Progress in Laser Systems for Precision Ranging, Angle Measurements, Photometry, and Data Transfer

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The following recent developments of the Institute for Precision Instrument Engineering (Moscow) will be briefly reported:

- **Upgrading and testing of a compact easy-deployable station for SLR, angle measurements, and photometry.**

  Test sessions demonstrated the capability for daytime ranging of GLONASS satellites with a receive optical system of only 25 cm in diameter.
  Orders for fabrication of more than 20 such stations have been received – mostly for GLONASS spacecraft monitoring, space debris observations, astrometric and photometric observations of geostationary spacecraft, etc.
- **Astrometric and photometric observations with a 35-cm-diameter wide-FOV optical system and a 16-megapixel CCD demonstrated a capability for observation of stars up to 19-th magnitude at nighttime and up to 5-th magnitude at daytime (using color and polarization filters), while angle measurement accuracy of 0.4 arcsec has been achieved.**
- **The BLITS (Ball Lens In The Space) experiment is planned to start late 2008. What are the possible benefits from a satellite with a target error less than 0.1 mm?**
- **Development of an intersatellite ranging / data transfer link for upgraded GLONASS satellites using (transponder) ranging technology.**

  An early one-way laser link experiment will be also reported.

SAZHEN-TM Modular Laser/Optical System (laser ranging version)

Purpose:

- **Precision orbit parameter measurement**
- **Photometry (using reflected sunlight) for failed**
- **Spacecraft and space debris monitoring**
- **Precision measurements of missile flight**
- **Trajectories during test flights (at testing sites).**

Parameters:

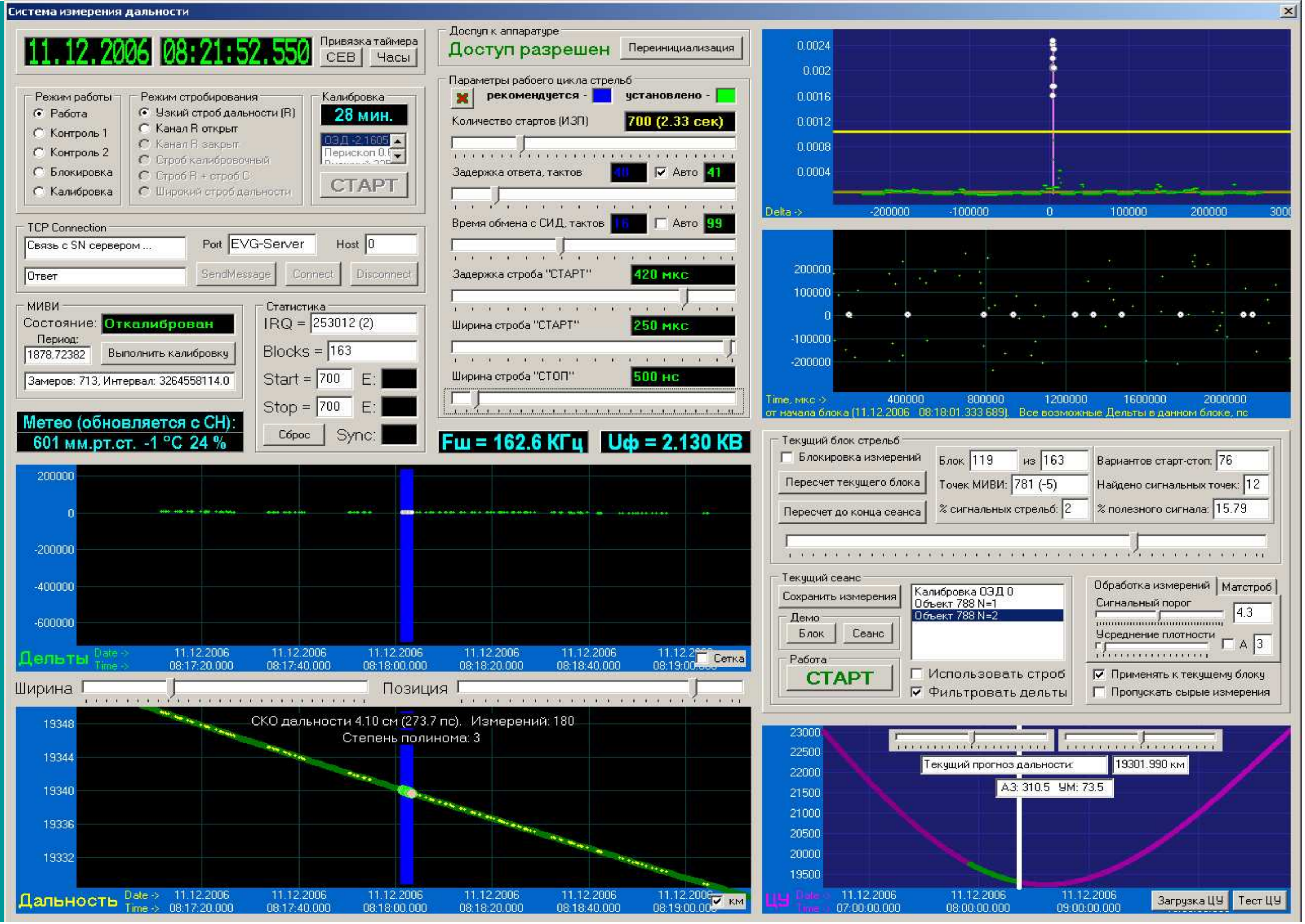
Nighttime ranging measurements with spacecraft orbit heights 400 to 25,000 km daytime measurements with orbit heights up to 6,000 km; ranging RMS less than 1 cm.

