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USING GPS TECHNOLOGY ON A GLOBAL LEVEL

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Abstract. *GPS (Global Positioning System) is a technology that represents one of the most important applications of GNSS(Global Navigation Satellite Systems), providing essential positioning, navigation, and timing services worldwide.It has informations about the main GNSS systems: GPS (United States of America), Galileo (European Union), GLONASS (Russia), and BeiDou (China) presenting their characteristics, evolution, and accuracy. It also shows the practical applications of GNSS receivers in many fields: automotive transport, aviation, maritime navigation, and industrial activities:transportation,logistics,drones and robotics,precision agriculture, construction, and mining. The study emphasizes the role of GNSS technology in optimizing routes, increasing safety and efficiency, and supporting autonomous driving. ,it examines the concept of the GNSS SSV (Space Service Volume) , which extends GNSS services to altitudes between 3,000 and 36,000 km, ensuring the operation of space navigation systems. It provides detailed information about location helping you to find the place or finish the job faster. There are six GEO satellites and are part of the equatorial orbital plane,60 degrees in longitude or four hours in time. GEO and MEO orbits are almost in phase with each other. The conclusions that the global use of GPS technology contributes to the development of smart infrastructures, transportation safety, and scientific progress, demonstrating the essential role of GNSS in the modern society,helping you saving time.*

Keywords: *GNSS , GPS , satellite , transportation , navigation , altitude.*

INTRODUCTION

GNSS (Global Navigation Satellite System) is a network of satellites that provide global positioning, navigation, and timing services by broadcasting signals that a receiver can use to calculate its location. Here are some well-known and important examples of satellites: GPS (United States of America), Galileo (European Union), GLONASS (Russia), BeiDou (China).

GPS is the United States of America's global navigation satellite system launched in 1973.The first satellite was launched in 1978.After the 24 satellites were placed in orbit in 1995, the system became fully operational.

Galileo is the European Union's global navigation satellite system launched in 2011, but the Galileo spacecraft was launched earlier by NASA in 1989. The historical figure Galileo Galilei is also famous for discovering Jupiter's four largest moons in 1610, which are now called the Galilean satellites .He also published the same day his findings in Siderius Nuncius.

GLONASS is the Russian global navigation satellite system launched in 1982 that provides positioning and timing information globally using a constellation of 24 satellites and offers accuracy comparable to GPS.GLONASS was developed initially by the Soviet Union, now is operated by Russia and is used in civilian applications like smartphones, automotive navigation, and law enforcement.

BeiDou is the China's global navigation satellite system launched in 1994 , the first satellite being launched in 2000.The system was developed in three phases: the first phase was completed in 2000 for services within China, the second phase was completed in 2012 for the

Asia-Pacific region, and the third phase was officially commissioned in 2020 to provide global coverage . BeiDou 3 generations are:BeiDou-1(experimental regional system), BeiDou-2(regional system for Asia-Pacific),BeiDou-3(global system).

MATERIAL AND METHODS

MATERIAL

To use GNSS equipment, first set up the receiver on a stable mount and connect it to a controller via cable or Bluetooth. Then, turn on both the receiver and controller, and use the controller software to establish a reference position, by using a known coordinate or by averaging the position over 45-60 seconds for an unknown location.

For precise measurements, especially in RTK (Real-Time Kinematic) or PPK (Post-Pro-cessed Kinematic) applications, set up a base station and a rover, and ensure the base is connected to the controller and receiver.

METHODS

GNSS systems are used through various methods and technologies, but it depends on the accuracy and the application field. One method that is very simple is the GNSS receives signals from at least four or more satellites that calculates its own position and it needs latitude, longitude and altitude for it.

GPS can be used through: car navigation, mobile phones , tourism apps , search and rescue , basic aviation.

The industries that use GNSS are: cadastre , autonomous machines , mapping drones , construction , geodetic surveying.

METHODS OF USING GNSS AS AUTOMOBILE RECEIVERS

Automobiles can be equipped with GNSS receivers at the factory or after. Units often display moving maps and information about location, speed, direction, and nearby streets and points of interest,including turn-by-turn navigation, location-based services, and advanced driver assistance systems(ADAS). For autonomous driving, high-precision GNSS is critical, providing centimeter-level accuracy by compensating for errors and integrating with other sensors to ensure reliable and safe vehicle localization.Every year the technology becomes more and more accurate.

