on the UTM43 projection (derived from the GRS80 ellipsoid and aligned with the ITRF2014 reference frame); Table 3 presents Cartesian coordinates; Table 4 shows geographic coordinates; and Table 5 offers another set of rectangular coordinates.

Table 2 -The Universal Transverse Mercator

Station	Y(m)	X(m)	Zone	Ellipsoid height (m)	Geoid height (m) EGM2008
FABR	613333.875	4781702.827	43	909.637	952.855

Table 3- Cartesian coordinates, obtained results of ITRF2014.

Station	X (m)	Y (m)	Z (m)	Geoid height (m) ITRF2014
FABR	1095957.288	4528248.272	4342694.931	28/09/2024

Table 4- Geographic coordinates

Station	Latitude GMS	Longitude GMS	Height (m)	Geoid height (m) EGM2008
FABR	$43^0 10' 46.54998$	$76^0 23' 40.25009$	909.431	952.325

Table 5- Rectangular coordinates

Station	Y(м)	X(м)	Zone	Ellipsoid height (м)	Geoid height (m) EGM 2008
FABR	613333.452	4781702.015	43	912.996	956. 325

Summarizing the GNSS processing results at the factory base station, the determined coordinates and spatial position exhibit high accuracy. This level of precision not only guarantees efficient station operation but also provides a robust foundation for advancing the telecommunications network (Kenzhekhan, et al., 2022; Nurpeisova, et al., 2025).

Discussion. During processing, raw static-mode GNSS data is collected and then processed using specialized software - such as BERNESE or SGO. At this stage, the processing algorithms account for satellite clock errors, atmospheric effects, and orbital deviations, thereby refining the final position estimates for enhanced accuracy.

This section presents the study's results and a comparative analysis between the two processing programs, BERNESE and SGO. Data processed by each software are summarized in Tables 6 and 7. Comparison evaluates the key performance criteria including accuracy, reliability, and processing speed - to assess the overall performance of the two programs (Dosanov, 2019).

Table 6 - Relative error indicators

Criteria	BERNESE (Accuracy)	SGO (Accuracy)
Mean square error (MSE), m	0,4	0,6
Absolute errors (m)	0,3	0,5
Relative errors (%)	0,2	0,4

Table 7- Program reliability coefficients

Programs	Reliability coefficient (%)
BERNESE	96
SGO	91

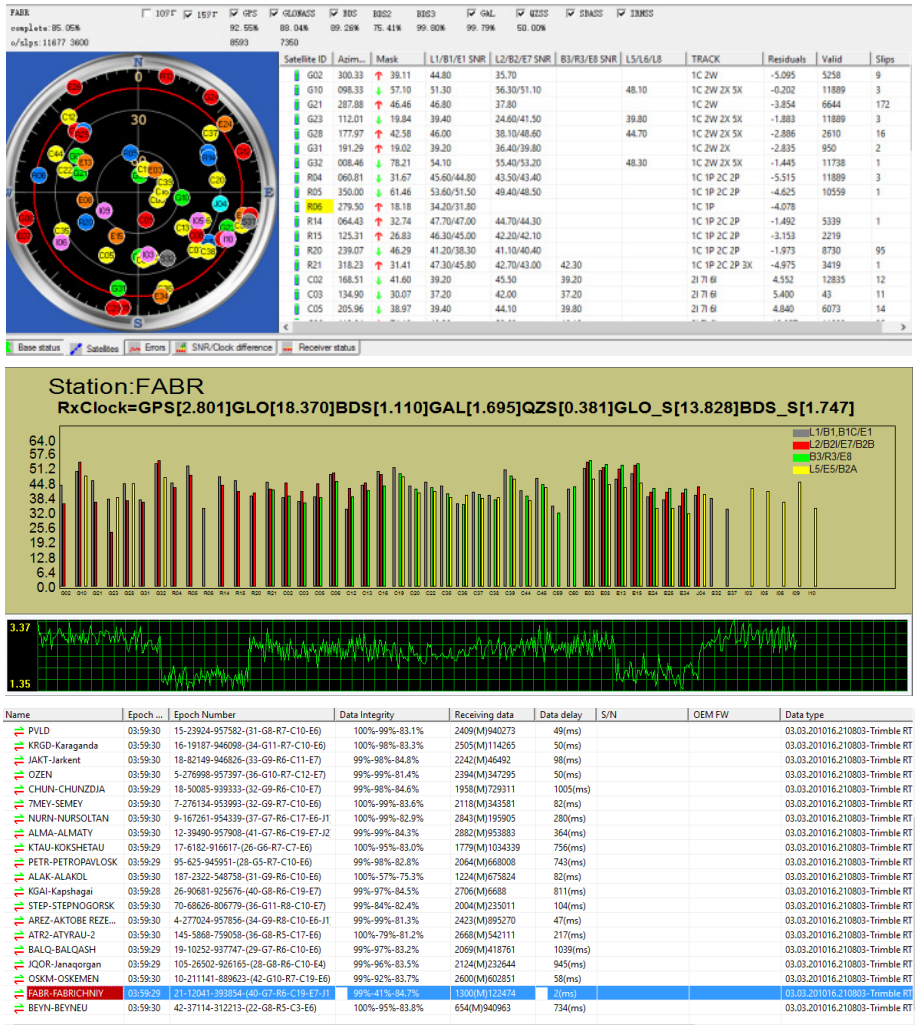
Data processing speed of the two programs is shown below:

