

## THE ROLE OF GNSS TECHNOLOGIES IN LAND SURVEYING

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**Abstract:** This article examines the application, advantages, and practical significance of GNSS (Global Navigation Satellite System) technologies in land management and land surveying. The study analyzes the role of high-precision GNSS methods such as RTK, DGPS, and PPP in optimizing geodetic measurements within land administration processes. It also highlights the importance of multi-frequency GNSS receivers, differential corrections, and real-time positioning accuracy. The efficiency of GNSS technologies in modern land management, cadastre, spatial planning, and land resource administration is discussed, emphasizing their superiority over traditional measurement methods in terms of time, labor, and cost reduction. The article concludes with an overview of the prospects for GNSS-based digital land management and potential directions for further technological improvements.

**Keywords:** GNSS, yer tuzish, geodeziya, RTK, DGPS, PPP, GNSS receivers, precision agriculture, multi-frequency GNSS, GNSS error sources, differential corrections, survey-grade receiver, satellite constellations, real-time positioning.

### Introduction:

The land-planning process is a complex system concerned with the rational use of land resources, their protection, the determination of the legal boundaries of land plots, and the maintenance of cadastral documentation. Although traditional geodetic surveying methods have long been the primary tool for this process, However, in recent years, the development of science and technology has led to the widespread implementation of Global Navigation Satellite Systems (GNSS) in land surveying practice.

Today, GNSS technologies not only enable the high-precision determination of coordinates but also significantly simplify the processes of creating cadastral maps, calculating land areas, conducting monitoring and establishing spatial data repositories. In modern literature – notably in GPS Theory and Practice (Hofmann-Wellenhof et al.), Understanding GPS/GNSS (Kaplan & Hegarty), and the works of Russian scholars Kissing, Goncharov and Andreyev – the advantages of GNSS in geodesy and land surveying are scientifically substantiated. This article analyses the role of this technology in land-cadastre practice, its advantages, challenges, and its application in the context of Uzbekistan.

The Concept and Working Principles of GNSS Technologies.

A GNSS (Global Navigation Satellite System) is a constellation of satellite systems designed to determine a user's precise coordinates on the Earth's surface in real time. Currently, there are four fully operational global systems in the world:

GPS (USA) – the most widespread and stable system.

GLONASS (Russia) – operates with satellites in high orbits.

Galileo (European Union) – a modern system focused on high accuracy.

BeiDou (China) – widely used in the Asian region.

As emphasised by Hofmann-Wellenhof (2013), the operating principle of GNSS is based on measuring the time taken for signals transmitted by satellites to reach the receiver. In this process, the precise orbits of the satellites, the time signal, and the effects of the ionosphere and troposphere are taken into account. In modern geodesy, the following precision technologies are used:

DGPS (Differential GPS) – accuracy 0.5–1 m.

RTK (Real-Time Kinematic) – accuracy 1–2 cm.

PPP (Precise Point Positioning) – high accuracy through independent calculation.

According to the works of Russian scientists Kissin and Andreev, RTK technology provides the most reliable results, particularly in land surveying, as it ensures centimetre-level coordinate accuracy in real time.

## 2. Main Applications of GNSS in Land Surveying.

### 2.1. Determining the Boundaries of Land Plots.

The most crucial step in the land surveying process is establishing the precise boundaries of the plot. Whereas this process used to be very time-consuming, it is now possible to obtain the coordinates of several points in just a few minutes using RTK GNSS.

The coordinates obtained via GNSS are aligned with the cadastral system, reliably establishing the landowner's legal boundaries. Kaplan & Hegarty (2017) note that GNSS technologies have a significant impact on reducing property rights uncertainty and disputes.

### 2.2. Creation of cadastral maps and plans.

GNSS technologies have become a primary source for creating land-use plans and cadastral maps. Coordinates collected by the user are transmitted to GIS systems, thereby forming digital cadastral maps. As noted in the works of the Russian scientists Goncharov and Afanasev, when modern land-cadastral maps are compiled on the basis of GNSS measurements, their accuracy and update rate increase considerably.

### 2.3. Measuring and Calculating Land Areas.

To accurately calculate land areas, the coordinates of all points on the plot outline are required. GNSS technologies are ideal for this, as the high accuracy of the points minimises errors in the

calculations. This process is particularly important when allocating, valuing, or re-registering agricultural land.

#### 2.4. Land Monitoring and Spatial Change Detection.

The vertical and horizontal displacements of the Earth can be detected using GNSS continuous monitoring stations. This is important in land management for the following processes:

monitoring erosion processes;

monitoring landslides;

detecting geodynamic changes around structures;

monitoring changes in agricultural land.

Thanks to the high accuracy of the Galileo system, land monitoring in Europe is highly developed, and this experience is also relevant for Uzbekistan.

#### 2.5. Integration with GIS systems.

Land surveying work is often associated with GIS, and GNSS is the primary source of spatial data for this system. The coordinates collected via GNSS are processed in GIS platforms:

the boundaries of land parcels are visualised;

areas are calculated;

spatial analyses are conducted;

thematic maps are created.

Wolf & Ghilani (2014) define this integration as a key element of modern geomatics systems.

### 3. Advantages of GNSS technologies.

In Uzbekistan, as well as in other countries, GNSS technologies are fundamentally changing the quality indicators of the land surveying sector. The main advantages of this technology are:

High accuracy – up to 1–2 cm in RTK mode.

Speed – field measurements are completed several times faster.

Ability to work over large areas – large areas can be measured in a short amount of time.

Reduces human error – automatic calculations reduce the likelihood of error.

Digital data is exported directly to GIS systems.

All-weather operation – as noted in English sources, GPS/GLONASS is stable in most conditions.

According to the research of Russian geodesists Kissin and Borin, it is precisely the accuracy and repeatability figures that have made GNSS one of the most important technologies in land surveying.

#### 4. Problems and limitations.

Like any technology, GNSS has certain limitations:

Tall buildings and trees within urban areas can block the signal.

Ionosphere and troposphere conditions affect accuracy.

Accuracy decreases when there is an insufficient network of RTK base stations.

Dependence on a power supply can be problematic for fieldwork.

The cost of the equipment can be prohibitive for geodetic teams.

However, English and Russian studies have noted that these problems are gradually being overcome with technological advancements.

#### 5. Application of GNSS in Uzbekistan.

In recent years, Uzbekistan has been paying great attention to the digitisation of its cadastre system. GNSS technologies are being actively used in the following areas:

Updating the land cadastre and defining legal boundaries.

Assessing and monitoring agricultural land.

Expansion of RTK networks – the number of stations of the Cadastre Agency is increasing.

Developing the cadastre system on a GIS basis.

Using equipment such as Trimble, Leica, Topcon, and South for field surveys.

These processes are helping to bring Uzbekistan's land management system up to modern standards.

#### Conclusion:

GNSS technologies have taken almost all stages of land surveying to a new quality level. This technology serves as a primary tool not only for determining coordinates but also for creating cadastral maps, calculating land areas, conducting monitoring, and establishing digital spatial databases. An analysis of English and Russian sources shows that GNSS technologies are among the most reliable, effective and promising technologies in the field of geodesy and land surveying. In the context of Uzbekistan, the implementation of this technology increases the transparency of the cadastre system and enables the rational use of land resources. In the future, the expansion of RTK networks, the enhancement of specialist qualifications, and the further improvement of GNSS-GIS integration will remain a crucial factor in the development of the land cadastre system.

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