The Capacity of upgraded SLR LS-105 System Station
(ILRS code name 1884 Riga)
Results of Observations and Research

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The Riga SLR at sunset
The SLR technology is based on 2 fundamental constants: \( c \) in vacuum which is a defined value and the \textbf{second/hertz} which is one of the best physically realized magnitude.

All error sources are known/explained and can be corrected by modeling or calibration.

The SLR space segment is VERY cost-effective and long-lived, the \textbf{LaserRetroReflectors} do not need Power, Electronics or Telemetry.

The further the use of GNSS and Doris systems to define solutions of the \textbf{International Terrestrial Reference Frame}, needs to be tested against SLR to guarantee the full convergence of the individual reference frames.

All radio electronic Precise Navigation Systems on Board (GPS, Doris, PRARE) has to be calibrated against SLR orbital data.

All Altimetric and InSAR systems on-board needs to be calibrated against SLR data.

New advanced applications:
- Time transfer using the ISS (ACES experiment).
- Space Debris monitoring.
- Deep Space SLR tracking using transponders.
Why Riga SLR?

• The SLR station Riga 1884 is one of the oldest continuously operating SLR stations in the world.

• Currently the only operational SLR system in Northern Europe on the Baltic region.

• The SLR station in the area with the longest and consistent data set of measurements in the area, helping for the study of the long-term Geodynamical variations.

• It is an international space geodesy reference point contributing to the ITRF (International Terrestrial Reference Frame).

• The Fundamental Latvian Geodetic reference point is realized at the observatory by SLR and GPS/Glonass/Galileo measurements.

• The Riga high latitude permits measuring multiple passes per day on the satellite path while flying over the North Polar Area improving the sampling distribution for the orbital determination.
Key SLR subsystems using technology from the Soviet Era close to collapsing or below the current standards.

The efficiency of the system was decaying in an alarming rate. The number of measurements for the LAGEOS satellites was falling down to very low number.

In late 2012/early 2013 Riga SLR Station was not able to get returns from LAGEOS 1&2.

Missing new technologies which are becoming standard in the SLR community for international security requirements: ADS-B receiver for air traffic surveillance monitoring, All-Sky camera, Wide field TV Camera.

Regular observations are now limited to night time, with the satellite illuminated by the Sun. The observational paradigm and data flow need to be updated.

The hardware/software available is a limiting factor to reach the maximum observational potential of the SLR Riga 1884.
Modernization and Upgrading, main points

- **Replacement** of obsolete equipment.
- **Introduction of new technologies** to improve the operational capabilities and to agree with international security requirements.
- **Upgrading the calibration and test equipment** to control the system performance.
- **Improving the operating conditions** at the SLR building.
- **New computers** and supplementary equipment.
- Secondary meteo station.
- **Recovering and updating operational know-how** and methodologies.
- **Upgrading the SLR hardware**.
- Full **experimental analysis** of the Receiver Chain.
- **Improvements** on the current SLR control and operational software.
- **Calibration** against external standards.

- An important upgrading for the Observatory: A new IGS/EUREF GNSS receiver with GPS/Glonass/Galileo capability.
Operation Schedule During the Upgrade

Normal points measured during 2011-2015
Operation Mode During the Upgrade

- The station is not working regularly.
- After a round of modifications a short observation campaign is done to insure that the SLR is working properly and identify any problem.
- Then tracking stops for the next round of tests/modifications.
- The official status of the Riga 1884 SLR station at the International Laser Ranging Service is on **upgrading mode** marked as **active/quarantine**.
- The test data is accepted and analyzed but the final official release of all the data will be done once the regular tracking starts again and sufficient amount of new LAGEOS data is delivered.

- Not all the upgrades can be done at the same time.
- Any modification/exchange of the SLR control software cannot, and will not, be carried out until all the new telescope hardware components and associated electronics are installed, tested and operationally available.
Main results, up to now

- The reference time and frequency standard has been upgraded, its operation simplified, and its performance compared and calibrated.
- The SLR internal calibration stability is improved and its single calibration RMS reduced using a new single mode optical fiber with improved optical coupling and thermal stability.
- The new test and measurement equipment allows to measure, evaluate and doing diagnosis not possible before.
- The updating of the Telescope mount model and the improved optical alignment already gives a better satellite pointing stability.
- The telescope and monument stability was verified.

The Final Goal:

Once all the new hardware, electronics and software became operational, regular “night in shadow” and daylight tracking up to the GPS-like satellites will be possible, increasing the station data value, precision, resolution and productivity.
Publishing the Results

- For the SLR community a main venue for publications and presentations are the International Laser Ranging Workshops, supported by the ILRS.
- During the period 2012-2014, two International Laser Ranging Workshops has been carried out:
  - 18th in Fujiyoshida, Japan (2013)
  - 19th in Annapolis, USA (2014)
- We participated on both with a total of 3 oral presentations and 4 Posters.
- One oral presentation at the 1st International Conference Nocturnal Atmosphere and Laser Ranging, Riga 2014.

Our participation in these events was supported by the

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A few Photos
Laser Mirror Head and Start Photodiode (old laser to the right)

Optical Head for the fiberoptics calibration loop
Time Service: Before and After

Including new Leica GPS and Air-Traffic monitoring ADS-B receivers
Dew control for the telescope optics

The New GPS/Glonass/Galileo Receiver Antenna
Doing Science...
...The Hard Way!
Paldies!

To the FOTONIKA-LV Team!
To all our external collaborators!