Angular measurement RMS 1…2 arcsec (up to 14th star magnitude).

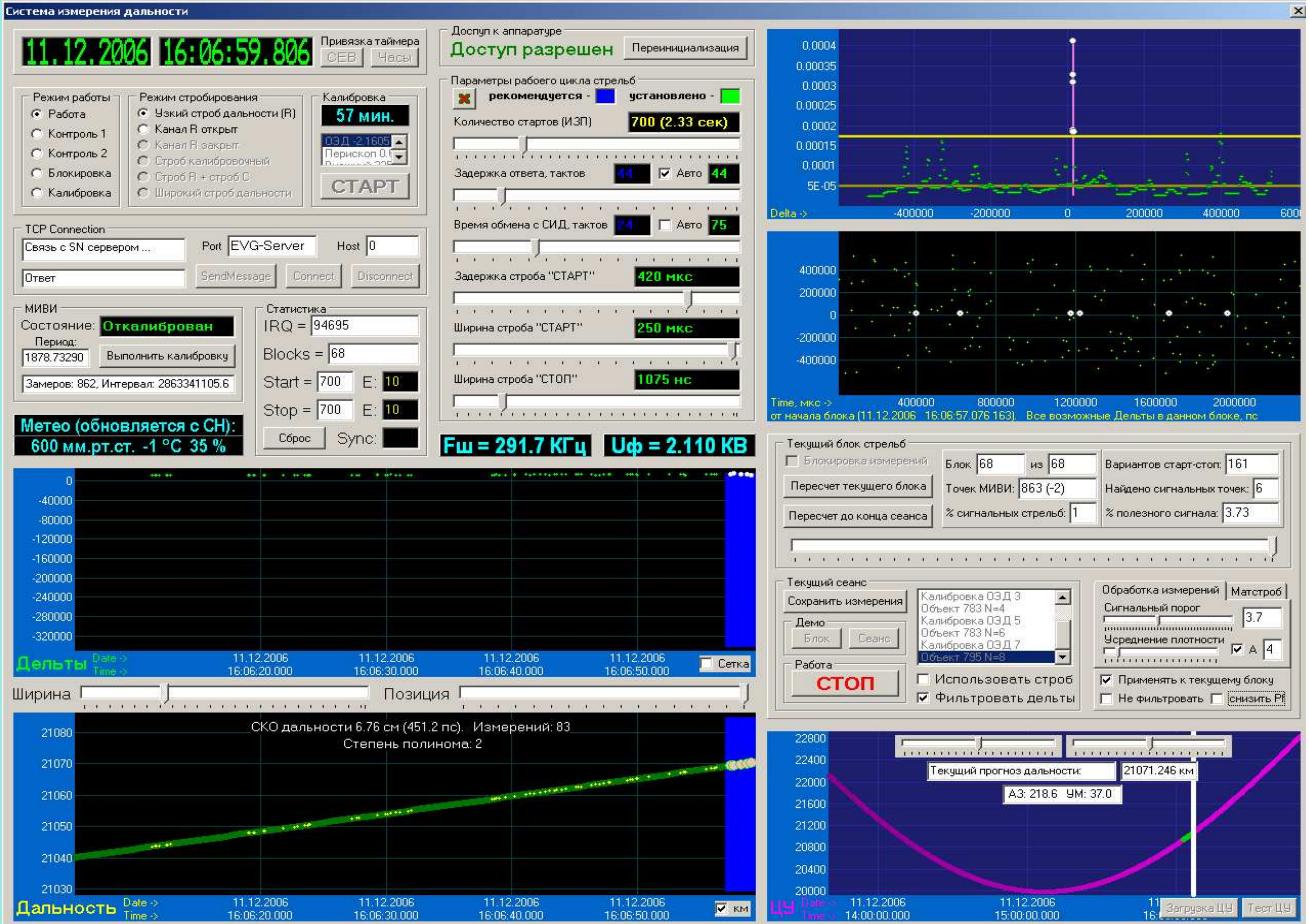
Brightness measurement accuracy better than 0.2 star magnitude units (at up to 10th star magnitude).

Twin optical system diameter 25 cm; laser pulse repetition rate 300 Hz; pulse energy 2.5 mJ; mount weight (including laser/optical modules) 120 kg.

