New Russian Systems for SLR, Angular Measurements, and Photometry

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Abstract

A brief description is presented of two novel-type stations providing satellite laser ranging, angular measurements, and photometry (in reflected sunlight), recently developed in the Institute for Precision Instruments Engineering (IPIE). Putting the stations in operation will expand the Russian Laser Tracking Network to six stations.

Compact station

The compact station with two 25-cm diameter optical systems (the first one used for transmission/reception of laser ranging signals, and the second one for angular measurements and photometry) has the following design features:

- The weight of any single unit of the system (in package) does not exceed 50kg, with system total weight less than 300kg. Thus, no special lifting mechanisms are needed for installation.
- An autonomous cover for the optical unit and mount allows installation on a small pier, without erection of a special fixed tower.
- Low power consumption (≤2.5 kW) allows supply from single-phase mains or from a portable power generator.
- Low cost in serial production (about 750K USD) and simple technology provides manufacturing by existing industrial firms.

Compact Laser/Optical Station Parameters

SLR of spacecraft with retroreflectors

- Spacecraft orbit height range: 400 to 40000 km
- Daytime and nighttime measurements for spacecraft with orbit heights 400 to 6000 km
- NP RMS errors 0.5 to 2 cm (averaging interval 60 s)
- Residual (systematic error) 0.5 to 2 cm
- Elevation range 20 to 85 deg.

Angular measurements

- Visual star magnitude: ≤ 12^m
- RMS error for spacecraft angular velocity up to 40 arcsec: ≤ 2’’

Photometry

- Visual star magnitude: ≤ 10^m
- Brightness determination error: ≤ 0.2^m

The option for mounting on a fixed position has a weight of 170 kg (optics + mount). No lifting mechanisms are needed for installation. The station has been tested near the 6-

meter telescope of Russian Academy of Sciences (in Northern Caucasus) during 2005. Currently, serial manufacturing is organized of the compact station for the Russian Laser Tracking Network. It is planned to produce 15 stations more until 2010.

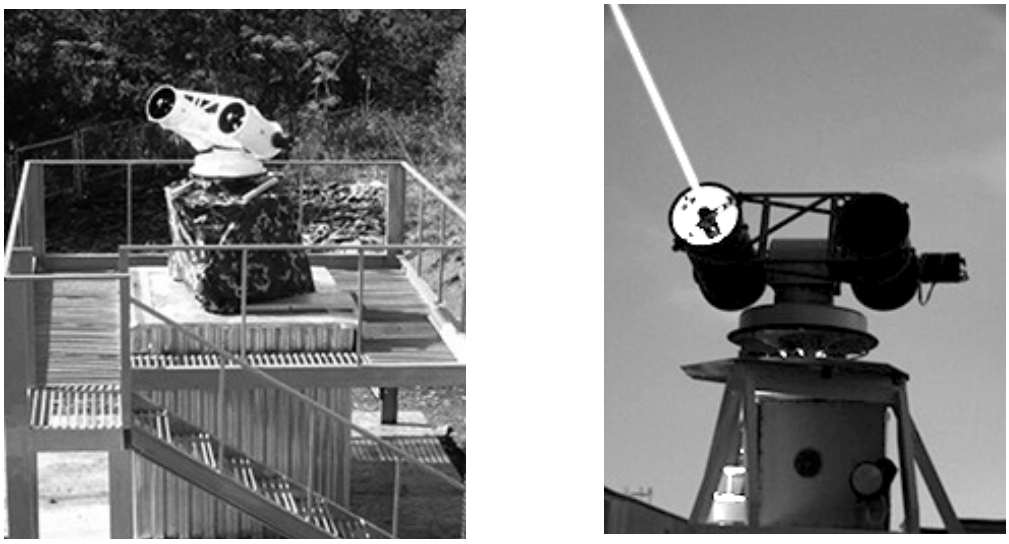


Figure 1: *Compact SLR station in operation*

Mobile Station

The mobile station is placed into 3 containers installed on wheels for transportation. The weight of optics and mount units is 12 tons. Except this unit, the system comprises an equipment container with operator's workplace, as well as a "house" for operator's rest. The mobile station acceptance tests have been completed on the Russian cosmodrome "Baikonur" in Kazachstan.

Pointing/tracking system and mount of the compact station

Mount parameters

- Mount type: Az-El, with two flanges for equipment mounting
- Digitally controlled torque motor drive
- Equipment weight on each mount flange:≤ 20 kg
- The mount is provided with an autonomous cover
- Angular rotation range:
  - Elevation: 5 to 95 deg
  - Azimuth: -278 to +278 deg
- Maximum angular speed 30deg/s;
- maximum angular acceleration 30deg/s^2

Mobile laser/optical station parameters

SLR of spacecraft with retroreflectors

- Spacecraft orbit height range: 400 to 40000 km

- Daytime and nighttime measurements for spacecraft with orbit heights 400 to 6000 km
- NP RMS errors 0.5 to 2 cm (averaging interval 10 s)
- Residual (systematic error) 0.5 to 2 cm
- Elevation range 20 to 85 deg

Angular measurements

- Visual star magnitude:≤ 14^{m}
- RMS error for spacecraft angular velocity up to 40 arcsec:≤2”

Photometry

- Visual star magnitude:≤ 12^{m}
- Brightness determination error: ≤ 0.2^{m}

The mobile station with a 60 cm diameter receive telescope and two separate optical systems for laser beam collimation and TV camera, has the following basic parameters.

