

Status of the Russian Laser Tracking Network

M.V. Baryshnikov, V.B. Burmistrov, V.D. Shargorodsky, V.P. Vasiliev
IPIE, Russia

Abstract

Brief description is given of the laser tracking network present status, as well as of further development plans and intentions.

The Russian laser tracking network includes the following SLR stations:

Komsomolsk-on-Amur (ID1828)
Maidanak-1 (ID1864)
Maidanak-2 (ID1863)

The stations general view and their basic technical parameters are shown in Figures 1 and 2.



Telescope

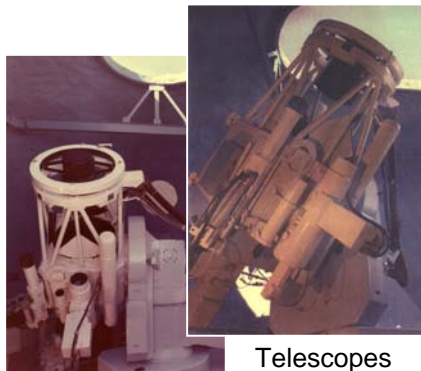


Technical building

Figure 1. Laser Tracking Station near Komsomolsk-on-Amur

Upgrade completed:

- ◆ Introduction of a coude path
- ◆ New laser transmitter: $\lambda = 532 \text{ nm}$, $\tau = 200 \text{ ps}$, $E = 40 \text{ mJ}$, rep. rate = 5 Hz



Telescopes
1.1 m in diameter



General view
2750 m above the see

Figure 2. SLR station on top of Maidanak mountain (Usbekistan)
The station is operable since December, 2002. It operates under the Russia/Usbekistan agreement on its joint control and use.

Two more stations are operating in an experimental mode (no data are still delivered to the international data analysis centers). The stations, shown in Figures 3 and 4, are:

Shelkovo (near Moscow) (ID 1111)

Altay optical and laser tracking center (ID 1050)

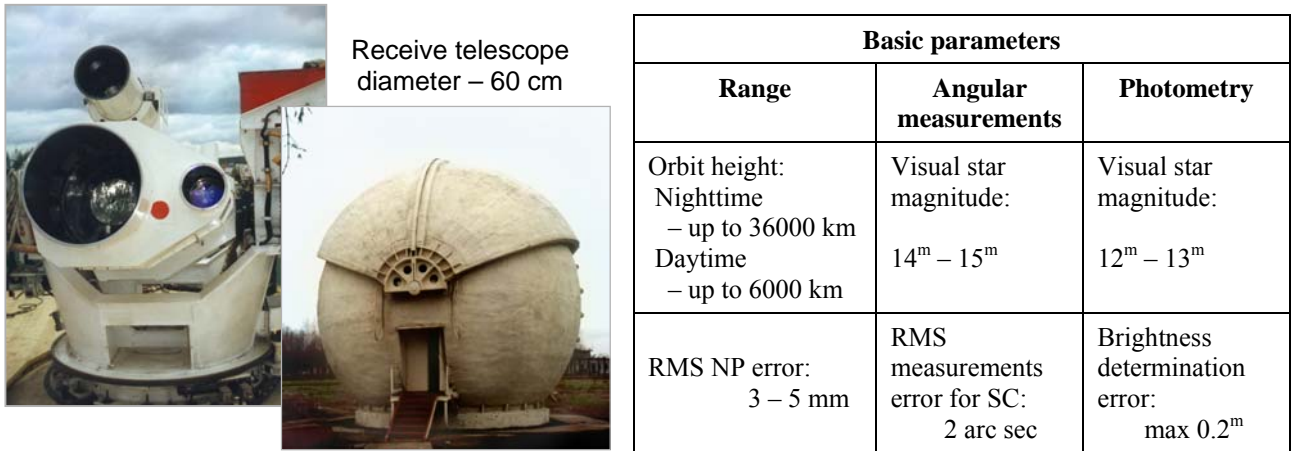


Figure 3. SLR station near Moscow. The station is in regular operation since 2003. Data delivery to ILRS will be provided after permission to participate in international programs.



