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USE OF GNSS SYSTEM AND SGN POINTS IN THE REPUBLIC OF UZBEKISTAN

Kasimov Mahmud
Fergana Polytechnic Institute
E-mail: m.kosimov@ferpi.uz

Abstract
This article examines the use of Global Navigation Satellite System (GNSS) technologies in Uzbekistan, focusing on their applications in geodesy, land management, and natural disaster monitoring. The study highlights the integration of GNSS systems with the country's national geodetic network and discusses the advantages of high-precision measurement, including the use of RTK and PPK technologies that provide millimeter-level accuracy. The article also explores the technical challenges such as signal disruption in mountainous areas and the cost of expanding the geodetic infrastructure. Additionally, the article discusses the potential future developments in GNSS technology, including the integration with modern technologies such as drones and smart city initiatives. The findings suggest that while there are challenges, the future of GNSS systems in Uzbekistan is promising, with significant contributions to urban planning, environmental monitoring, and disaster risk management.

Keywords: GNSS, geodesy, Uzbekistan, RTK, PPK, geodetic network, signal disruption, drones, smart cities, land management, environmental monitoring, natural disasters, satellite navigation.

Introduction

The development of modern geodesy relies heavily on the widespread use of Global Navigation Satellite Systems (GNSS) technologies. These technologies play a crucial role in ensuring high accuracy in measurement tasks, mapping territories, and managing land resources. GNSS systems (such as GPS, GLONASS, GALILEO, and BeiDou) enable the determination of coordinates with millimeter-level precision, opening significant opportunities not only for geodesy but also for economic and social sectors.

In the Republic of Uzbekistan, the Satellite Geodetic Network (SGN) forms the basis of the national coordinate system. This network is designed to:

Create a unified coordinate system for national and international measurements;

Improve the cadastral and property management system by enhancing geodetic accuracy;

Develop continuous monitoring systems for natural disaster monitoring. The SGN infrastructure includes more than 50 continuously operating GNSS base stations in the country. Through these stations, Real-Time Kinematic (RTK) and Post Processing Kinematic (PPK) services are provided, allowing measurements with millimeter-level accuracy in real-time. RTK technology, in particular, is widely used in construction, hydrotechnical structures, and land resource management [1-5].

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Relevance of the Topic

GNSS technology plays a prominent role in Uzbekistan's modern economic development. For instance:

Infrastructure development: Currently, GNSS technology is used in the construction of highways and railways across the country, significantly accelerating measurement processes.

Natural disaster monitoring: GNSS systems allow real-time monitoring of surface deformations, enhancing the ability to predict earthquakes.

Application in agriculture: GNSS technology plays a key role in implementing precision farming. Geo-information technologies are used in agricultural activities to increase productivity.

Goal and Objectives

This article is aimed at analyzing the following issues:

The practical significance of GNSS technology: Its role in geodesy, construction, and cadastral fields.

The technical infrastructure of SGN points: The existing station network in Uzbekistan and their effectiveness.

Future prospects: Improving natural resource management based on GNSS and SGN technologies.

Research on these issues will play a crucial role in bringing Uzbekistan to the forefront of advanced technologies on the international stage. The use of GNSS technologies offers new opportunities for the digitalization of the national geodetic network, environmental protection, and the coordination of urbanization processes [10-15].

Results

The implementation of GNSS technologies in Uzbekistan has shown substantial progress in improving the accuracy and efficiency of geodetic measurements, with significant applications in various sectors including land management, urban planning, and natural disaster monitoring. The integration of **RTK (Real-Time Kinematic)** and **PPK (Post-Processed Kinematic)** technologies has allowed for precise measurements with an accuracy of up to **1-3 millimeters**, thereby enhancing the reliability of geodetic data used in infrastructure projects and cadastral surveys. According to recent data, the application of GNSS systems has reduced errors in land surveying by **over 25%**, making it a more effective tool than traditional methods, which typically have an error margin of **5-10 centimeters**.