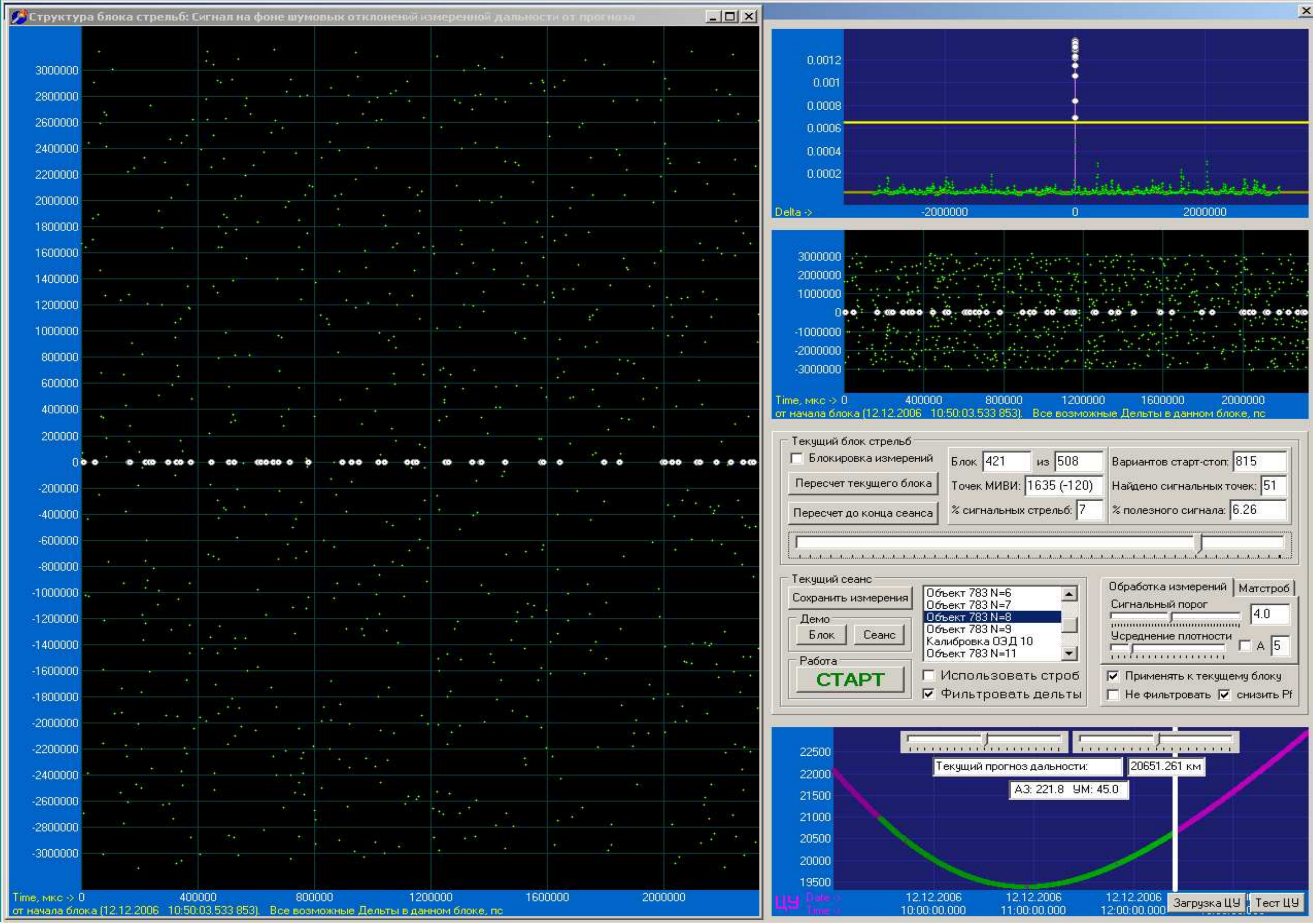
SAZHEN-TM Daytime SLR, GLONASS-84 (132-RR array) 11.12.2006, $08^h 21^m$ LT, El=73.5 deg., return rate ~5 cps (2%)



SAZHEN-TM Daytime SLR, GLONASS-94 (132-RR array)
11.12.2006, 16^h 06^m LT, El=37 deg., return rate ~3 cps (~1%)



SAZHEN-TM Daytime SLR, GLONASS-83 (396-RR array)
12.12.2006,10^{h} 50^{m} LT, El 45 deg., return rate ~22 cps (7%)



SAZHEN-TM Laser/Optical System
(video theodolite version)