Figure 4. Altay optical/laser ranging center

The main goals of laser tracking by Russian stations are

- ◆ Estimation of the GLONASS ephemeris and frequency/time accuracy during the navigation system operation period.
- ◆ Upgrade of spacecraft motion models.
- ◆ Better precision in Earth rotation parameter determination.
- ◆ Better precision of measurements for space geodesy and Earth gravity field parameter determination.
- ◆ Angular and photometric monitoring of spacecraft in high elliptical orbits (including SC failure cases).
- ◆ Failure-case backup of microwave SC tracking systems.
- ◆ Participation in international SC laser tracking programs for geodesy and geophysics, as well as for producing catalogues of SC and space debris.

Ephemeris data are routinely used by all five stations for tracking of more than 20 satellites, including GLONASS-84, GLANASS-87, GLONASS-89, ETALON-1, ETALON-2, ERS-2, TOPEX, STARLETTE, STELLA, AJISAI, GPS-035, GPS-036, LAGEOS-1, LAGEOS-2, GFO-1, BEACON-C, JASON, LARETS, METEOR-3M and CHAMP. The observation results are processed by the MCC SLR data analysis group.

After preliminary processing and filtration with use of STARK software, normal point data are formed and delivered to the European Data Center (EDC).

In addition to routine SLR, some work has been made recently on combining SLR with other techniques. An example of this is frequency drift monitoring of GPS/GLONASS on-board oscillators.

The accumulated experience on GLONASS operation shows that the navigation field quality depends primarily on time/frequency errors caused by the on-board frequency standard instability.

Thus, currently it is important to estimate the on-board standard frequency drift and to find the corresponding time/frequency correction values.

To implement this technology, the SLR station near Moscow is additionally equipped with an H₂ – maser having a stability of $7 \cdot 10^{-15}$ per day, as well as by a high-accuracy GLONASS/GPS signal receiver (ASHTECH Z-18) and corresponding software.

Figure 6 shows the GPS time-scale drift during a month-long period.

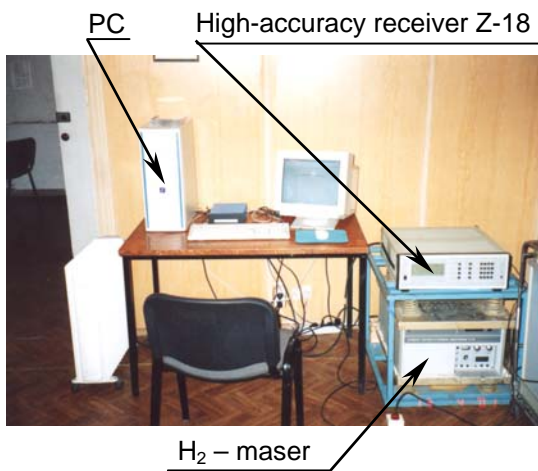


Figure 5. GPS/GLONASS frequency drift monitoring operator workplace

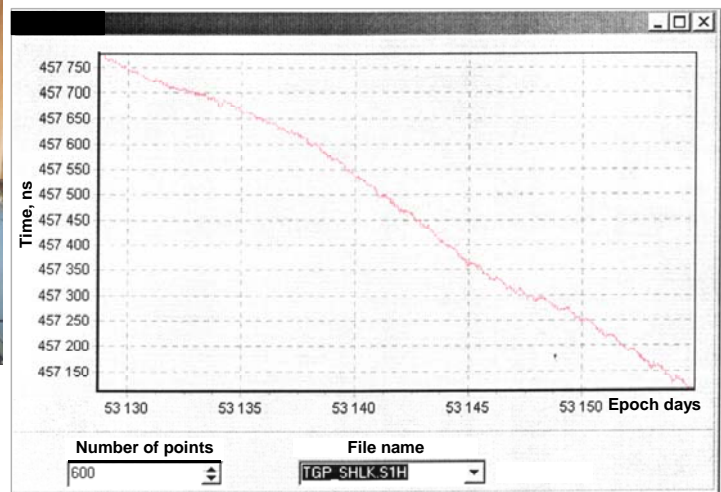


Figure 6. GPS time-scale drift 01-05-04 to 31-05-04

An important feature of Russian SLR development program is designing and manufacturing of transportable stations (Figure 7) and of miniature modular stations (Figure 8).