METHODS OF USING GNSS AS AIR NAVIGATION RECEIVERS

Air navigation systems usually have a moving map display and are often connected to the autopilot for navigation. Cockpit-mounted GNSS receivers and glass cockpits are appearing in general aviation aircraft of all sizes, using the technologies SBAS or DGPS to increase accuracy. Many are certified for instrument flight rules navigation, and some can also be used for final approach and the landing operations Joint precision approach and landing system.Glider pilots use GNSS Flight Recorders to log GNSS data verifying their arrival at turn points in gliding competitions to provide aircraft with precise positioning, velocity, and timing data. This enables more efficient navigation, including flying RNAV and RNP routes, making flights safer and more reliable from departure to landing.GNSS has replaced many traditional ground-based navigation aids, allowing for more direct and fuel-efficient routes.

METHODS OF USING GNSS AS BOATS RECEIVERS

Boats use GNSS for a wide range of marine applications, from precise navigation and tracking to vessel monitoring and even research. These systems provide accurate positioning for everything from large commercial ships to small research or fishing vessels by using data from multiple satellite systems like GPS, GLONASS, Galileo, and BeiDou to achieve better accuracy than GPS alone.This includes general navigation,vessel and traffic management, and scientific measurements. Boats and ships use GNSS to navigate all of the world's lakes, seas and oceans. Maritime GNSS units include functions useful on water, such as MOB(man overboard) functions that allow instantly marking the location where a person falls overboard, which simplifies rescuing.GNSS may be connected to the ships self-steering gear and Chartplotters using the NMEA 0183 interface. GNSS can also improve the security of shipping traffic by enabling AIS.

METHODS OF USING GNSS AS WORKERS RECEIVERS

Heavy equipment can use GNSS in construction, mining and precision agriculture. The blades and buckets of construction equipment are controlled automatically in GNSS machine guidance systems. Agricultural equipment may use GNSS to steer automatically, or as a visual aid displayed on a screen for the driver. This is useful for controlled traffic and row crop operations and when spraying.Harvesters with yield monitors can also use GNSS to create a yield map of the paddock being harvested.In construction, it powers machine control for grading and leveling and improves accuracy. For agriculture, it enables precision planting, spraying, and harvesting to reduce waste. In mining, GNSS guides autonomous vehicles, optimizes haul routes, and ensures accurate drilling to improve safety and yield.GNSS guides heavy equipment like bulldozers, excavators, and graders to precisely follow 3D design models, which reduces the need for survey stakes and minimizes rework.

GNSS SPACE SERVICE VOLUME(GNSS SSV)

The GNSS SSV is extending from 3000 km to 36000 km altitude.GNSS system service in SSV has three key parameters:signal availability,minimum received power and pseudorange accuracy.SSV covers a large range of altitudes and GNSS performance will degrade with increasing altitude.

THE GNSS SPACE SERVICE VOLUME

SSV is divided into two areas that have different quantity of signals available to users in those regions:lower SSV and upper SSV.

LOWER SSV

Lower SSV is from 3000 km to 8000km altitude where Medium Earth Orbit(MEO) is located. This area has reduced signal availability when it is just the zenith-facing antenna,but when it is also the nadir-facing antenna it increases when they are both used.

UPPER SSV

Upper SSV is from 8000 km to 36000 km altitude where High Earth Orbit is located.This area has reduced signal and availability due to most signals travelling across the Earth.Users are able to process GNSS signals above 36000 km altitude with adequate antenna.

