GLONASS General Designer on Improving Navigational Precision

OE Watch Commentary: The accompanying excerpted interview of the General Designer of GLONASS, Sergei Karutin, conducted by the *TASS* news service, mentions future improvements to the GLONASS to increase navigational precision. In addition to improved hardware and software, Karutin also mentions plans to deploy the GLONASS high-altitude orbital system (VKK). This system essentially consists of a few modified GLONASS-K (sometimes referred to as GLONASS-V) satellites placed in a highly elliptical modified orbit to increase regional navigation precision. When operational, the VKK will reportedly improve location accuracy in urban canyons and increase satellite redundancy in longitudes between 20° and 160° east, which covers most of Russia.

The accompanying excerpted article from *Moskovskiy Komsomolets* discusses Russian plans to use "state-of-the-art mathematical and software methods of processing satellite signals" to achieve three centimeter accuracy with the current GLONASS constellation. Although the article is sparse on the details of how this is to be accomplished, the improved precision apparently involves using data from existing and future ground measurement stations. If possible, this development would be remarkable, as GLONASS's current navigational precision averages 3-3.5 meters, and precision to this higher level was not envisioned until the fielding of a new ground control segment and a constellation filled with new GLONASS-K2 satellites. **End OE Watch Commentary (Bartles)**

"Research has shown a growing demand for navigation services in challenging conditions, when a spacecraft is visible at angles greater than 25 degrees above the horizon. To meet the customer needs for high-quality services using new code signals, we will begin to create the GLONASS high-altitude orbital system (VKK) in 2021. With the launch of the first satellite in 2025, and the full deployment of the constellation of six spacecraft in three planes by the end of 2027, navigation accuracy in the Eastern Hemisphere will be improved by 25%."

-The general designer of GLONASS, Sergei Karutin

11F654M Glonass-M spacecraft.

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Continued: GLONASS General Designer on Improving Navigational Precision

Source: Интервью генконструктора ГЛОНАСС Сергея Карутина (An Interview with the General Designer of GLONASS, Sergei Karutin)," *Roscosmos Online*, 2 October 2020. http://www.roscosmos.ru/29340/

...The General Designer [генконструктор] of GLONASS, Sergei Karutin, spoke with TASS about the development of GLONASS, the work to improve the accuracy of navigation, and about new electronic components added to certain satellites.

What main functions are performed by GLONASS?

2020 marks yet another decade of development of GLONASS, the Russian Global Navigation Satellite System. The retrofitting of the system, which began in 2006, is bringing visible results. Today, our everyday life is difficult to imagine without the permanent artificial radio navigation field, provided by the GLONASS orbital system since 2011 to customers on a global scale. The GLONASS signals are used to save lives during road accidents; to monitor and dispatch air, land, and water transportation systems; to synchronize mobile communication networks and energy systems; to manage transportation and agricultural equipment; and more...

To what extent has the accuracy of navigation improved?

In 2014, the error margin of the navigation equipment was 1.4 m. However, we are constantly working on improving the accuracy. This work does not stop even for a single day. On January 30 of this year, the error margin of these satellites has dropped to 0.9 m, and during a one-week period the error margin did not exceed 1.15 m.

In addition, the second to last GLONASS-M satellite, launched on March 16, demonstrated the accuracy of the baseline service of 0.38 m during a daily interval, and its best weekly result was 0.63 m. It should be noted that GLONASS-M satellites, in particular, allowed customers all over the world to receive navigation service in two frequency ranges for the first time, which reduced the influence of the ionosphere on navigation accuracy. Acquisition of signals in two ranges provides navigation under atmospheric turbulence in a layer during magnetic storms caused by solar activity. Turbulence in the ionosphere causes higher error margins of the navigation parameters and time synchronization by several times.

Previously, General Director of ISS Reshetnev (a Roscosmos company) Nikolai Testoedov announced the creation of a new segment of the GLONASS satellite system. When do you expect the first launch for this program?

