Compact SLR-system suitable for serial production

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Abstract

A compact system is developed in the Institute for Precision Instrument Engineering (Moscow) for laser ranging and measurement of angular coordinates using reflected sunlight. It is designed for use with satellites of various orbit height (up to GEO) and is capable of range measurements with RMS errors less than 1 cm. Angular measurements are possible with satellite brightness more than m=12. Real-time photometric observations of satellites are also possible.

The laser ranging and TV equipment is mounted in a fixed thermostabilized housing providing an output aperture of 50 mm in diameter. For beam collimation and pointing, an azimuth/elevation-type mount is used with a 250-mm telescope and a coude path.

For transportation, the three parts (telescope, mount, and laser system in housing) are separated, so that each transportable part weight is no more than 50 kg.

The system is provided with a shelter, and is powered from 220 V AC mains, so it does not need any construction works for its installation.

Introduction

To quickly restore the Russian SLR network after its deterioration with the fall of Soviet Union, the Russian Aerospace Agency two years ago decided to start a development of a compact SLR-station suitable for serial production.

The system design should provide a low cost of equipment as well as minimum expenses for construction and installation.

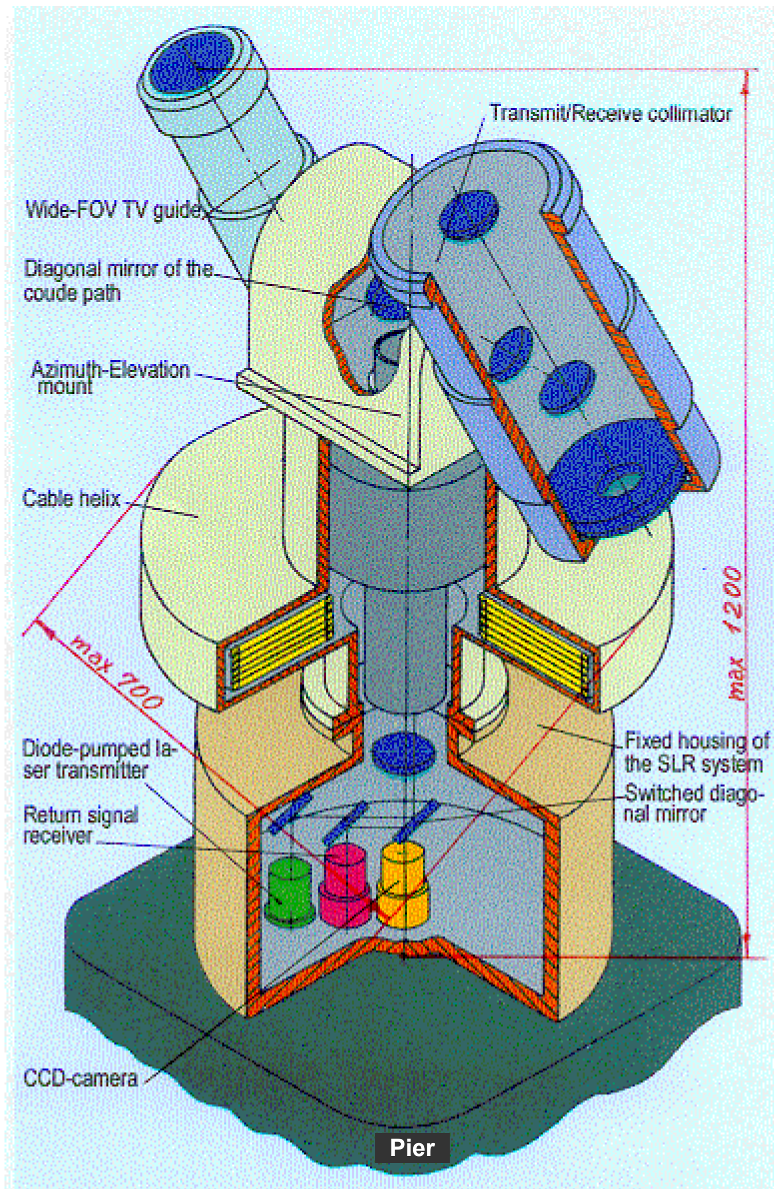
To minimize the number of required stations, the SLR-station should provide mobility and quick installation without use of special machinery. The equipment should be powered from mains, with low power consumption.

To minimize the expenses for construction, instead of a tower with a dome it has been decided to use an optical system with an autonomous shelter and an electronic equipment operating in standard office-type rooms. It was also necessary to minimize the deployment time.

In 1998, the Institute for Precision Instrument Engineering won a tender for this work, and during the 1990-2000 period the system design has been made.

Currently all parts of the system are in production. The first system should be finished in mid-2001. Until end of 2001, it is planned to finish its field tests, an in 2002 to start serial production of such systems.

