Aspects on the use of GNSS technology in maritime and fluvial navigation

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Abstract: It presents the use of global navigation technology, NAVSTAR-GPS and GLONASS systems in maritime navigation and some aspects that are encountered in maritime navigation, using these systems. The use of GNSS technology in maritime navigation is beneficial and at the same time it can be used in the civil domain, the system which is eminently civil, being the Galileo European positioning system. Commercial vessels sailing on the seas and on the planetary oceans can be monitored and managed in real time, if the GNSS-type global positioning systems are used. The global positioning systems of the GNSS type include all the positioning systems, but especially those of the NAVSTAR-GPS, GLONASS, GALILELO, BEIDOU type. The advantages of using in the navigation of global positioning systems is unmatched and it makes sailing much more useful and safer on the seas and oceans of the earth. River navigation is a component of trade and water transport, which can be managed using modern means of navigation by satellite type GNSS, Romania participating with neighboring countries in different European programs. There is a brief introduction of the notion of global positioning system to the general mode and a specific appreciation of each global positioning system in part and to the general mode of GNSS global positioning systems. Important aspects are presented in the use of GNSS technology, in the maritime and related fields, the advantages of this technology in relation to the classical technologies and the judicious cooperation in the extreme cases between the two technologies. The sources of positioning errors in the use of global GNSS positioning systems and the methods by which they can be eliminated or reduced are presented. It presents the calculation of the navigation coordinates in different projection systems and the stages of transformation of the coordinates in the WGS-84 system, specific to the Navstar-GPS positioning system in different coordinate and projection systems. Maritime navigation is guided by specific methods, but lately, global positioning systems are a beneficial presence in the steering and navigation component of the world's seas and oceans. Finally, conclusions and proposals regarding the judicious and beneficial use of the GNSS positioning system in navigation are presented.

1. Introduction
The introductory part presents the use of global navigation technology, NAVSTAR-GPS and GLONASS systems in maritime navigation and some aspects that are encountered in maritime navigation, using these global positioning systems.
The use of GNSS technology in maritime and river navigation is of great importance and reflects the state of development of modern technologies.

Merchant ships navigating inland rivers, seas and planetary oceans can be monitored and guided in real time, using global positioning systems, generically called GNSS (NAVSTAR-GPS, GLONASS, GALILEO, BEIDOU).

River navigation is a component of trade and water transport, which can be managed using modern means of satellite navigation of GNSS type, Romania participating with neighboring countries in various European programs or having developed its own monitoring programs.

The notion of global positioning system is presented in a general way and the NAVSTAR-GPS positioning system is described. The general form accepted at the level of the public and users is GPS.

The paper presents the sources of positioning errors briefly but also the methods by which they can be eliminated.

Maritime navigation is guided by specific methods, but lately, global positioning systems are a beneficial presence in the component of guidance and navigation on the seas and oceans of the world.

Currently, the tendency to accumulate as much information as possible for humans is constantly accompanied by new discoveries in the field of terrestrial measurements interoperable with GIS and GNSS, the advantage of their technology and computerization opening wide perspectives for a better understanding of the environment and phenomena occurring within it.

The evolution of the specialized GNSS technique, starting from its initial aspects and going to the current geodesy based on the automatic processing of satellite information once again reflects the desire of man to impose his dominion over the notion of time and space and to use science for the purpose of the evolution of society of which he is part of.

In this new context, GNSS Global Positioning Systems create new opportunities for surveyors and their profession, serving a wide range of beneficiaries.

Among the special applications aimed at using this state-of-the-art technology we can mention those related to the field of cadastre, agriculture, mining, air and maritime navigation and mainly to land navigation.

Today, the global positioning system (GNSS) is being used more and more widely also because of the spectacular development of products in the field [1].

Moreover, technological progress determines changes at the institutional and organizational level, changes that will have a strong impact on users of this technology but also on the entire community.

2. GPS/DGPS positioning system

2.1 GPS system
The GPS system consists of three segments: the satellite constellation, the terrestrial control and monitoring network, and user reception equipment. The formal GPS terms for these components are: space, control and user equipment [2].

