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 Instrument Engineering (IPIE). Putting the stations in operation will expand the Russian Laser Tracking Network to 6 stations.

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: ≤ $0,2^m$

DESIGN FEATURES OF THE COMPACT STATION

- The weight of any single unit of the system (in package) does not exceed 50 kg with system total weight less than 300 kg. Thus, no special lifting mechanisms are needed for installation.
- An autonomous housing for the optical unit and mount allows installation on a small base, without erection of a special tower.
- Low power consumption (≤ 2,5 kW) allows supply from single-phase mains or from a portable power generator.
- Low cost in serial production and simple technology provides manufacturing by existing industrial firms.

COMPACT SLR STATION IN OPERATION

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.

Autonomous cover of the compact SLR station

Right half of the housing is installed

COMPACT STATION OPERATOR'S WORKPLACE

All electronic equipment is on desktop

Pointing/tracking system and mount of the compact station

Mount parameters

- Mount type: Az-El, with two flanges for equipment mounting
- Digitally controlled high-torque motor drive
- Equipment weight on each mount flange: ≤ 20 kg
- The mount is provided with an autonomous housing
- Angular rotation range:
  - Elevation: 5 to 95 deg
  - Azimuth: - 278 to +278 deg
- Maximal angular speed 30 deg/s; maximal angular acceleration 30 deg/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: ≤ $0,2^m$

Operation site with installed equipment (containers and telescope)

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 Kazakhstan.

Mobile station under housing

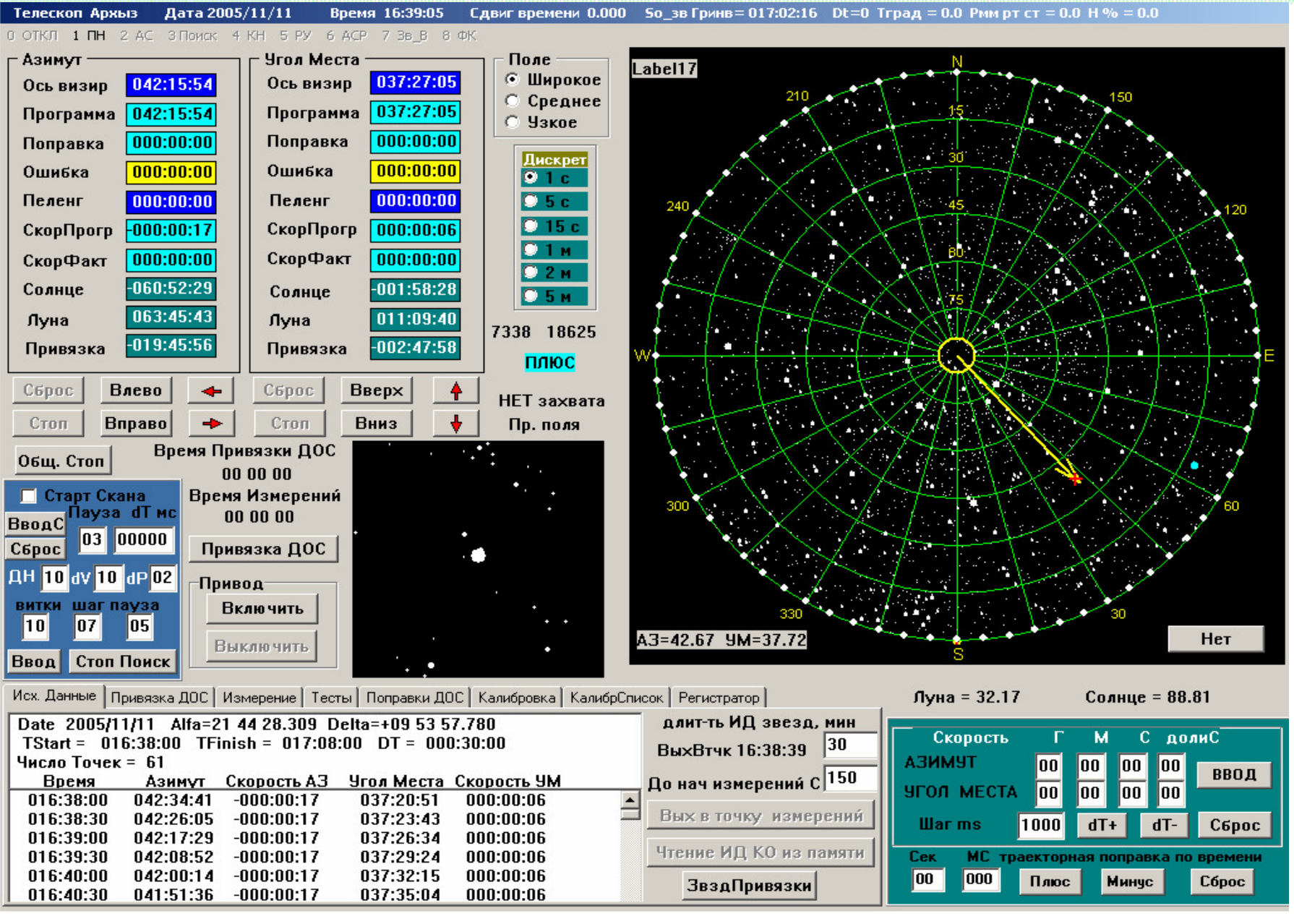
Mobile station during transportation

Mobile station preparation for operation.