Station of both types have similar laser ranging system with the following parameters:

Operation wavelength..... 0.532 μm
Pulse repetition rate..... 300 Hz
Laser pulse duration ..... 250 ps
Laser pulse energy..... 2.5 mJ
Output beam divergence ..... 5 arcsec
Receive telescope diameter
– compact station ..... 25 cm
– mobile station ..... 60 cm
Timing accuracy (measurement position on time scale) ..... 200 ns

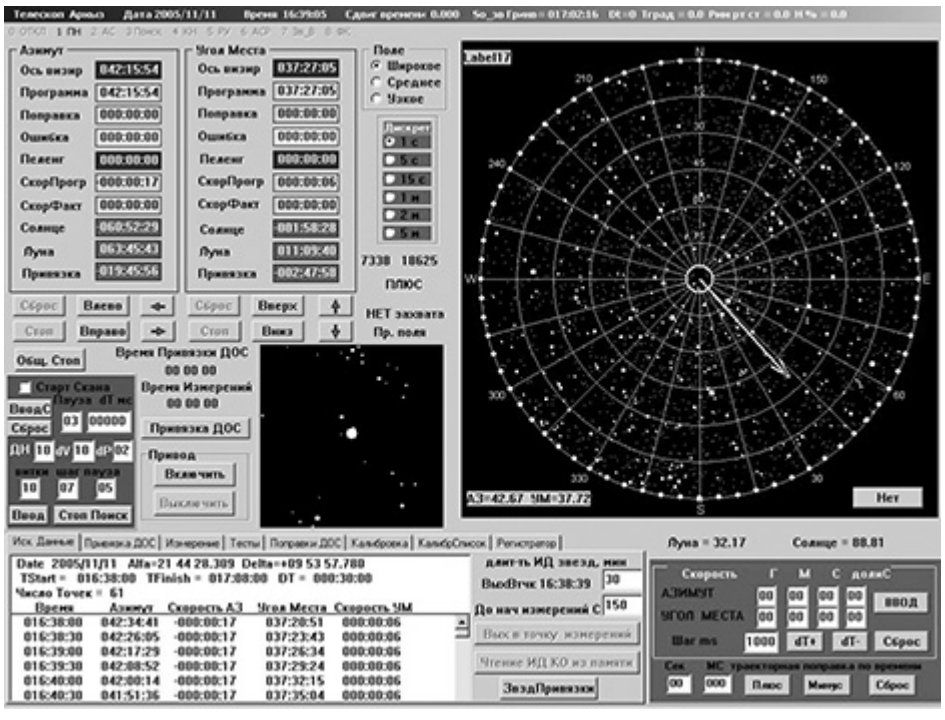
Figure 2*: Operation site with installed equipment (containers and telescope)*

***Figure 3**: Mobile station preparation for operation*

***Figure 4:** Mobile station during transportation*

***Figure 5**: Mobile station in operation*

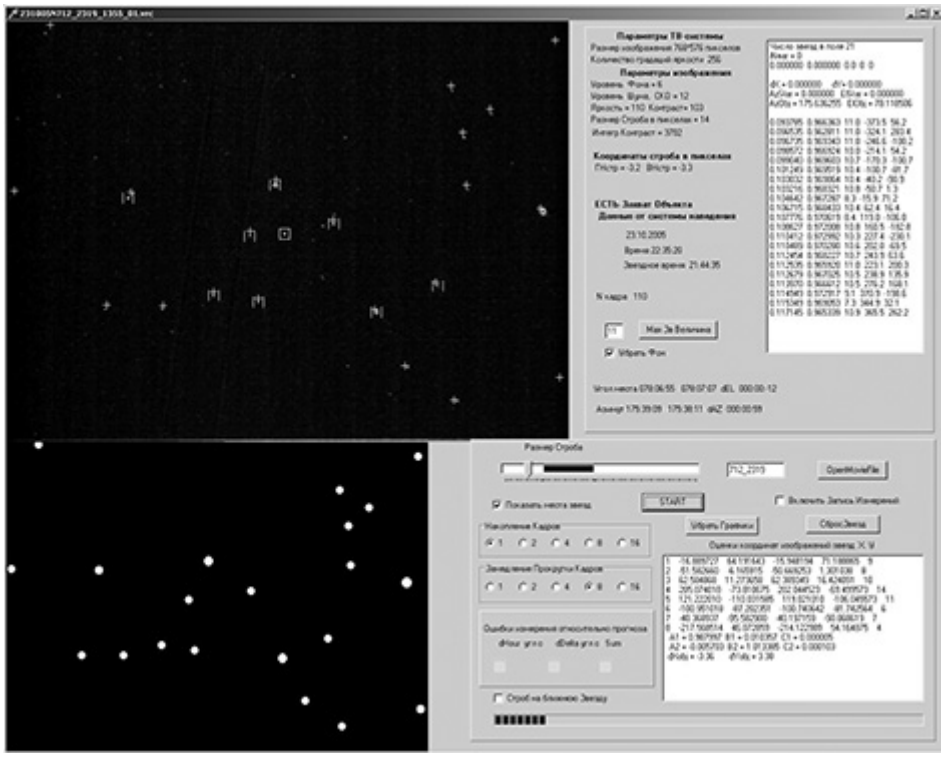
***Figure 6**: Mobile station operator workspace*