The satellite network consists of a number of satellites in orbit that provide the signal for determining the distance and the data packets to the receiving equipment. The control segment tracks and maintains satellites in space. The control segment monitors the status of the satellites and the signal integrity and also maintains the orbital configuration of the satellites. Moreover, the control segment updates the clock corrections and the ephemeris of the satellite as well as many other essential parameters to determine the three parameters (position, speed, time) of the user. Finally, the receiving equipment performs navigation, synchronization or any other specific function [3].

2.2. Presentation of the space segment
The space segment is the constellation of satellites from which users make measurements to determine distance. Satellites transmit the signal in the PRN code from which measurements are made.
This concept makes GPS a passive system only by transmitting the signal, and the user also receives the signal passively. Thus, an unlimited number of users can use GPS simultaneously. The signal transmitted from a satellite is modulated with a data signal containing information on the position of the satellite.

2.3. Presentation of the GPS control system

The control system is responsible for the proper functioning of the satellites. This includes keeping the satellites in their correct position in orbit and monitoring the satellite's state subsystem. The control system also monitors the battery level and the fuel level used to maneuver the satellite and change its position.

The control system activates the backup satellites (if available) in order to maintain system availability. The control system updates the clock, ephemeris and other indicators in the satellite navigation message at least once a day. Updates are made more often when improved navigation accuracy is required. Frequent updates of the clock and ephemeris lead to a reduction in measurement errors. If accurate ephemeris is used the accuracy increases considerably, but this aspect is especially useful for geodynamic measurements.

The ephemeris describes the orbit of the satellite and is valid only for an interval of 4 hours a day for a normal program. Depending on the satellite block, the navigation message may be stored for a minimum of 14 days to a maximum of 210 days at 4 or 6 hour intervals for one-time uploads every 2 weeks and at intervals of more than 6 hours for uploads that cannot be insured for a period of 2 weeks.

The almanac is a subset of low precision ephemeris parameters. It consists of 7 of the 15 parameters of orbital ephemeris. The information in the almanac is used to predict the approximate position of the satellite and to aid in acquiring the signal [4].

The control system consists of three different physical components: the main control station, the monitoring stations and the ground antennas.

2.4. Presentation of the user segment

This segment is represented by the user's reception equipment. Each piece of equipment is actually a GPS receiver that processes the L-band signals transmitted from the satellites to determine the user's position on water, on land or in the air. Although user position determination is the most common use, the receivers are also designed for other uses, such as altitude calculation or as a synchronization source.

2.4.1. Description of the space segment. The space segment has two main aspects: one is the constellation of satellites in terms of orbits and positioning in orbits, and the other is represented by the characteristics of the satellites that occupy each orbital slot.

2.4.2. Description of the satellite constellation. The GPS configuration consists of 24 satellites. In this configuration, the satellites are positioned on six orbital planes, around the Earth, with four satellites corresponding to each plane. Each satellite makes a complete rotation around the Earth in 12 sidereal hours, respectively in 11 local hours and 56 minutes, each day the "sunrise" and "sunset" of each satellite being done 4 minutes earlier.

The orbits are approximately circular with respect to the Earth's surface and have an inclination of 55° with respect to the Earth's equatorial plane, the satellites evolving at an altitude of about 20,200 km.

The space segment, which is currently complete, ensures that at any time, in any place on the Earth's surface, regardless of weather conditions, during the day or at night, radio signals can be received from at least 4 satellites (even 6 or 8) at an elevation angle of 15° above the horizon, conditions absolutely necessary for GPS positioning (figure 1).
2.5. Accuracy of positioning or navigation measurements

The accuracy of positioning or navigation measurements, performed using GPS technology, is directly proportional to the accuracy with which the distance from the satellite to the receiver is determined. Errors that can be committed in this type of measurement using GPS are of two types:

- Accidental measurement and observation errors, such as error due to multipaths, electronics of satellite and receiver equipment, electromagnetic interference, eccentricities of the antenna phase centers, etc.;
- Systematic errors (bias), such as errors due to satellite and receiver clocks, refractive errors caused by the troposphere and ionosphere, errors due to satellite orbits, etc.

