

# REFLECTOR, LARETS and METEOR-3M(1) what did we learn from tracking campaign results

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## Abstract

Brief description is presented of main observation results, as well as conclusions and recommendations drawn from the campaign results.

## REFLECTOR

The REFLECTOR microsatellite detailed description was presented at the 12-th Laser Ranging Workshop in Matera (Italy), and later some observation results were presented in Washington, DC (USA) during the 13-th Laser Ranging Workshop. The specialty satellite (Fig. 1), designed exclusively for calibration of large active optical observation systems, has been successfully tracked during a period from 21.12.2001 to 07.03.2003.



Figure 1. REFLECTOR microsatellite outlook

The REFLECTOR satellite has the following orbit parameters:

Major semiaxis of the orbit	7391 km
Inclination	99.64 deg
Eccentricity	0.0008
Orbit height	1018.63 ±10.71 km
Orbiting period	105.34 min

The tracking campaign results demonstrated the operability of its passive attitude control system, while the oscillation damping (with help of magnetic hysteresis rods) was slower than anticipated prior to launch (Fig 2).

The SLR observations also demonstrated that, using adequately arranged retroreflectors (or RR groups) on board of a spacecraft (SC), it is possible to determine the SC attitude from distance measurements at any moment with an accuracy sufficient for practical purposes (Figures 3 and 4; the data were kindly provided by the Herstmonceux SLR station staff).

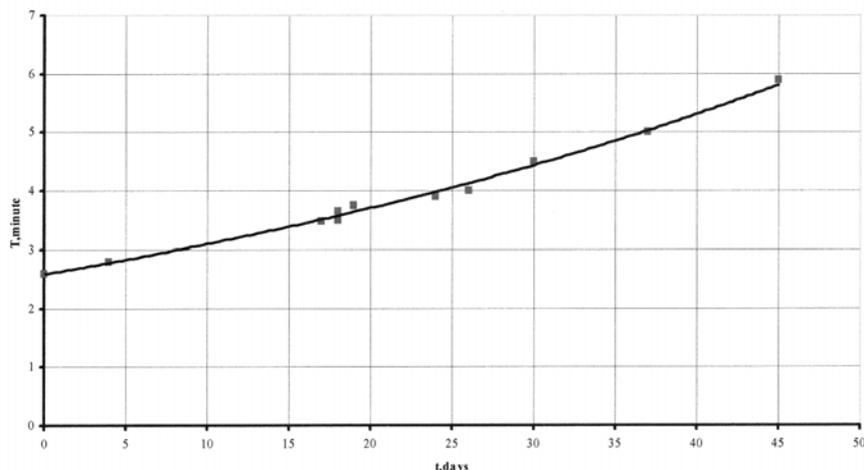


Figure 2. Variation of the period of fluctuation (rotation) REFLECTOR satellite (from the results of observations 23.12.2001 to 06.02.2002)

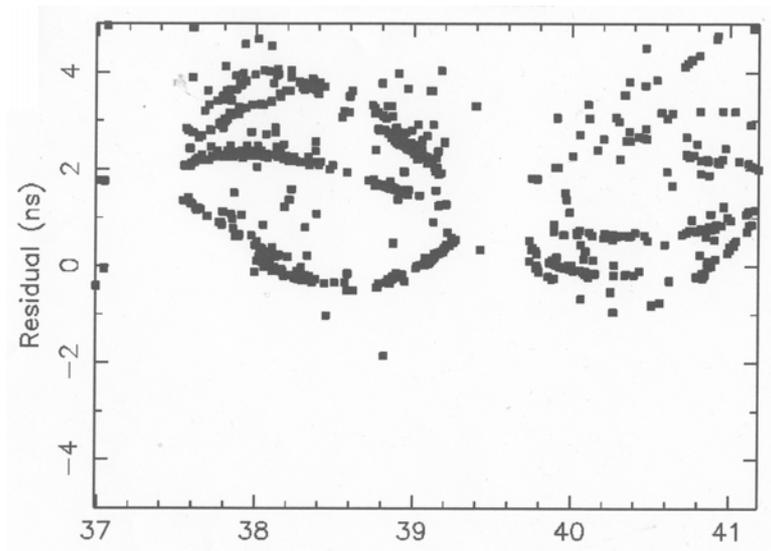


Figure 3. Pass 637 REFLECTOR. 19.01.2004, 21 hrst+

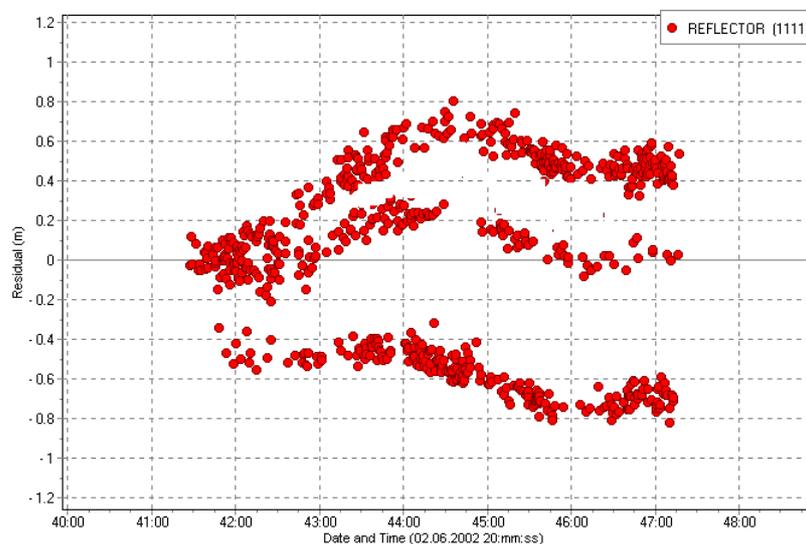


Figure 4.