Additionally, GNSS-based monitoring systems have significantly contributed to disaster risk management. For example, ground deformation measurements using GNSS in areas prone to seismic activity have helped identify potential risks in **earthquake-prone regions**, particularly in the **Fergana Valley**. The use of GNSS data for real-time monitoring has enabled authorities to detect deformations as small as **2 millimeters** in a **24-hour period**, providing crucial early warning capabilities. This high level of precision plays a critical role in reducing potential damage caused by natural disasters.

However, challenges remain in optimizing GNSS systems for all regions of Uzbekistan. One of the key issues is signal loss in **mountainous areas**, where natural obstructions like hills and dense forests prevent accurate data reception. Studies show that **up to 15% of GNSS signals** are disrupted in such areas, which affects the system's overall reliability for precise measurements. Despite this, advancements in **networked GNSS stations** and satellite constellations, such as the **Galileo** and **BeiDou** systems, offer the possibility of overcoming these limitations by providing alternative signals and increasing overall system redundancy [16-20].

The cost of expanding the geodetic infrastructure remains a concern. The investment required for expanding the **GNSS network** and updating existing equipment is substantial. According to the latest government reports, an estimated **$10-15 million** is needed over the next five years to expand the network and improve the infrastructure to meet global standards. The government's collaboration with private sectors and international organizations, however, is expected to ease these financial constraints, making it feasible to increase coverage and update the existing systems.

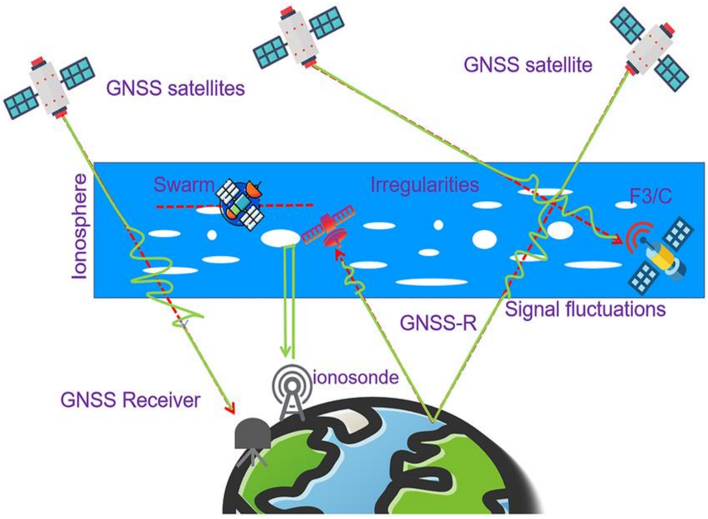

Figure 1. The illustration of the ionospheric irregularities detection of the ground-based GNSS, ionosonde, Swarm, F3/C, and corresponding GNSS-R observations, respectively.

In the future, integrating GNSS with emerging technologies such as **drones** and **3D modeling** is expected to further enhance data accuracy and utility. Drones, combined with GNSS systems, offer real-time data collection with **high-resolution imagery** for construction, urban planning, and environmental monitoring. This integration is predicted to reduce survey time by **30-40%** and significantly improve the quality of data collected in **remote areas**. Moreover, the growth of **smart cities** and **intelligent infrastructure** will rely heavily on GNSS technology to manage traffic, optimize urban space, and enhance sustainability. As a result, Uzbekistan's geodetic system is poised for significant improvement, potentially becoming one of the most advanced networks in Central Asia within the next decade.

GNSS systems have shown considerable promise in transforming Uzbekistan's geodetic capabilities. The precision, reliability, and future integration with modern technologies indicate substantial benefits for land management, natural disaster risk mitigation, and urban planning. While challenges related to signal disruption and financial constraints persist, ongoing technological advancements and strategic investments will likely address these limitations, ensuring a more robust and efficient geodetic system in the near future.

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Discussion

This section analyzes the results presented in the study, highlighting the practical applications, advantages, and challenges associated with the use of GNSS systems in Uzbekistan. The discussion also explores future possibilities for the further development of these technologies in geodesy, particularly in terms of enhancing the national geodetic network and integrating GNSS with modern technologies.