Mobile station in operation

Mobile station operator’s workplace

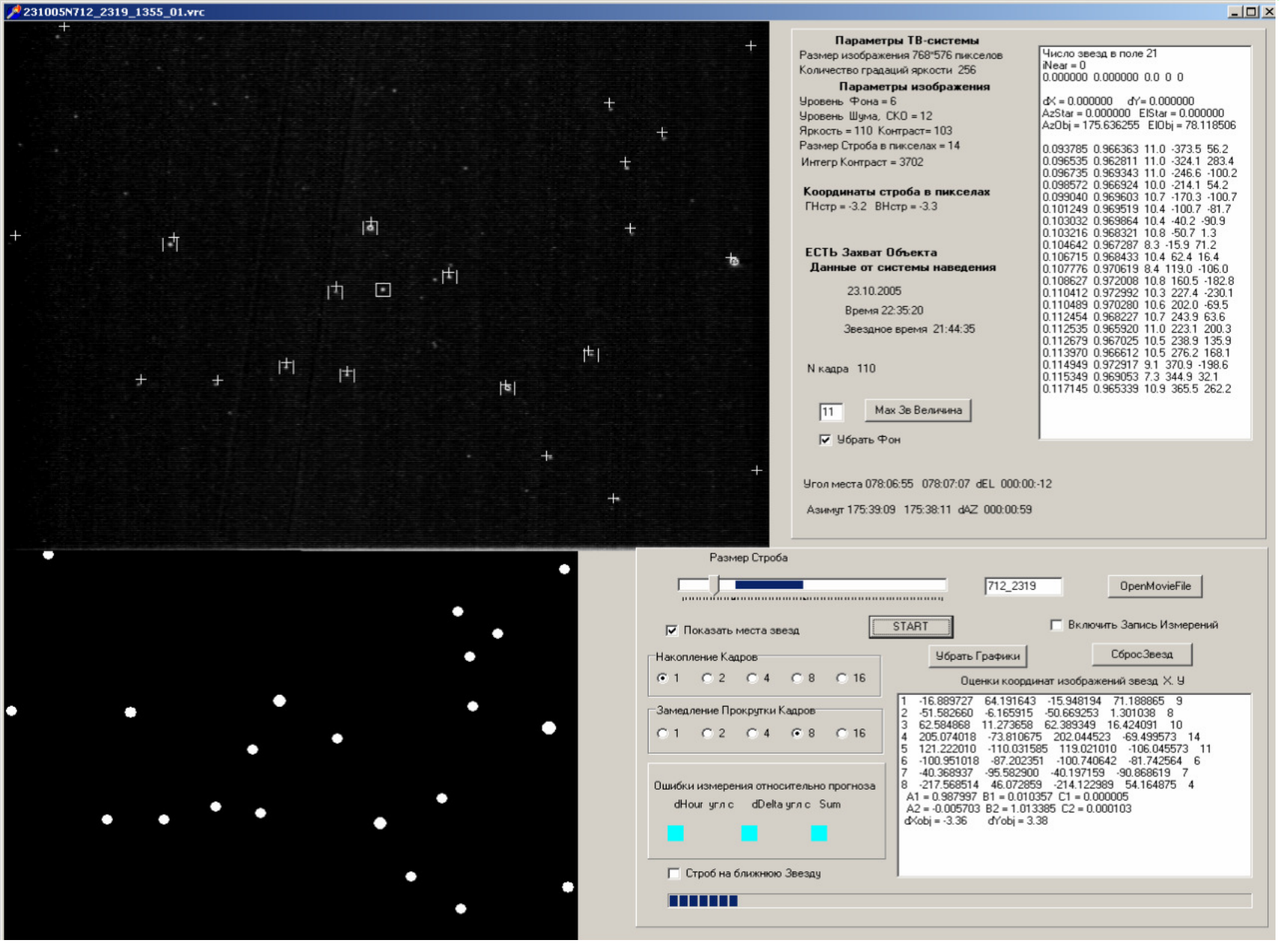
Versatile pointing/tracking control virtual panel



Right: image of star catalog.

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

Versatile angular measurement (astrometric) virtual control 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)

Stations 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 sm
- mobile station	60 sm
Timing accuracy (measurement position on time scale)	200 ns

Laser ranging control virtual panel (daytime observation of LAGEOS)