After termination of the ILRS tracking campaign, the REFLECTOR microsatellite is open for observations in accordance with its basic purpose.

### LARETS



The satellite (Fig. 5) is a modified version of the formerly launched GFZ-1 and WESTPAC (a spherical brass body 21.5 cm in diameter, 23.9 kg mass, carrying 60 cube corner retroreflectors). The CCRs are recessed in the brass body to limit the single CCR field of view (instead of using external baffles, like on WESTPAC). Thus, we increased the target cross-section, and eliminated the dead time intervals between the bursts of return signals, typical for WESTPAC. LARETS has also a much higher rotation rate than WESTPAC. The RMS target error of LARETS (about 1.5 mm) is only slightly more than with WESTPAC, while the cross-section, according to preliminary estimations, is approximately one fourth of that one of STELLA and STARLETTE, but much higher than that one of WESTPAC.

Figure 5. LARETS. Orbit height 690 km.

Used for scientific and applied tasks in geodesy and geodynamics

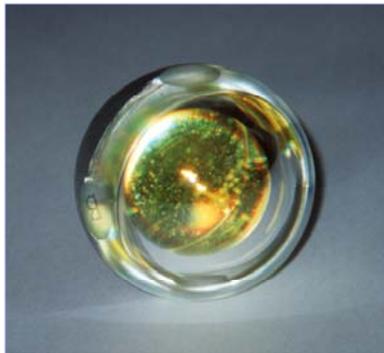
The LARETS satellite appears to be a reasonably successful design. Observation results demonstrate that actually a single cube corner reflector is active at any moment of ranging. We are very interested in the SLR community opinion on preferable orbit heights where the application of such a satellite will be most efficient.

Currently, an investigation program is conducted to estimate the LARETS characteristics, as well as effort to use it for calibration of high-accuracy optical and microwave measurement systems. Therefore, we ask to extend the LARETS observation campaign for one year more.

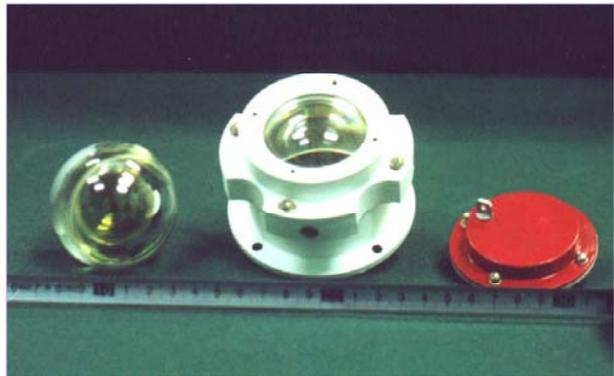
### METEOR-3M(1)

The operational principle and design of the retrereflector based on the optical Luneberg lens idea has been reported at three previous Laser Ranging Workshop (Deggendorf, Germany, 1998; Matera, Italy, 2000; Washington DC, USA, 2002).

The first experimental spherical retrereflector, 6 cm in diameter, mounted on board the METEOR-3M(1) spacecraft, has been successfully tracked during 2.5 years. The initial part of tracking campaign demonstrated a good agreement with pre-launch predictions based on theoretical calculations and lab measurements (Figure 6). A preliminary analysis of the campaign results shows that the initial cross-section value has gradually decreased; this is possibly due to the non-radiation-resistant glass used in the experimental retrereflector (the initially planned observation period was only 6 weeks — just to verify the design parameters).



RR outlook



RR and holder

Figure 6. First spherical retrereflector

Currently we have completed the manufacturing of two larger spherical retrereflectors (17 cm in diameter, and about 7,5 kg mass) (Fig. 7); after a period of parameter investigation, we will be ready for launching of at least one of them as an autonomous SLR satellite with a practically zero target error. Such a target satellite may be used for extreme accuracy measurements in geophysics, geodynamics, etc., and may stimulate further SLR hardware development to obtain better precision. The ILRS Government Board has addressed the Federal Space Agency of Russia to support an appropriate launching; IPIE will now take responsibility for organizing and preparation of a corresponding launching.

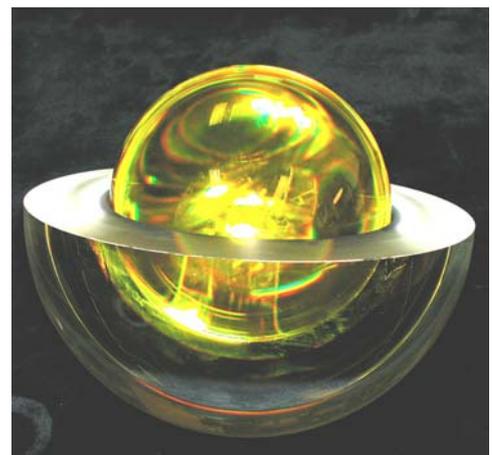


Figure 7. 17 cm-diameter spherical retrereflector (dissembled)