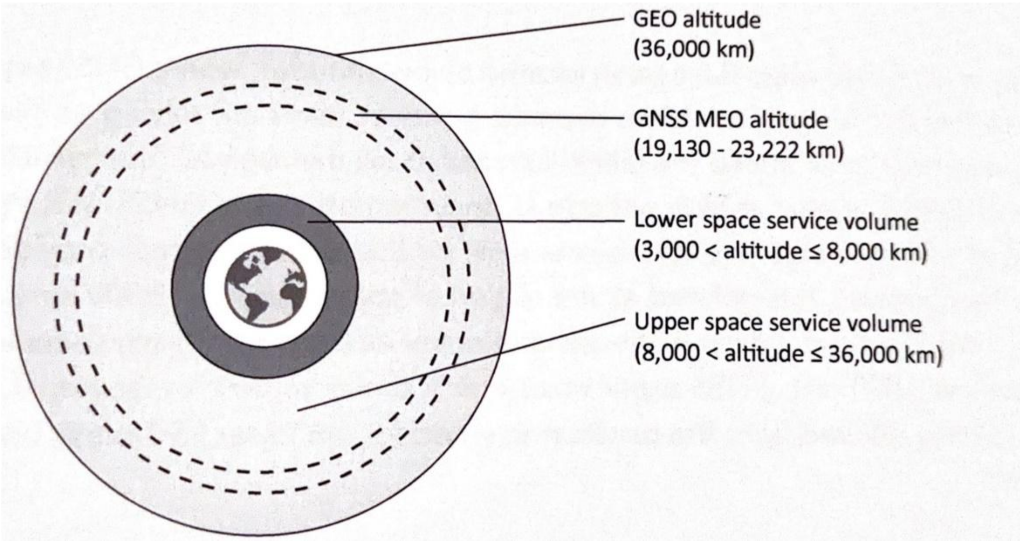

Figure 1. The GNSS space service volume and its regions

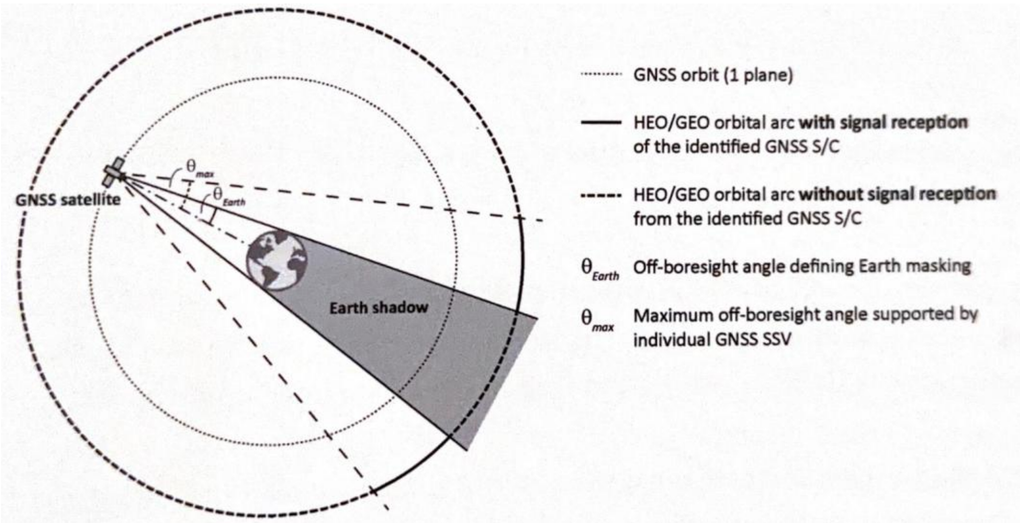

Figure 2. Signal reception geometry in the upper space service volume

GLONASS SPACE SERVICE VOLUME CHARACTERISTICS

There have been three generations of GLONASS:GLONASS, GLONASS-M,GLONASS-K. The three generations are broadcasting five navigation signals:L1OF(open Frequency Division Multiple Access(FDMA) in L1),L2OF(open FDMA in L2),L1SF(secured

FDMA in L1) , L2SF (secured FDMA in L2), L3OC (open CDMA in L3). GLONASS is using its own reference system PZ90.