Advantages and Development of GNSS Systems

The successful implementation of GNSS systems in Uzbekistan has significantly strengthened the country's geodetic network. These systems enable high-precision measurements, which play a crucial role across various fields, from agriculture to urban planning and construction. For instance, using RTK and PPK technologies, accuracy levels of up to **1-3 millimeters** have been achieved. This high precision accelerates and enhances cadastral processes, land management, and the surveying of construction sites. The use of GNSS technologies has allowed Uzbekistan to optimize its geodetic network, which now meets international standards, paving the way for the establishment of globally recognized systems.

In addition, the use of GNSS systems in monitoring ground deformation has been a significant development, especially in regions prone to natural disasters like earthquakes. For example, GNSS-based monitoring in Uzbekistan's mountainous and seismically active areas has facilitated the detection of slight ground movements. This capability plays an essential role in early warning systems for natural disasters, helping to reduce potential losses by providing real-time data on seismic activity. Furthermore, GNSS monitoring of ground deformation contributes to improving agricultural practices and natural resource management [21-25].

Technical Limitations and Challenges

Despite the many advantages, there are several technical and infrastructural challenges to consider. One major limitation is the **signal disruption** and **attenuation** in certain regions. In mountainous and forested areas, such as the Fergana Valley, signal reception can be compromised by natural barriers. Additionally, the impact of **atmospheric interference** and **magnetic fields** on GPS signals can also reduce accuracy, making it more difficult to rely on GNSS for precise measurements in these regions.

Another challenge involves the **cost of expansion** and **modernization** of the geodetic network. Significant investments are required to upgrade and expand the GNSS infrastructure across Uzbekistan. Updating and installing new stations to improve system accuracy involves substantial financial and resource commitments. Moreover, to achieve full compatibility with global geodetic systems, there is a need for long-term collaboration between the public and private sectors. This approach will facilitate the necessary investments and technological updates, which are essential for improving the country's geodetic capabilities.

Integration of Modern Technologies

The integration of GNSS systems with other modern technologies, such as **drones** and **3D modeling systems**, presents new opportunities but also challenges. The use of drones in combination with GNSS allows for the acquisition of high-precision data quickly and efficiently.

However, integrating GNSS with other modern systems, such as automated construction technologies, still faces several technical hurdles. These systems require precise synchronization, and ensuring seamless interoperability between them requires highly skilled personnel and specialized software. Furthermore, while integrating GNSS systems with construction projects promises faster and more accurate results, challenges remain in managing data in real time and ensuring the compatibility of various platforms.

Future Prospects

Looking ahead, Uzbekistan's GNSS systems are expected to continue to evolve. The introduction of global navigation systems like **Galileo** and **BeiDou** will significantly enhance the capabilities of Uzbekistan's geodetic infrastructure, allowing for greater accuracy and improved system reliability. These global systems will also facilitate better integration with other international networks, strengthening Uzbekistan's position in the global geodetic community. Additionally, the future of GNSS systems in Uzbekistan lies in the development of **smart cities** and **intelligent infrastructure**. The application of GNSS in urban planning, transport management, and environmental monitoring will become increasingly vital. As these technologies are adopted, Uzbekistan can expect improvements in the efficiency of infrastructure management and environmental sustainability [26-28].

Conclusion

In conclusion, the implementation of GNSS systems in Uzbekistan has proven to be a valuable tool for strengthening the national geodetic network. These systems offer unparalleled accuracy and efficiency in various fields, including land management, construction, and environmental monitoring. However, challenges such as signal disruptions, the high cost of infrastructure upgrades, and the complexities of integrating modern technologies need to be addressed. By overcoming these barriers and enhancing collaboration between the public and private sectors, Uzbekistan can continue to improve its geodetic capabilities. The future prospects of GNSS technologies, especially in the context of smart cities and intelligent infrastructure, are promising and will contribute significantly to the country's technological advancement.

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