- BERNESE: 18 minutes (in average).

- SGO: 35 minutes (in average).

After receiving new geographic coordinates, they are entered into the server via the web interface of the net S9 receiver, as well as into the nrseaglserver and nrsstation programs, where the processed coordinates are named FABR_MSM4.

GNSS (Global Navigation Satellite System) is a global navigation system that allows you to determine the coordinates of a point in space with high accuracy using satellites. GPS, GLONASS (Figure 4) and other systems are part of GNSS and are the main tools for taking accurate measurements.



Name	Epoch ...	Epoch Number	Data Integrity	Receiving data	Data delay	S/N	OEM FW	Data type
PVLD	03:59:30	15-23924-957582-(31-G8-R7-C10-E6)	100%-99%-83.1%	2409(M)940273	49(ms)			03.03.201016.210803-Trimble RT
KRGD-Karaganda	03:59:30	16-19187-946098-(34-G11-R7-C10-E6)	100%-98%-83.3%	2505(M)114265	50(ms)			03.03.201016.210803-Trimble RT
JAKT-Jarkent	03:59:30	18-82149-946826-(33-G9-R6-C11-E7)	99%-98%-84.8%	2242(M)46492	98(ms)			03.03.201016.210803-Trimble RT
OZEN	03:59:30	5-276998-957397-(36-G10-R7-C12-E7)	99%-99%-81.4%	2394(M)347295	50(ms)			03.03.201016.210803-Trimble RT
CHUN-CHUNZDJA	03:59:29	18-50085-939333-(32-G9-R6-C10-E7)	99%-98%-84.6%	1958(M)729311	1005(ms)			03.03.201016.210803-Trimble RT
7MEY-SEMEY	03:59:30	7-276134-953993-(32-G9-R7-C10-E6)	100%-99%-83.6%	2118(M)343581	82(ms)			03.03.201016.210803-Trimble RT
NURN-NURSOLTAN	03:59:30	9-167261-954339-(37-G7-R6-C17-E6-J1	100%-99%-82.9%	2843(M)195905	280(ms)			03.03.201016.210803-Trimble RT
ALMA-ALMATY	03:59:30	12-39490-957908-(41-G7-R6-C19-E7-J2	99%-99%-84.3%	2882(M)953883	364(ms)			03.03.201016.210803-Trimble RT
KTAU-KOKSHETAU	03:59:29	17-6182-916617-(26-G6-R7-C7-E6)	100%-95%-83.0%	1779(M)1034339	756(ms)			03.03.201016.210803-Trimble RT
PETR-PETROPAVLOSK	03:59:29	95-625-945951-(28-G5-R7-C10-E6)	99%-98%-82.8%	2064(M)668008	743(ms)			03.03.201016.210803-Trimble RT
ALAK-ALAKOL	03:59:30	187-2322-548758-(31-G9-R6-C10-E6)	100%-57%-75.3%	1224(M)675824	82(ms)			03.03.201016.210803-Trimble RT
KGAI-Kapshagai	03:59:28	26-90681-925676-(40-G8-R6-C19-E7)	99%-97%-84.5%	2706(M)6688	811(ms)			03.03.201016.210803-Trimble RT
STEP-STEPNOGORSK	03:59:30	70-68626-806779-(36-G11-R8-C10-E7)	99%-84%-82.4%	2004(M)235011	104(ms)			03.03.201016.210803-Trimble RT
AREZ-AKTOBE REZE...	03:59:30	4-277024-957856-(34-G9-R8-C10-E6-J1	99%-99%-81.3%	2423(M)895270	47(ms)			03.03.201016.210803-Trimble RT
ATR2-ATYRAU-2	03:59:30	145-5868-759058-(36-G8-R5-C17-E6)	100%-79%-81.2%	2668(M)542111	217(ms)			03.03.201016.210803-Trimble RT
BALQ-BALQASH	03:59:29	19-10252-937747-(29-G7-R6-C10-E6)	99%-97%-83.2%	2069(M)418761	1039(ms)			03.03.201016.210803-Trimble RT
JQOR-Janaqorgan	03:59:29	105-26502-926165-(28-G8-R6-C10-E4)	99%-96%-83.5%	2124(M)232644	945(ms)			03.03.201016.210803-Trimble RT
OSKM-OSKEMEN	03:59:30	10-211141-889623-(42-G10-R7-C19-E6)	99%-92%-83.7%	2600(M)602851	58(ms)			03.03.201016.210803-Trimble RT
FABR-FABRICHNIY	03:59:29	21-12041-393854-(40-G7-R6-C19-E7-J1	99%-41%-84.7%	1300(M)122474	2(ms)			03.03.201016.210803-Trimble RT
BEYN-BEYNEU	03:59:30	42-37114-312213-(22-G8-R5-C3-E6)	100%-95%-83.8%	654(M)940963	734(ms)			03.03.201016.210803-Trimble RT