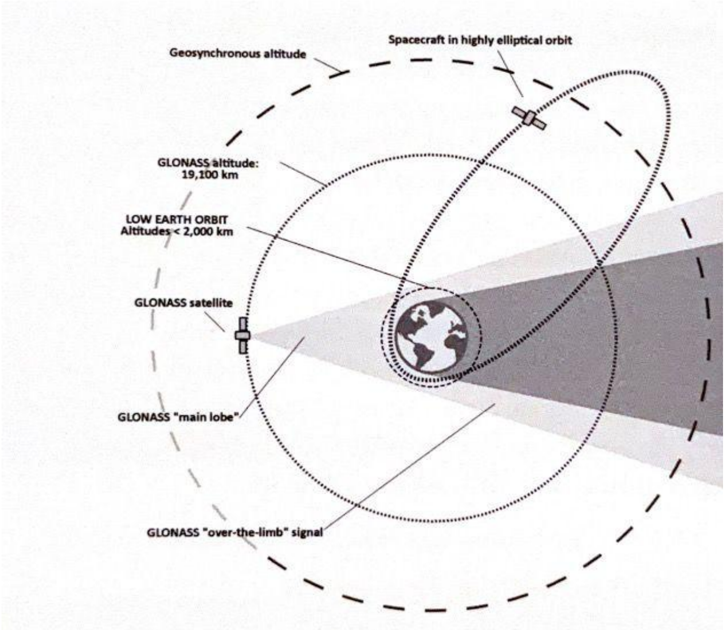

Figure 3. GLONASS geometry for space service volume characteristics

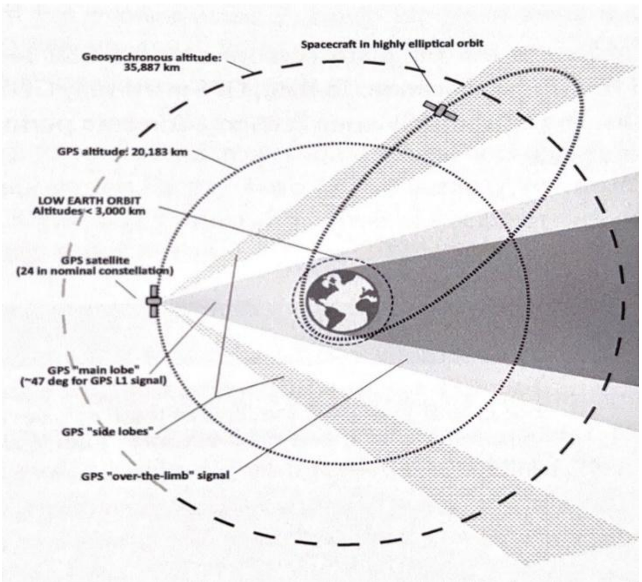

Figure 4. Global positioning system geometry for space service volume characteristics

BENEFITS TO USERS-GNSS

One of the benefits of using GNSS is efficiency in places that are based on location tasks.A few industries that use GNSS are agriculture,transportation,construction, telecommunication,robotics and drones,surveying where it needs positioning, precision,navigation and timing.It reduces time which helps the industries grow and discover new improved solutions in a short period of time.

Agriculture: GNSS is used for precise guidance in planting, fertilizing, and harvesting, leading to increased yields and more efficient use of resources.

Construction and Engineering: It enables the accurate positioning of heavy equipment like excavators and graders for site preparation and earthmoving, as well as for surveying and mapping.

Telecommunications: GNSS provides highly accurate timing signals to synchronize cellular base stations and other network components, ensuring reliable data transmission.

Logistics and Transportation: GNSS is used for tracking vehicles, optimizing routes, and managing fleets, which improves efficiency and delivery times.

Emergency Response: Emergency services use GNSS to locate and track individuals, facilitating rapid response and rescue operations.

Robotics and Drones: GNSS provides the crucial positioning data needed for navigation in robotics and drone applications.

Geospatial and Surveying: GNSS is fundamental to Geographic Information Systems (GIS) and surveying, providing accurate data for mapping and land management.

RESULTS AND DISCUSSIONS

RESULTS

The analysis of the main global navigation systems - GPS (USA), Galileo (European Union), GLONASS(Russia), and BeiDou (China) - revealed a high level of accuracy and reliability in providing positioning, navigation, and timing data.

The integration of multiple GNSS constellations improves positioning precision, reduces atmospheric errors, and ensures optimal signal availability under various geographical conditions.

It has been observed that simultaneous use of signals from several systems considerably enhances the stability and continuity of the services provided.

DISCUSSIONS

The analysis of GNSS systems demonstrates their essential role in supporting technological and economic progress worldwide.

GNSS constellations allows very good precision(centimeter), which is crucial for modern applications such as precision agriculture, autonomous transportation, and 3D mapping.

The concept of the GNSS SSV (Space Service Volume) highlights the technological of satellite navigation systems, allowing the use of signals up to the limits of the geostationary orbit.

This is particularly significant for space missions, cosmic exploration, and artificial satellite monitoring. The evolution of GNSS is closely linked to its integration with other modern technologies such as INS (Inertial Navigation Systems), AI (Artificial Intelligence), and the IoT (Internet of Things).