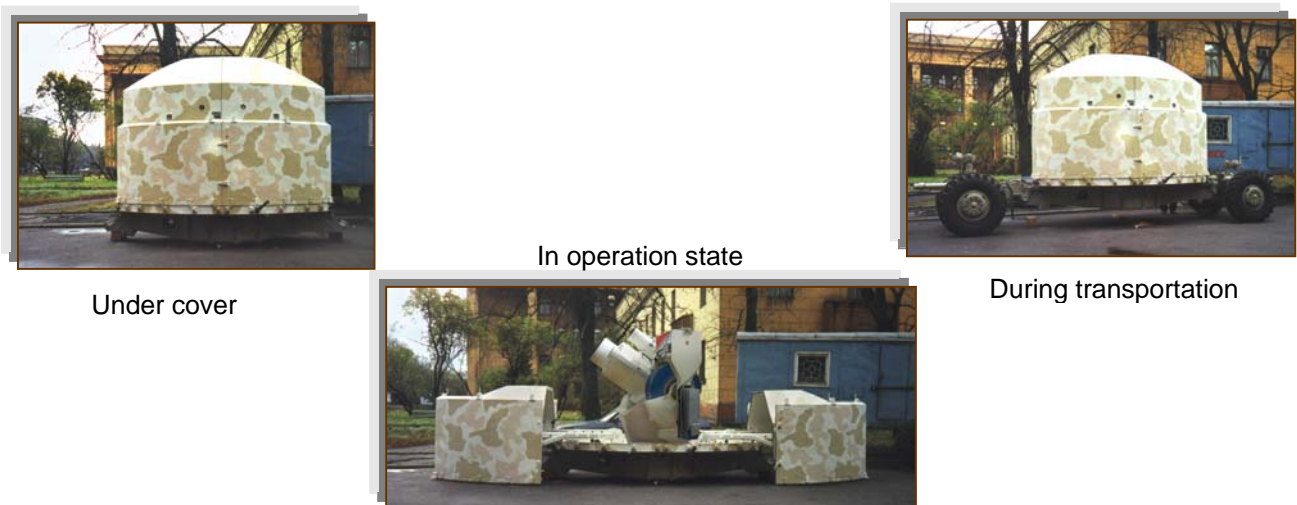


Figure 7. Transportable SLR station. It is planned to install the station at the Baikonur launching site during 2005.



Figure 8. Miniature modular SLR station

The modular station shown in Figure 8 may be used for ranging of CCR-equipped spacecraft in orbits as high as 23000 km at nighttime and 6000 km at daytime, as well as for angular measurements of spacecraft with brightness down to 14-th star magnitude, and photometric observations. The expected ranging accuracy is about 0.4 cm, and accuracy of angular measurements – less than 2...5 arc sec (depending on spacecraft brightness and atmospheric conditions).

The modular SLR station consists of the following subsystems and major components:

- ◆ Az/El mount with cover and tracking systems (2 arc sec accuracy)
- ◆ laser transmitter with optics unit:
 - $\lambda = 0,532 \text{ nm}$
 - $E = 2,5 \text{ mJ}$
 - Rep. rate = 300 Hz
- ◆ Tx collimator optics
- ◆ High-sensitivity TV system for angular measurements
- ◆ 250-mm diameter objective
- ◆ TV photometer
- ◆ GLONASS / GPS-controlled time/frequency standard
- ◆ Automatic weather station

The miniature diode-pumped laser transmitter combines high average power (0.75 W) with short pulse duration (250 ps). A narrow-band holographic filter is used in the receiver; as a photodetector, a Hamamatsu MCP PMT is used. The TV camera (MCP image intensifier +CCD) operates in photon-counting mode and has a FOV of 1°.

The total system weight is less than 350 kg; when dissembled (during transportation), the weight of any single module is less than 50 kg. Assembling and adjustment is made by two qualified operators during a single working day. After assembling, automatic angular sensor alignment using catalogue stars takes ~30 min (at nighttime). Ranging bias determination is made by means of a built-in calibration system. Cable length allows to place the optical unit as far as 50 m from the other equipment.

It is planned to produce more than 10 such stations, starting from 2005 (one station per year).

Thus, the Russian SLR tracking network is currently in a state of extensive development. We hope that until 2010 it will comprise 12...14 stations, more or less uniformly distributed over the State territory.