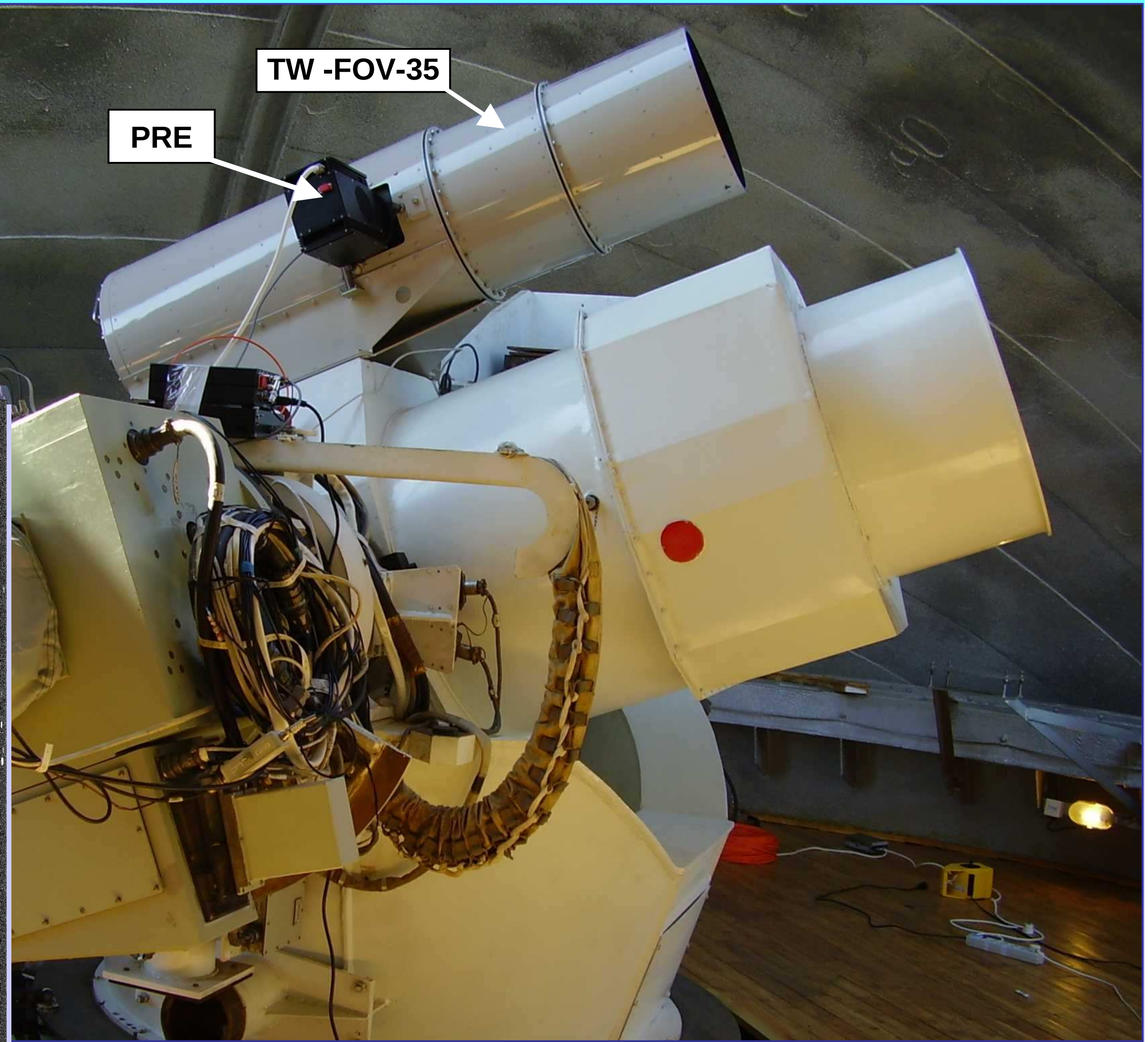
Purpose:

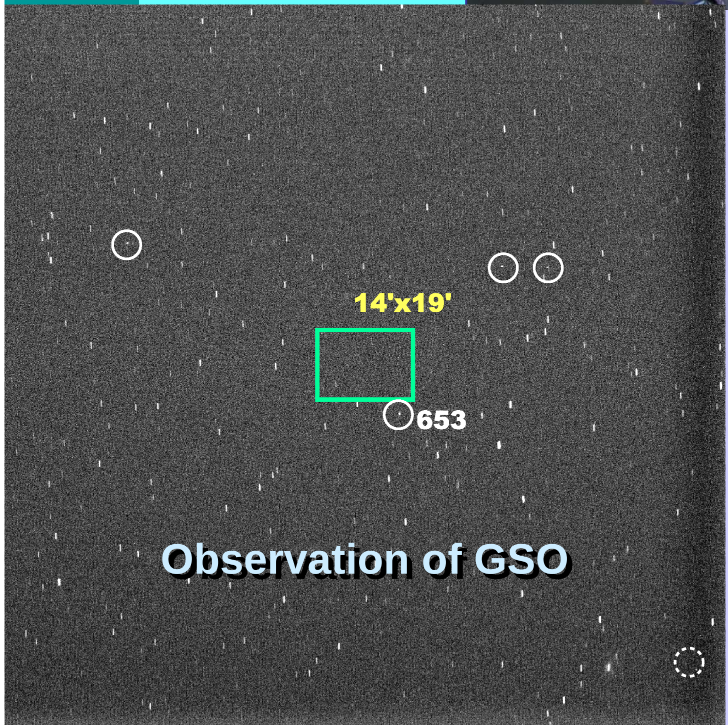
Target flight phase registration, angular measurements, and TV image provision during tests on cosmodromes and launching sites.

Parameters:

- **Point target angular measurement RMS no more than 5 arcsec**
- **Target tracking angular velocities up to 30 deg/sec**
- **Angular accelerations during tracking up to 150 radian/sec²**

35-cm-diameter wide-FOV observation and measurrment system within the Altay L/O Center