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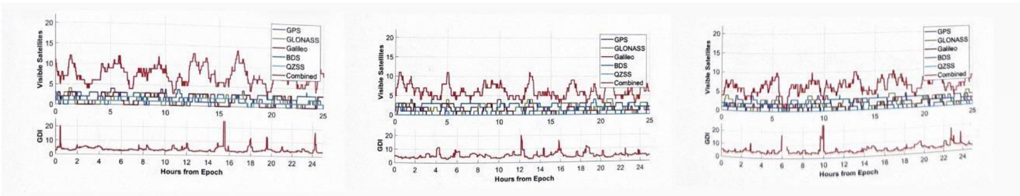

Figure 5. L1/E1/B1 visibility for GEO at 0 deg , 60 deg and 120 deg

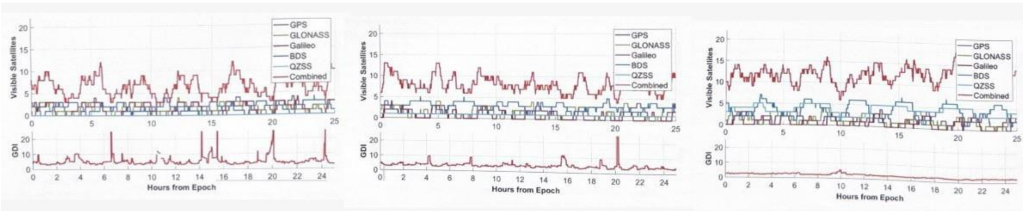

Figure 6. L1/E1/B1 visibility for GEO at 180 deg , 240 deg and 300 deg

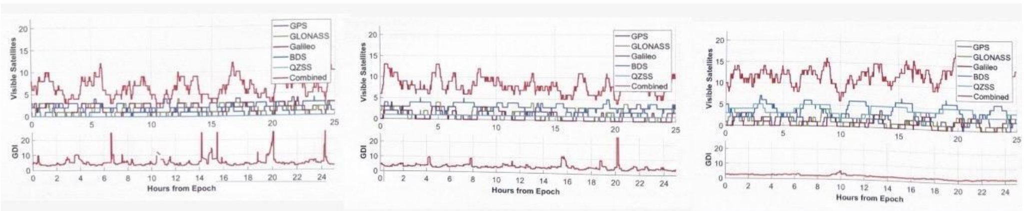

Figure 7. L5/L3/E5a/B2 visibility for GEO at 0 deg , 60 deg and 120 deg

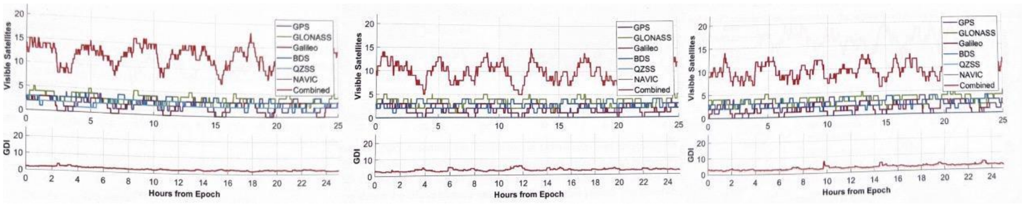

Figure 8. L5/L3/E5a/B2 visibility for GEO at 180 deg , 240 deg and 300 deg

CONCLUSIONS

Lastly, GNSS (Global Navigation Satellite System) represents a fundamental component of modern technological infrastructure, having a significant impact on global economic, scientific, and social development.GPS (United States of America), Galileo (European Union), GLONASS (Russia), and BeiDou (China) provide essential positioning, navigation, and timing services, contributing to the optimization of processes in fields such as land, air, and maritime transportation, precision agriculture, construction, telecommunications, and space research.

The integration of multiple satellite constellations leads to increased accuracy, signal availability, and system reliability, which are crucial aspects for the implementation of emerging technologies such as autonomous vehicles, intelligent drones, and IoT networks.The expansion of GNSS

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functionality within the SSV (Space Service Volume) highlights the progress of research in space navigation and the signals of geostationary altitudes.The global use of GPS and GNSS technology contributes significantly to the digitalization and automation of contemporary society and the advancement of space exploration. This demonstrates the indispensable role of satellite navigation systems in supporting technological and scientific progress worldwide.

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