We will maintain our traditional consumer focus. Research has shown a growing demand for navigation services in challenging conditions, when a spacecraft is visible at angles greater than 25 degrees above the horizon. To meet the customer needs for high-quality services using new code signals, we will begin to create the GLONASS high-altitude orbital system (VKK) [высокоорбитального космического комплекса (ВКК)] in 2021. With the launch of the first satellite in 2025, and the full deployment of the constellation of six spacecraft in three planes by the end of 2027, navigation accuracy in the Eastern Hemisphere will be improved by 25%...The GLONASS-K satellite, which has a proven reliability track record, will become the foundation of the high-altitude orbital system (VKK)...

Is there a quality control procedure for navigation services?

We give much attention to the quality control of GLONASS navigation services. To achieve this goal, we created a system of monitoring and verification of the system's technical parameters. It includes a network of GLONASS signal monitoring stations abroad, as well as specialized radio telescopes capable of analyzing the structure and power of radio signals near the Earth's surface. The results of objective monitoring confirm the correctness of the selected technical solutions...

How do you plan to improve the accuracy of GLONASS navigation in the near future?

One of the most important tasks of 2020 is the harmonization of the GLONASS consumer interface. I have already described the environmental effects on the navigation accuracy, therefore, the new editions of the GLONASS interface control documents (ICD) are being prepared for publication, which will describe the parameters of interaction between the GLONASS satellites and the consumer's navigation equipment.

We believe that the accuracy of GLONASS will be increased as a result of introducing frames of navigation messages with additional information into the reserve categories. In particular, mathematical models for calculating ionospheric and tropospheric delays will be introduced. The parameters of the ionospheric model will be included in the navigation message, and the tropospheric model only needs information about the latitude of the navigation receiver and the season of the year...Changes to the ICD for signals with frequency and code division for the transmission of additional information will provide backward compatibility for the fault-free operation of the existing fleet of user navigation equipment and the transmission of troposphere and ionosphere parameters in additional bits...

Continued: GLONASS General Designer on Improving Navigational Precision

"The GLONASS military and civilian global satellite navigation system has acquired a new quality. The accuracy of the military segment of GLONASS increased by an order of magnitude -- to three centimeters -- thanks to state-of-the-art mathematical and software methods of processing satellite signals."

Source: "Российские военные получили систему навигации сантиметровой точности, (The Russian Military Received a Navigational System with Centimeter Accuracy)," *Moskovskiy Komsomolets Online*, 22 October 2020. https://www.mk.ru/politics/2020/10/22/rossiyskie-voennye-poluchili-sistemu-navigacii-santimetrovoy-tochnosti.html

The GLONASS military and civilian global satellite navigation system has acquired a new quality. The accuracy of the military segment of GLONASS increased by an order of magnitude -- to three centimeters -- thanks to state-of-the-art mathematical and software methods of processing satellite signals. Moskovskiy Komsomolets (MK) asked an expert why ultraprecise satellite navigation is necessary.

"It is planned to bring the accuracy of determining position to three centimeters in a permanent mode," a Center spokesman said. Autonomous tests have been conducted and the system is undergoing experimental operation. Legal issues remain before it is accepted into the Russian Army inventory.

The GLONASS orbital grouping has 24 satellites used for the targeted purpose. In addition, the system has around 200 ground measurement complexes that track the position and status of the satellites. This entire establishment ensures navigational accuracy of a little over a meter. Now GLONASS military users will be able to determine location with an accuracy to three centimeters.

Specialists explained that the system proposes an enormously greater number of ground measurement assets. While there are around 200 measurement stations in the existing system, there are around 400 in the Defense Ministry precision navigation system. Measurement assets have become more precise. They perform a more detailed assessment of the position of satellites in orbit and take advantage of more state-of-the-art mathematical models.

Here is what Aleksey Leonkov, military expert and editor of the journal Arsenal Otechestva (Arsenal of the Fatherland) said about the importance of ultra-precise military navigation: "The Defense Ministry precision navigation system is a high-precision navigation system. The parameters of military navigation accuracy must be higher than for civilian systems. Three centimeters is a good figure, no worse than for the military segment of the American GPS."

Such navigation systems are needed for precision-guided munitions so that maneuvering missiles line up their flight along the route very accurately and hit the target "in the bull's-eye," as they say...

Thanks to our country's vast territory, there is an opportunity to increase the number of ground measurement assets. Joined in a single network, these ground complexes together with GLONASS satellites are capable of making navigation very high-precision.