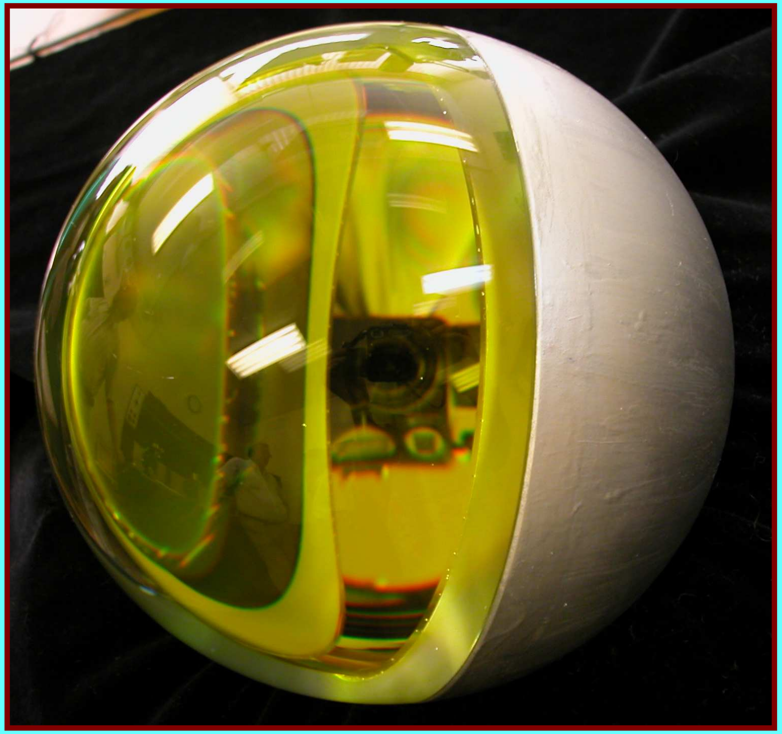




Zero-Signature Spherical Retroreflector Microsatellite (BLITS)

Microsatellite parameters

- Diameter: 17 cm
- Mass: 7.46 kg
- Cross-section: ~100,000 sq.m at λ=532 nm



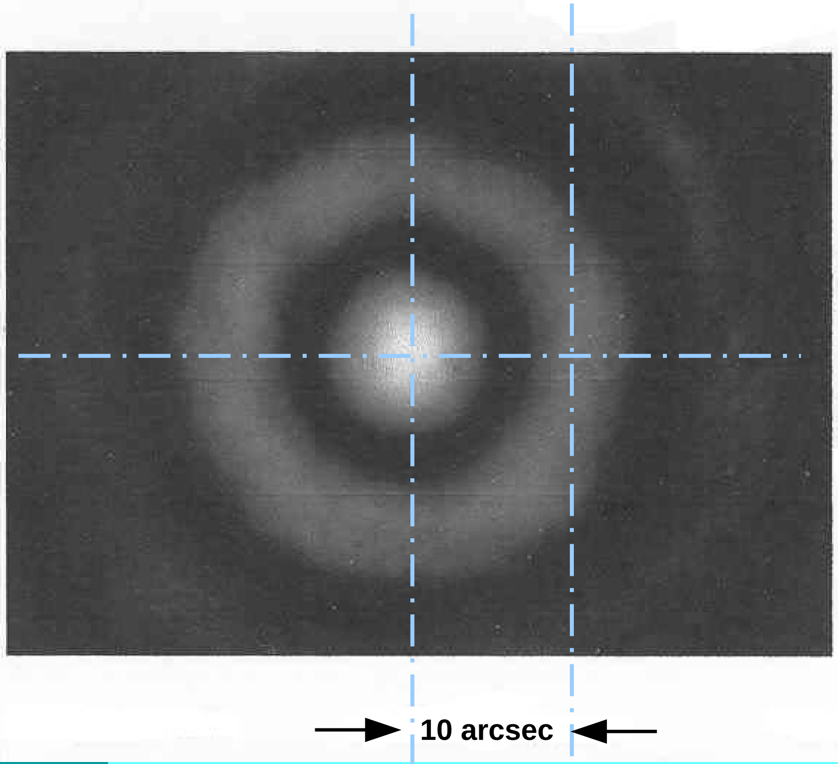
Current status

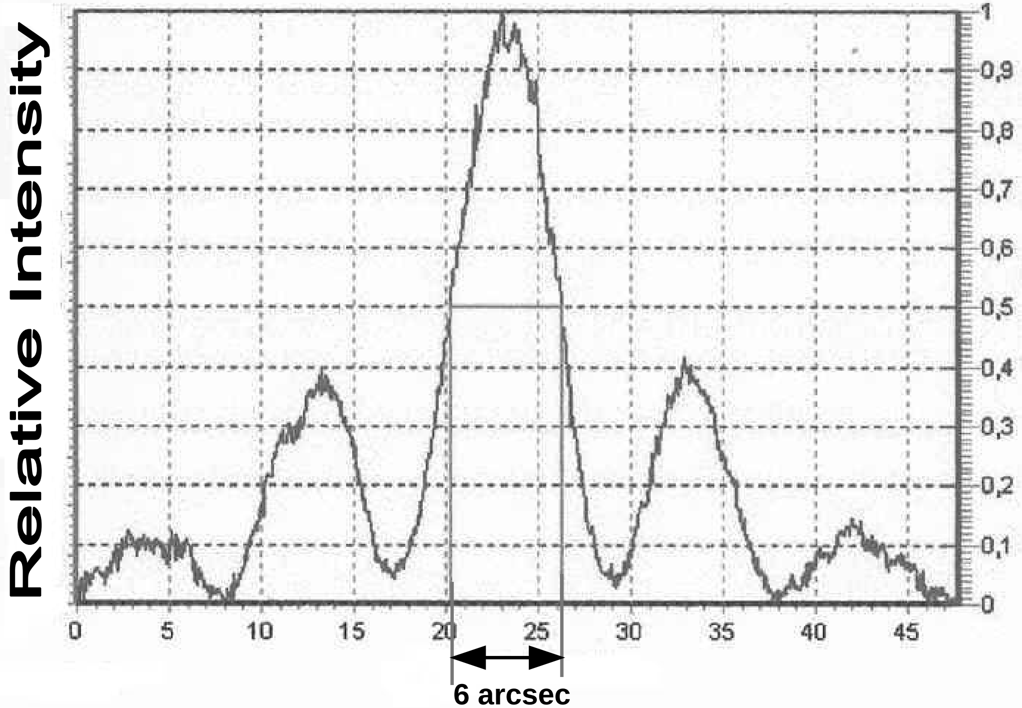
- Return pattern measurement under varying ambient conditions
- Separation system development