Fig. 4- Data Values FABR_MSM4

Conclusions: Processing static measurements is critical for ensuring the reliability and stability of base stations. Leveraging GNSS technologies in this process enhances base station efficiency and supports the development of robust

network infrastructure. Accurate and timely measurements help prevent equipment failures, maintain high communication quality, and provide users with stable connections. With increasing network load, automated systems for processing static data meet the stringent requirements for data collection, processing, and information provision. As a result, a well-maintained base station not only supports operational decision-making but also provides a dependable technical and topographic basis for network development and internet connectivity.

Daily static measurements from the Fabrichny base station—as well as data collected relative to the world base station (BUCU, DRAG, GLSV, KIT3, POL2, TASH, ZECK)—were processed to obtain geographic coordinates. The resulting rectangular coordinates, expressed in the ITRF2014 system, demonstrated high accuracy (see Tables 1–6).

The installed modern reference station offers several key advantages:

- High Efficiency and Accuracy: Enables real-time geodetic surveying.
- Ample Data Storage: Provides significant memory for data archival.
- Multiple Information Transmission Modes: Ensures flexible and reliable connectivity.
- Portability: Easy transportation and deployment.

Additionally, the installation of the base station, the control of existing trigonometric points, and the subsequent transformation to a conditional coordinate system were carried out in full compliance with established guidelines and standards.

This study was carried out within the framework of the State Fund of the Ministry of Health of the Republic of Kazakhstan AR23489372.

References

Alessandro Pisciotta Gino Dardanelli, Antonino Maltese, Claudia Pipitone, Mauro Lo Brutto (2021) NRTK, PPP or Static, That Is the Question. Testing Different Positioning Solutions for GNSS Survey. https://doi.org/10.3390/rs13071406. (in English)

Author's certificate of the Republic of Kazakhstan No. 47995. Metodika sozdaniya opornoy geodezicheskoy seti v seysmicheskikh rayonakh [Methodology for creating geodetic reference network in seismic areas] (in Russian)

Dosanov A. (2019) Jerseriktik navigaciyalik juielerdin kazirgi damui [Current development of satellite navigation systems], Journal of Engineering Sciences. – P. 144 -146. (in Russian)

Kashkin V.B., Sukhinin A.I. (2001) Distantsionnoye zondirovaniye Zemli [Remote sensing of the Earth]. Digital image processing: Tutorial. - M.: Logos, 264 p. (in Russian)