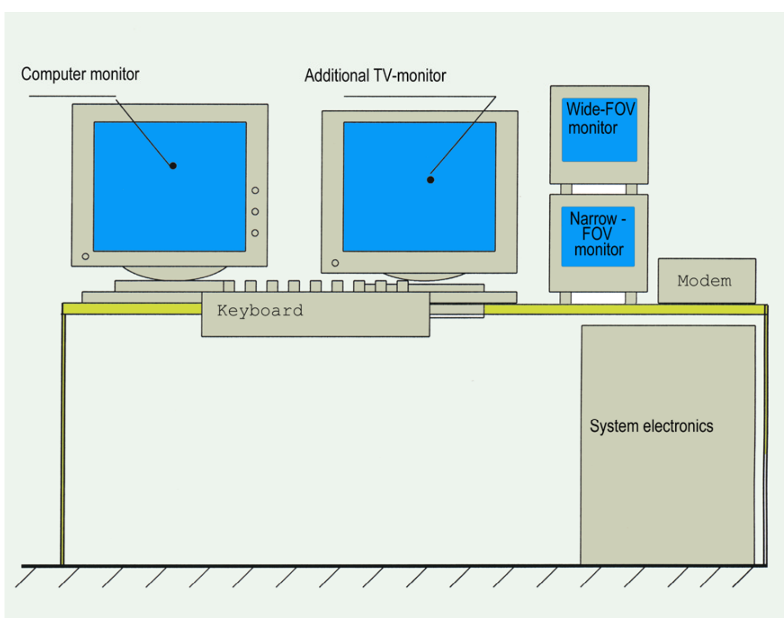
The basic system parameters and technical solutions used to meet the specifications are presented below.



Optical system structure of the compact SLR system

Basic system parameters

- Measurement of distances to spacecraft with orbit height 400 to 36,000 km, with an RMS error less than 1 cm at elevations exceeding 20 deg.
- Measurement of angular coordinates of sun-illuminated spacecraft with an RMS error 2...5 arcsec (depending on the spacecraft angular velocity) for spacecraft brighter than 12-th star magnitude.
- Real-time measurement of spacecraft brightness (for spacecraft brighter than 10-th star magnitude) with an RMS error less than 0.2 star magnitude.
- The measurements should be made at elevations more than 20 deg. The dead zone near zenith should not exceed 5 deg.
- Ranging should be made by a near-zenith atmosphere transparency better than 0.7, at any time (day or night).
- The system deployment time should not exceed 3 hours, including the system testing time.
- Maintenance/Installation team: 2 persons;
  Measurement team: 1 person.



System operator workspace

Basic solutions used in the system design

- A non-traditional optical antenna design. The laser ranging system and the TV system for angular measurements and photometry are mounted in a small-size thermostabilized housing; the output aperture is 50 mm.
- The azimuth-elevation mount for beam pointing and tracking has a coude path and a collimating telescope 250 mm in diameter, fastened over the ranging system output optical system. At the second flange of the mount a wide-FOV (2.2 deg.) TV guide is installed.
- The optical system may be dissembled for transportation. The ranging system in its housing, the mount, the collimator, the wide-FOV guide, and the electronics are transported separately (in separate cases). The weight of each part does not exceed 50 kg; the total weight is less than 150 kg. No special equipment is needed for installation and dismounting.
- The optical antenna is mounted on a small pier or on a separately supplied tripod. No shelter is needed. The electronic equipment is placed on a table, in a suitable room with warming.
- The system is powered from a single-phase 220 V AC, 50 Hz mains. The power consumption does not exceed 2.5 kW.
- For the azimuth and elevation drives, torque motors are used providing angular velocities up to 30 deg/sec. The drives are controlled by a digital pointing/tracking system with 21-bit resolution sensors (0.44 arcsec). The system provides an RMS tracking error less than 1 arcsec.
- In the ranging system, a compact laser transmitter is used with laser diode pumping, providing the following parameters:
  - pulse width: 250 ps
  - output energy: 1 mJ
  - pulse repetition frequency: 100 Hz
  - wavelength: 532 nm

- A PMT is used as a photodetector. Preliminary design is made for a transfer to the 1064 nm wavelength; it is intended to use an Intevac TE-IPD photodetector with a quantum efficiency ≥8% at 1064 nm. It may considerably improve the system power budget.

- In the TV system, a high-sensitivity CCD with a special filtering system is used, providing observation of 14-th star magnitude objects within a 10x10 arcmin FOV.

- The TV system may be used for calibration of angular-measurement sensors by comparison with catalogue stars, for tracking monitoring of sun-illuminated satellites, as well as for angular measurements and real-time photometric observations of satellites.