Mission

- Carrier satellite: METEOR-M
- Carrier satellite orbit parameters: Height: 835 km (circular)
  Inclination: 99.7°
- Planned launch date: Late 2008

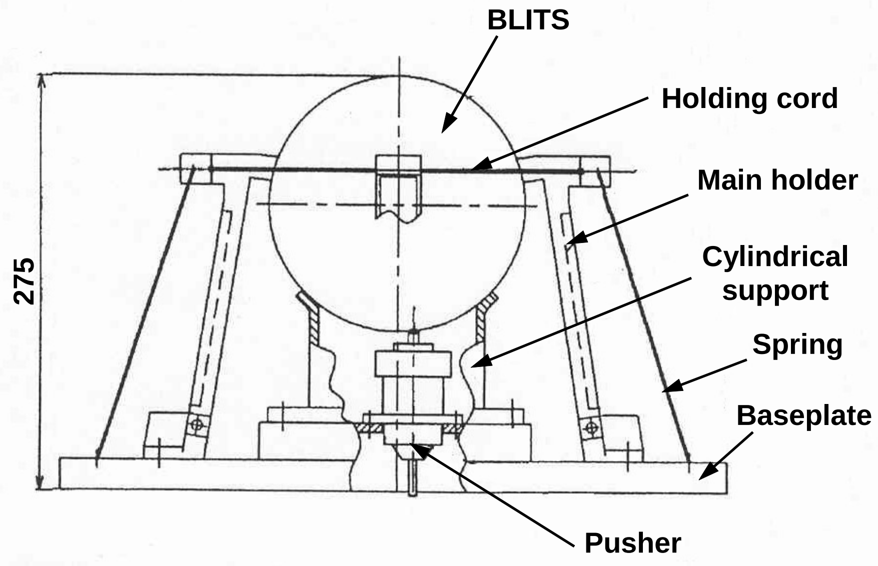
Far-field diffraction pattern

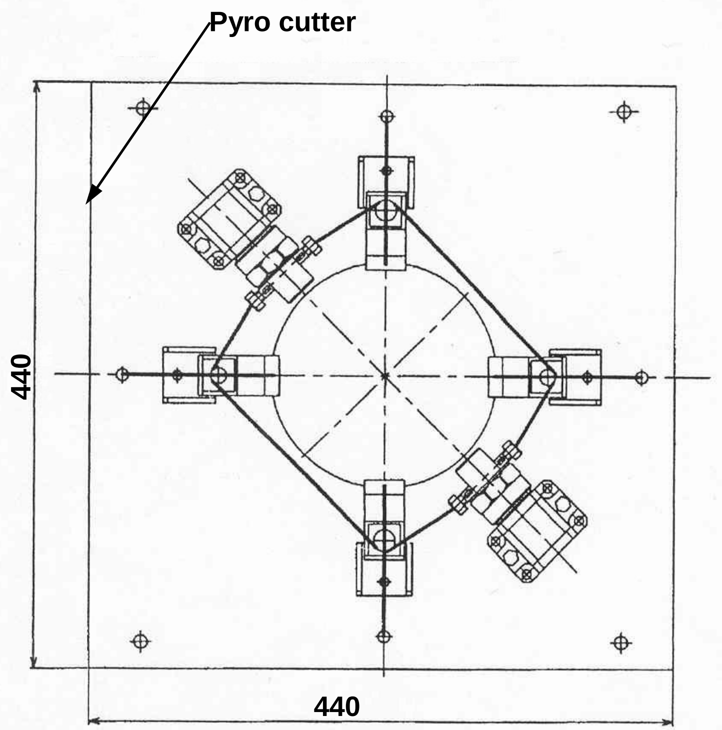