These errors are permanently present in the measurements. Apart from them there are other errors knowingly induced by those who manage the GPS positioning system and which, even if they do not act permanently, aim to degrade the positioning and navigation accuracy in real time, action which is called Selective Availability - SA and Anti-spoofing – AS[5].

Taking into account the different sources of error, we find that the absolute positioning performed with the help of code measurements, as a planimetric positioning accuracy, would be of approx. +/- 100 m. If these errors are tolerable, in the case of applications concerning the calculation of the speed of movement of a mobile or its positioning, for geodetic and geodynamic purposes these precisions are intolerable, and in this sense the analysis of errors, their causes and removal methods, or diminishing them is strictly necessary[6].

3. AIS (Automatic Identification System)

3.1. AIS (Automatic Identification System)

Automatic Identification System is a modern technology for identifying the routes of sea and river vessels, transmitting the most important parameters and data of a dynamic and static nature related to the identity of the ship, cargo, important characteristics and data related to its navigation status at any time of day and night. Introduced for the first time in maritime and river navigation, the AIS system has significantly improved navigation safety because, combined with Inland ECDIS, it allows for the practical replacement of much of the position and distance information for similar vessels in the surrounding area.
AIS technology is also considered suitable for the automatic identification and tracking of ships in navigation on the inland waters of riverside countries. In particular, the real-time performance demonstrated by the AIS system and the international availability of guideline standards are particularly useful for safety and security applications in the field of inland waterway transport. As Inland AIS is compatible with IMO SOLAS AIS, the system allows a direct exchange of information between sea and river vessels, which is especially useful in areas with mixed ship traffic (e.g. on the maritime sector of the Danube).

Inland AIS represents:
• An original navigation system developed for maritime navigation, according to IMO and SOLAS regulations, currently fully functional and for inland navigation;
• A means of communicating operational data between two ships, between a ship and the shore, or disseminating information from a competent shore authority to all ships in the AIS coverage area;
• A data communications system with special requirements for availability, continuity and reliability;
• A real-time data communication system, useful in the direct exchange of information between ships;
• An autonomous system, with self-organized operation, without dispatcher operator;
• A system based on a solid package of standards;
• An approved system for use in emergency situations, intended to increase the safety of navigation, as a result of well-developed certification procedures;
• An interoperable system with maritime AIS.

3.2. AIS (Automatic Identification System) base stations
The AIS system is the main means of locating and identifying ships. However, it is restricted by the active presence of the AIS transponder on board ships. In addition, it can be a means of transmitting messages between the operator and the ship.

The AIS system, consisting of AIS base stations and the network of AIS servers, ensures the monitoring and management of ship traffic on the Danube equipped with AIS transponders in the coverage area of the stations.

Both Maritime AIS base stations for the Maritime Danube, and Inland AIS base stations are used. The structure of the system is the one in the figure below (figure 2).

Maritime AIS base stations are located in Sulina and Mahmudia and Inland AIS base stations in Giurgiu and Drobeta-Turnu Severin.

NMR500 regional and NMR800 + NMR1000 national servers ensure the collection, registration and distribution of AIS data.

Figure 2. The structure of AIS (Automatic Identification System).
4. Conclusions
The use of global navigation technology, NAVSTAR-GPS, GLONASS, GALILEO systems, all generically called global satellite positioning systems (GNSS), in maritime and river navigation has a special contribution, compared to classic LORAN or DECCA navigator systems.

The use of GNSS technology in maritime navigation is beneficial and at the same time it can be used in the civil field, with a high precision in a differential way.

Merchant ships navigating the sea and oceans can be monitored and directed in real time, if global positioning systems and specific systems are used. The current paper presents the automatic identification system (AIS).

River navigation is a component of trade and water transport, which can be managed using modern means of satellite navigation of GNSS type, Romania participating with neighboring countries in various European programs and developing its own navigation and real-time monitoring programs.

Maritime navigation is guided by specific methods, but lately, global positioning systems are a beneficial presence in the component of guidance and navigation on the rivers, seas and oceans of the world.

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