Right: image of star catalog.

Center: image of calculated catalog star positions in the TV camera field of view (around the telescope pointing direction).

***Figure 7:** Versatile pointing/tracking control virtual panel*



Upper left: TV frame with GLONASS-712 spacecraft in the center.

Lower left: star catalog fragment. + marks: position of catalog stars in the TV frame.

II marks: star tracking gates (stars selected for spacecraft angular position measurements).

Figure 8: *Versatile angular measurement (astrometric) virtual control panel*

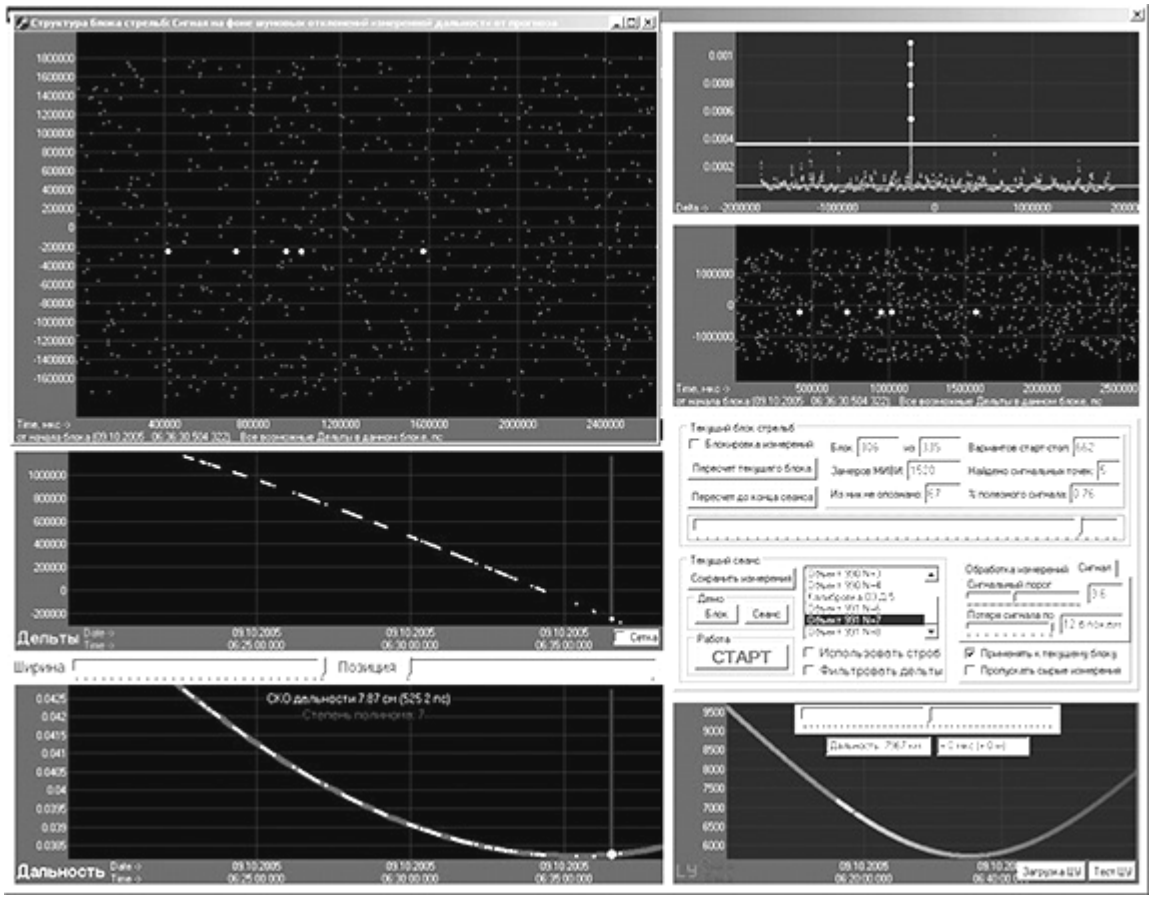


Figure 9: *Laser ranging control virtual panel (daytime observation of LAGEOS)*