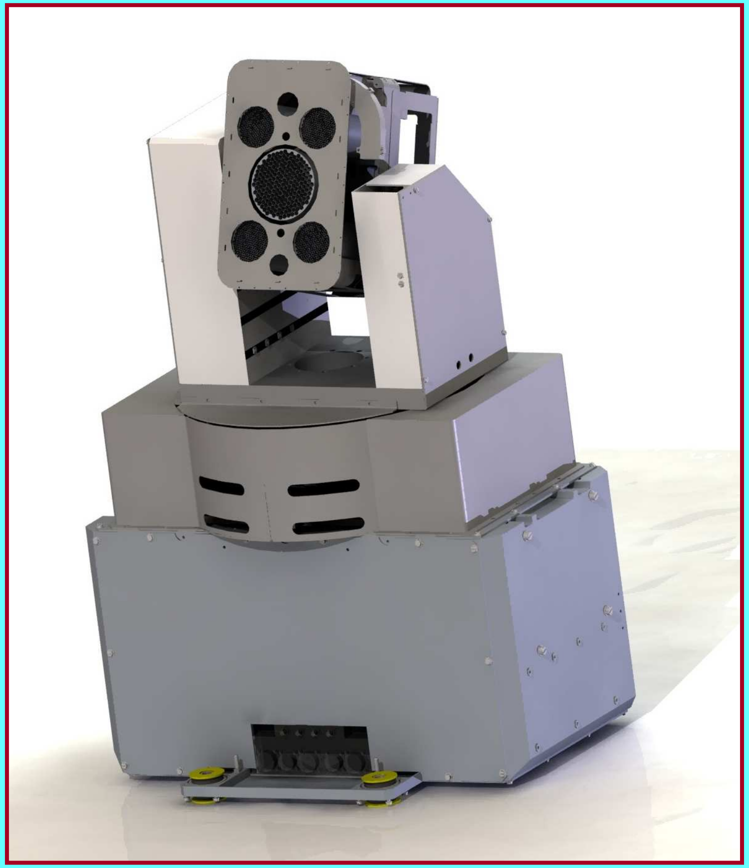
Most of the return signal energy is in the first-order annular mode

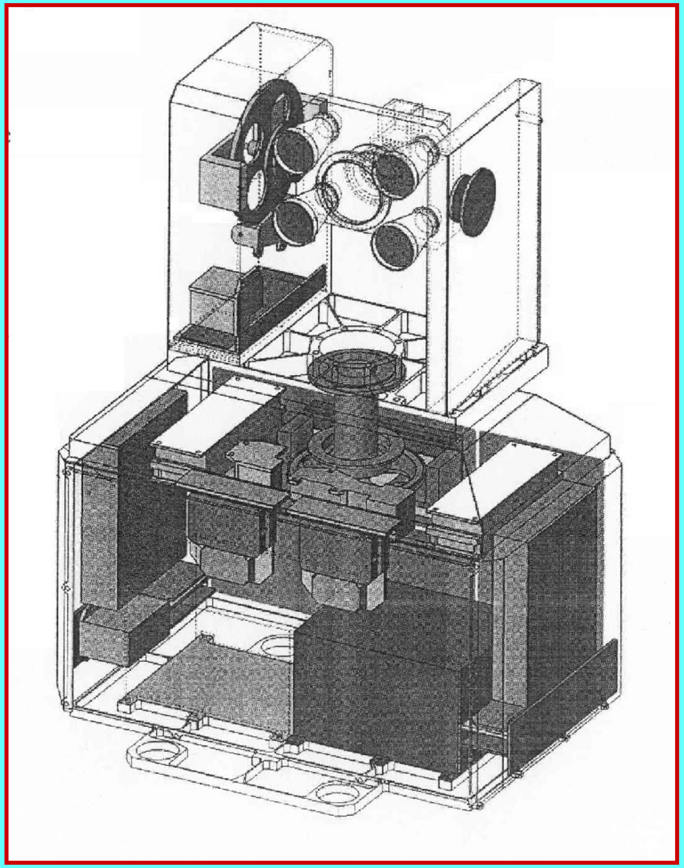
BLITS Separation System





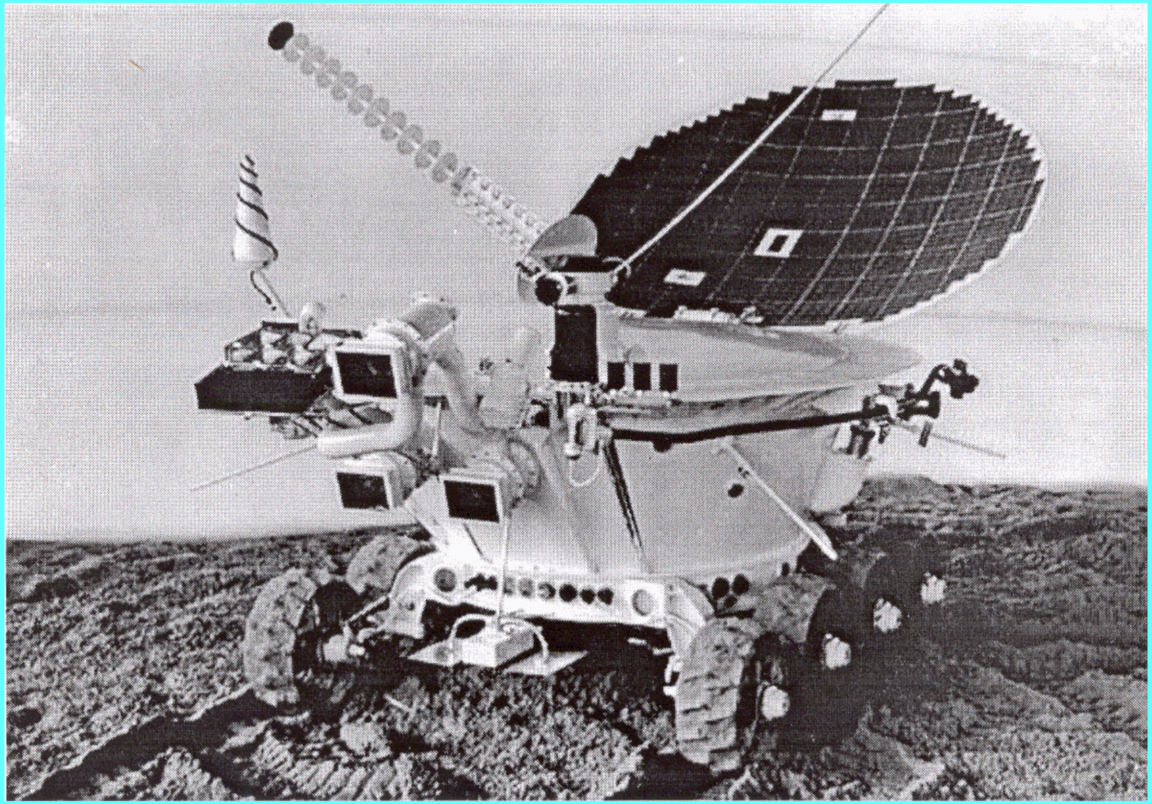
Intersatellite Time and Data Transfer System (ITDTS)



