

## Development of SLR, GNSS MS and VLBI nodes for refinement of GLONASS

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**Abstract.** *Maintaining of the GLONASS competitive characteristics ensuring decimeter accuracy of navigation requires the deployment of fundamental coordinate/time support and, with the goal to improve the accuracy of navigation field by an order of magnitude.*

*Therefore, the following specific requirements should be met:*

- *accuracy of geodynamic data calculation < of 1.5 cm in linear measure,*
- *coordinate accuracy of stations involved in the ephemeris determination < 1 cm relative to the center of mass, and 0.3 cm in relative binding,*
- *accuracy of the account for refraction: < 1 cm around the zenith,*
- *delay calibration accuracy in the GLONASS navigation signals < 3-5 cm.*

*These problems are solved by collocation of different methods: SLR- one-way RF ranging -VLBI -WVR. Improving of the GLONASS geodynamic value is achieved by refinement of the actual earth rotation parameters 3-4 times a day. The VLBI network will provide operative definition of World time using antennas of small diameter (about 12m) and new equipment for data collection and correlation.*

*Combining WVR and one-way RF systems, will provide mutual scaling of direct measurements of the water vapor concentration and verification of the hydrostatic component of refraction in the troposphere. Geodetic accuracy is also achieved using the advantages of different instruments. To improve the accuracy of GLONASS, the new Federal program includes “BLTS-M” satellites with millimeter target error in 1500 - 3000 km high orbits with simultaneous creation of new generation of submillimeter-accuracy SLR stations.*

*To calibrate the delays in the GLONASS navigation signals, a one-way laser ranging system is provided. Testing of the first such system is underway on «Glonass-M» № 47. Deployment of collocation sites SLR, one-way RF system and VLBI provides a new level of accuracy for the GLONASS system as a whole.*

GLONASS is an actively developing system including its space complex and functional additions. In the near future, GLONASS itself will be able to provide approximately half a meter level of navigation accuracy, and its functional additions will allow for a decimeter level – 10-15 cm in real time and centimeter level – 3 cm in posterior mode. To achieve this level of accuracy, the following has to be improved:

- geodynamics data accuracy to 1.5 cm in linear measure;
- accuracy of knowledge of coordinates of stations participating in ephemeris calculation to not worse than 1 cm in reference to the center of mass and 0.3 cm in relative reference;
- accuracy of refraction parameters to not worse than 1 cm in zenith delay;
- accuracy of calibration of delays in GLONASS navigation signals to not worse than 3-5 cm.

These problems of fundamental support are to considerable degree solved by collocation of different types of systems: SLR (satellite laser ranging)-GNSS MS (GNSS master station)-VLBI (very large base interferometry)-WVR (water vapor radiometer).

The problem of improvement of GLONASS geodynamics support is solved by maintaining actual values of Earth rotation parameters, refining them 3-4 times a day. For this, a VLBI network

collocated with GNSS MS-SLR-Doris is being created in the Russian Federation to solve a problem of obtaining Universal time in real-time mode using small-size antenna systems: about 12 meters in diameter as well as to create new generation of collection and correlates system which is widely integrated in international projects.



Figure 1 Use of collocation nodes for improvement of geodynamics support

VLBI is collocated with water vapor radiometers to take into account refraction parameters in processing of intensive sessions of single-base interferometer.

Placement of new-generation stations at existing collocation nodes allows to use previously performed scaling of stations coordinates as well as to use SLR for geodetic support and to perform a new task – to calibrate WVR with good clarity of atmosphere.

Collocation of WVR and GNSS MS allows performing mutual scaling of direct measurements of water vapor concentration and results of refinement of hydrostatic component of signals refraction in Earth troposphere, as shown in Figure 2.

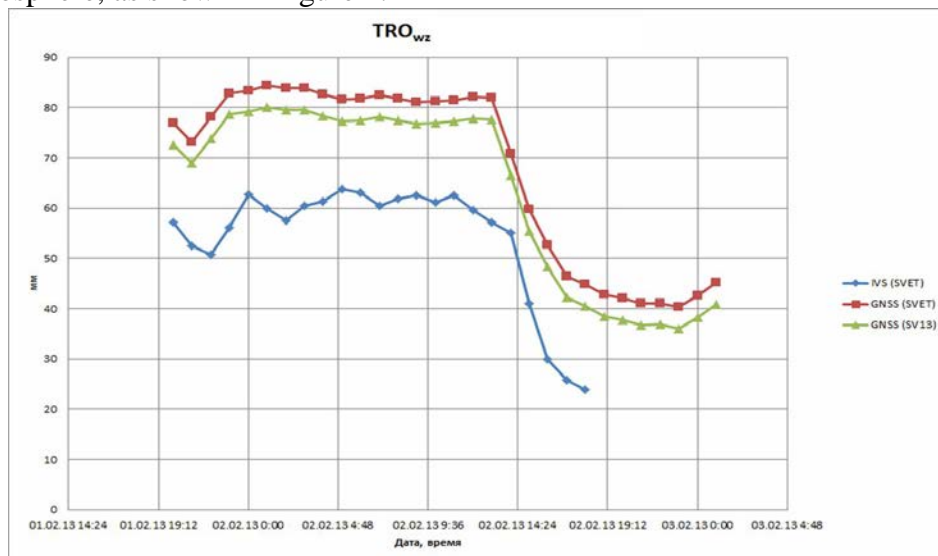


Figure 2 mutual scaling of VLBI, SLR and WVR delays

Universal Time calculation is improved using results of refinement of zenith latency obtained from GNSS MS phase measurements at collocation node.

Accuracy of geodetic support is also achieved by using advantages of various instruments:

- SLR to determine geocenter or collocation station coordinates reference to geocenter;
- VLBI for orientation, scaling and relative reference;
- GNSS MS for transmission of collocation node coordinates at great distances, for calculation of parameters of dynamic variations of coordinates;
- DORIS for description of movement of geocenter.

To improve GLONASS accuracy, the new Federal Development Program foresees launch of a passive spacecraft BLITS with millimeter-level target error at ~3000 km orbit, with simultaneous development of a new-generation SLR. The decision about refinement of orbital height and means of delivery to that orbit is under way now.

It is known, that significant signal path latencies at different frequencies are possible with GLONASS signals frequency separation. New generation SLRs include one-way pseudorange rangefinders for calibration of delays in GLONASS navigation signals. Experimental sample of such rangefinder has been developed and it showed successful results onboard GLONASS-M #47 spacecraft.

Development of VLBI-GNSSMS-SLR collocation nodes is a priority of GLONASS Federal Program for 2012-2020.

For solution of GLONASS fundamental tasks and Russian Federation (RF) integration in international projects, there is foreseen deployment of Russian GNSSMS and SLR stations (45 and 6 respectively) in foreign territories. Taking into account importance of development of collocation nodes specifically, RF proposes to deploy Russian GNSS MS and SLR abroad at ILRS, VLBI, DORIS stations with high priority. It is proposed to support RF effort in development of international collocation nodes.