Kenjekhan E.B., Aben A. (2022) Geodezicheskiye izyskaniya i prakticheskoye primeneniye tekhnologii GPS [Geodetic surveys and practical applications of GPS technology] Proceedings of the International scientific-practical conference dedicated to the 115th anniversary of the Corresponding Member of the Kazakh SSR Academy of Sciences A.Zh. Mashanov and the 100th anniversary of the Academician of the Kazakh SSR Academy of Sciences Zh.S. Erzhanov «Innovative technologies in geospatial digital engineering». Almaty. – P. 34-36. (in Russian)

Khabarova I.A., Khabarov D.A., Chugunov V.A. (2018) Razrabotka metodik lesotaksatsionnogo deshifrirovaniya s ispol'zovaniyem GIS-tekhnologiy po kosmicheskim snimkam [Development of methodology of lesotaxation dechifring with the use of GIS technologies for cosmic images]. International Journal of Applied Sciences and Technologies «Integral». №1. 18 p. (in Russian)

Kim, J.; Song, J.; No, H.; Han, D.; Kim, D.; Park, B.; Kee, C. Accuracy Improvement of DGPS for Low-Cost Single-Frequency Receiver Using Modified Flächen Korrektur Parameter Correction. ISPRS Int. J. Geo-Inf. 2017. 6. 222. (in English)

Madimarova G**.** Suleimenova D., Pentayev T., Baydauletova G., Miletenco N. Monitoring of displacements of objects of terrestrial surfaces by interferometry method. News of the academy of sciences of the republic of kazakhstan.Series of geology and technical sciences 5(443) September – October 2020. – P. 106-116. https://doi.org/10.32014/2020.2518-170X.110 (in English)

Mikhailov S.I. (2011) Primeneniye dannykh distantsionnogo zondirovaniya Zemli dlya resheniya zadach v sfere sel'skokhozyaystvennogo proizvodstva [Application of Earth remote sensing data for solving problems in the field of agricultural production]. Earth from Space. Issue 9. – P. 17-23.. (in Russian)

Nurpeisova M.., Kurmanbaev O.S., Dzhangulova G.K., Sarsembekova Z.K., Ormanbekova A., Kakimzhanov E.Kh. Creation of geodetic reference network for monitoring transport interchanges in seismic areas. News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technical sciences. ISSN 2224–5278 Volume 4. Number 466 (2024). – P. 209–223 https://doi.org/10.32014/2024.2518-170X.436 UDC 528.236:528.48 (in English)

Nurpeisova M., Kurmanbaev O., Turegaliyeva, Zh. Nukarbekova Zh., Baiturbay O. Innovative technologies in the urban planning cadastre. News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technical sciences. ISSN 2224–5278 Volume 1. Number 469 (2025), 155–№ https://doi.org/10.32014/2025.2518-170X.482 (in English)

Nurpeisova M., Kyrgizbayeva G., Donenbaeva N., Bek A., Bekbassarov S., Madimarova G., Zhaksylyk A. Development of geodetic methods of monitoring of open-pit sides stability// Bioscience biotechnology research Communications. 2019. Vol. 12 №.5. – P. 67-78. (in English)

Sizov A.P., Khabarov D.A., Khabarova I.A. (2018) Novyye podkhody k razrabotke metodov formirovaniya semanticheskoy informatsii dlya monitoringa zemel' na osnove obrabotki i analiza kartograficheskoy informatsii [New approaches to the development of methods for the formation of semantic information for land monitoring based on the processing and analysis of cartographic information]. Geodesy and aerial photography, №4. – P. 434-441. (in Russian)

Smirnov L.E. (2005) Aerokosmicheskie metodi geograficheskih issledovanii[Aerospace methods of geographical research], St. Petersburg: Publishing house of St. Petersburg University, 349 p. (in Russian)

CONTENTS

Publication Ethics and Publication Malpractice
in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайтах:
www:nauka-nanrk.kz
http://www.geolog-technical.kz/index.php/en/
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Директор отдела издания научных журналов НАН РК *А. Ботанқызы*
Редакторы: *Д.С. Аленов, Ж.Ш.Әден*
Верстка на компьютере *Г.Д.Жадыранова*

Подписано в печать 15.04.2025.
Формат 70x90$^{1}/_{16}$. Бумага офсетная. Печать – ризограф.
14,5 п.л. Заказ 2.

РОО «Национальная академия наук РК»
050010, Алматы, ул. Шевченко, 28, т. 272-13-19