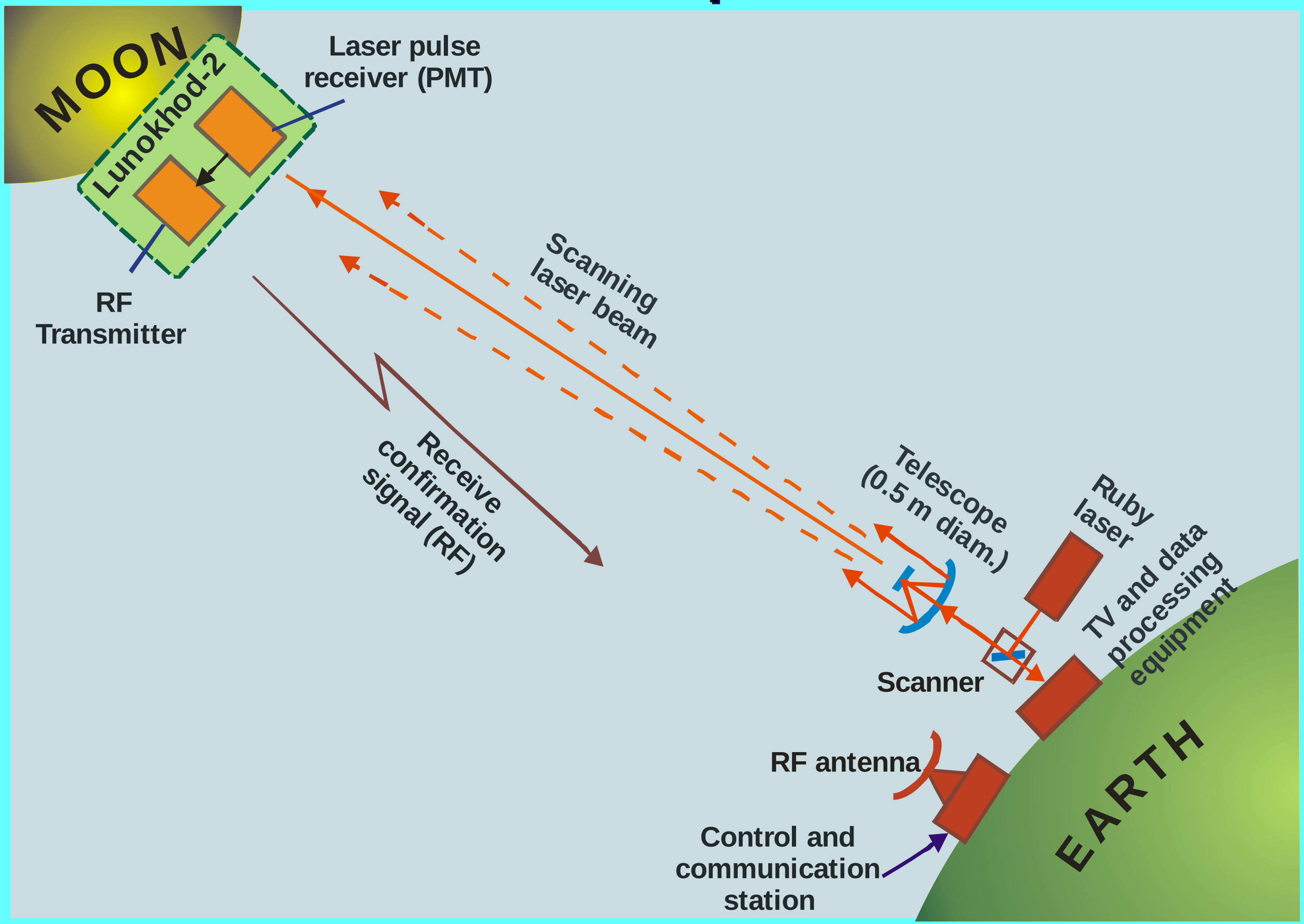


- Maximum range: 51,000 km
- Timing precision: 0.3 ns
- Data transfer bitrate: 5 kbps

Lunokhod-2 (Luna-21 lunar rover)



Lunokhod-2 Landing Point Position Determination Experiments



Successfully implemented early 1973, identifying the landing point position (within the Lemonier lunar crater) with an accuracy of ±0.5 km (~0.25 arcsec).