2017 ILRS Technical Workshop

Riga Latvia
October 02-05, 2017

Workshop Summary

Every two years the ILRS conducts Technical Workshops to focus on a few timely topics that impact the quality of our data products and our operations. These workshops are held in intervening years between the full International Workshops on Laser Ranging and are intended to provide time to articulate the issues carefully, allow for in-depth discussion, and formulate a path forward. The 2017 ILRS Technical Workshop, sponsored by the Institute of Astronomy at the University of Latvia and the ILRS, was held in Riga, Latvia, October 2-5, with the theme "Improving ILRS Performance to Meet Future GGOS Requirements". The workshop focused on addressing the following questions:

- What are the current and anticipated laser ranging requirements for the various satellites and have we defined them properly?
- How do we evaluate our current performance and is it adequate?
- What factors are currently limiting our network performance?
- What operational steps and tools would help us to better meet satellite ranging accuracy and scheduling requirements?
- What automation capabilities have been implemented or are planned for implementation, and what automation capabilities should stations consider?

Over 120 people from 21 countries participated in the meeting. The program included over 50 oral presentations, as well as many relevant posters.

The first day discussed user requirements and how well the ILRS is addressing these requirements. It started off with a reminder that laser ranging is one of the fundamental techniques for GGOS in its role of advancing our understanding of the dynamic Earth system by quantifying our planet's changes in space and time to:

- advance Earth science (Earth, oceans, ice, atmosphere, etc.)
- help us better understand the processes
- help us make intelligent societal decisions

The most stringent challenge for SLR comes from the mm reference frame requirement from GGOS, however other requirements such as altimetry and GNSS validation are not far behind.

Technologies are maturing; new technologies are on the horizon, and the core network is growing; international and political recognition (UN-GGIM) is increasing; and our space geodesy products (e.g., unified height systems, unified sea level model, natural hazard warning tools, etc.) require integration of measuring techniques.

A recent user survey revealed that that essentially all of the satellites on the ILRS tracking roster are being used in current research, but that data requirements varied greatly in terms of quantity and quality. Presentations were given on the requirements of several user disciplines

including the reference frame, ice and ocean altimetry, GNSS, CubeSat technology, time varying gravity field, and atmospheric drag.

(photo courtesy of Toms Grinbergs, University of Latvia)

Review of network output showed that some applications, in particular the reference frame and GNSS tracking, need better SLR global distribution of the stations and more uniform station performance. We also examined some ideas on how to rate station performance and task the stations in order to increase the total efficiency of the network. Several stations are supporting other applications such as tracking space debris and time transfer applications. These are certainly of interest and, at present, do not appear to have a significantly negative impact on the tracking schedule.

The second day of the workshop addressed how we evaluate our current performance. Work continues on the Station Systematic Errors Pilot Project and its conversion into an operational product later this year or early 2018. Examination of network data on SLR satellites over many years revealed interesting signatures correlated with the elevation and azimuth of the passes, day versus night-time conditions, and ascending vs. descending pass segments. These topics are under study, but the main focus is now on the primary sources of systematic errors that map directly onto geodetic products, such as errors in satellite center-of-mass models, data sampling issues, and incorrect modeling of system processing of return signals. Range measurement dependence on pulse length, rise time, signal strength, and detection system will need closer attention as we seek mm and sub-mm results.

T2L2 is providing an epoch standard for keeping track of timing errors throughout the network to levels of a few 10's of nsec. The new Russian "Tochka Station" configuration with two SLR systems offers greatly expanded satellite tracking coverage and frequent co-location to

enhance quality control. Presentations and discussion also covered new web tools, websites and on-line forums to encourage communication and distribution/sharing of diagnostic information.

The third day focused on obstacles that are currently limiting network output and operational steps that could improve ranging performance. The usual culprits were equipment problems, budget, weather (the usual), and daylight tracking limitations. Language and culture issues may be a communications problem in some cases; regional telephone conferences might help. Event timer replacement of time interval units (TIUs) by NASA has demonstrated a parallel data flow technique that allowed data from both paths to be viewed simultaneously for very detailed performance comparisons. Comparisons of single and multiple photon operations led to considerable discussions on operational convenience, range bias elimination, and data stability.

Studies continue on using correlation techniques on the return signals to reduce range biases (particularly on the spherical passive satellite) and new potential methods for bias-free range measurements at the mm-level with MCP and silicon photomultiplier-type detectors. Recent timing experiments with T2L2 have shown that there are some uncompensated optical time and frequency distribution at the nsec level in the tested systems. This points out the need to continue this work with future timing missions and to develop methods at the stations to implement improvements made possible through active control and closure measurements. Several groups are studying the sensitivity of SLR observations to tropospheric horizontal gradients and atmospheric asymmetry, however, our low elevation data yield is still a very small fraction of the total for this to be of any consequence. There was some discussion on refining the definition of normal point durations to try to minimize the amount of data necessary to reach 1 mm normal point RMS. It was also noted that some stations that are geographically close could plan some shared tracking campaigns to help expand satellites' coverage and carry out tracking experiments.

The fourth day concentrated on automation and autonomous station operations. It was pointed out that Alexander Neidhardt's new book "Applied Computer Science for GGOS Observatories" provides a very nice reference on the topic including a thorough discussion on the relevant software issues.

Representatives from many of the stations described their activities underway and planned from automated scheduling through full operations and optimal automated operations using situational awareness from multi-sensor data. There was also a discussion on when automation make sense.

Automation of SLR stations has the potential for dramatically increasing the data volume while at the same time reducing the operating costs. However, full automation isn't for all stations as it involves development and implementation costs. It is probably most cost effective to fully automate a network of stations rather than a single station. Fortunately, automation can be implemented in stages and can range from supporting the operational manpower (making the station easier to operate) to full automation where there is no human operator at all.

There remain many challenges for full automation including personnel, system, and area safety and aircraft avoidance. Other challenges discussed included automating the signal

determination, telescope pointing optimization, cloud considerations and weather considerations, and dynamic (real-time) scheduling. Finally, security remains a challenge, including both physical plant and IT security. A fully automated SLR system must protect against illegal physical and IT entry.

To promote automation at the stations, more effort should be made to share information and experience, including algorithms, relevant procedures and software, and commercially hardware. It was also suggested that the ILRS develop general guidelines and an overview of successful implementations to date.

The workshop concluded with summary presentations from the chairs of the four sessions as well as the chairs of the standing committees and study groups. In addition, the participants supported resolutions that (1) urged to the community to seek more SLR stations in the southern Hemisphere, (2) asked the relevant agencies in Argentina and China to make every effort to complete the upgrade of the San Juan SLR station, and (3) thanked the University of Latvia and the local Organizing Committee for all of their work in making the Workshop a great success. Finally, the closing session included a presentation on plans for the 21st International Workshop on Laser Ranging which will hosted by the Space Environment Research Centre (SERC) and will be held in Canberra Australia, November 05-09, 2018.