2015 ILRS Technical Workshop
Matera Italy
October 26-30, 2015

Workshop Summary

The 2015 ILRS Technical Workshop was held at Casa Cava in Matera Italy, October 26-30, 2015. The Italian Space Agency (ASI) and the ILRS sponsored workshop, which was attended by over 100 international colleagues. The theme of the workshop was "Network Performance and Future Expectations for ILRS Support of GNSS (Global Navigation Satellite Systems), Time Transfer, and Space Debris Tracking." Representative from various global GNSS, such as the U.S. GPS, Russia's GLONASS, Europe's Galileo, and China's Beidou, presented their requirements for and satisfaction with the ILRS network's laser ranging support of their systems. The ILRS hopes to use this information to better define satellite tracking priorities and strategies. Results from tracking campaigns showed that the ILRS stations were able to provide additional data on select GNSS satellites but work remains to define a more detailed strategy that will not impact tracking of other high-priority targets.

Summaries by session are given below.

Session 1: GNSS Session A: Synergy of SLR and GNSS Data Products

The first of two GNSS sessions focused on the user needs for GNSS tracking. SLR tracking on GNSS is required for validation of the radiometric systems and the improvement of spacecraft and force models to improve POD and better understanding of clock behavior. The need will be long-term. GNSS laser ranging campaigns conducted by the ILRS showed the usefulness of the data, but GNSS mission users are asking for at least twice the present tracking coverage. The issue faced by the ILRS is how we trade this desire with the projected increase in the number of GNSS satellites on the ILRS roster. The GNSS constellations are the primary "disseminators" of the ITRF so orbits must be accurately centered, oriented and scaled in the current ITRF. We also need to recognize the general importance of the co-location in space that SLR provides.

Session 2: GNSS Session B: ILRS Network Performance and Improvement

Presentations during this session discussed how the ILRS is responding to user demands by improving data-yield and improving the LRAs on future spacecraft. We should stimulate the discussion between the 'providers' (ILRS) and the 'users' (missions, scientists) to make sure our efforts are focused in the most productive manner and that we are 'recognized' for having made the effort. Although the schedule is pretty heavy, there is still a lot of potential capacity, especially as stations move toward kHz ranging and more automation. Campaigns organized to increase GNSS tracking, showed no reduction on LAGEOS and LEO data yield. Stations need to respect priorities and work to improve daylight tracking. The LNF has proven to be very powerful resource for the characterization of GNSS LRAs.

Session 3: Space Debris

The amount of space debris in orbit around the Earth is increasing as is laser ranging to debris targets; there is growing interest for a number of institutions (ESA, EU Commission, etc.), and

several SLR stations have started ranging activities. New techniques (nanowires, etc.) are in testing, and campaigns have been started to measure attitude motion and light curve properties.

Session 4: Time Transfer

Timing applications are becoming are becoming an important application for laser ranging. The mission scenario and the requirements for participation in the ELT Time Transfer Activity for the ACES clocks in space were presented. Since variable and unrecognized time delays are usually present at all stations, time cannot be an observable in space geodesy. To mitigate the effects from hidden delays and in preparation for the ELT mission, the Wettzell station is switching to an actively delayed compensated time and frequency distribution system starting in the first half of 2016.

T2L2 has already shown impressive time transfer results; another non-common-view campaign is being planned. The Russian network routinely uses time transfer, for good resolution and stability in the GLONASS network. A successful pilot experiment at MLRO for the transfer of a quantum cryptography key was introduced.

Session 5: System Bias Session A: Analytic Results

The ILRS uses two approaches to estimate system biases:

- • Fast delivery quality check: pass-by-pass estimation of range and time bias available for some satellites;
- • Longer-term estimation: weekly, monthly, yearly biases typically estimated in multiyear solutions by some satellites, particularly LAGEOS-1 and -2.

Systematic trends are seen in many stations, including long period biases and characteristics that give strong indications of particular issues. It is essential to understand individual system behavior through careful scrutiny of the data, careful calibration techniques, and on-site testing that can all provide indicators of performance degradation and malfunction. We need to realize that POD is a very powerful tool, but there is risk of false alarm and the results are take time. Strong station-analyst interaction is essential. It would be very helpful if we could reach agreement on station coordinates (especially new stations), separation of the short and long (calibrating) pass estimation (use the long passes for both range bias and time bias estimation), and better/more timely communication and coordination among the analysis centers on perceived bias estimations.

Session 6: System Bias Session B: Station Issues

The second session on system biases focused on good practices and recommendations:

- Strive for single photon operation (if practicable);
- Higher system stability is a prerequisite for smaller biases;
- Maintain maximum system delay stability (selection of components, environment, procedures);
- Permanently try to identify new possible bias sources ("Suspect everything" Herstmonceux, 2015);
- Repeatedly check the individual contributors using more accurate references;
- Calibrate and maintain the laser emission epoch verses UTC;

- Use optically correct calibration targets; 2D hollow retro recommended for separate transmit/receive;
- Use efficient spatial filtering; small field of view suppresses spurious reflections;
- Ensure perfect alignment of the receiver optics (start tracker/scanning is a good check);
- Use multiple targets at different azimuth and range to check systems delay consistency;
- Re-survey the target geometry; regularly use various scales, techniques, etc.
- Keep detailed records of all system modifications; report any modifications to the ILRS.

Session 7: Closing Session

The workshop wrap-up session was held on the last day. The following recommendations were presented and accepted by the attendees:

- The ILRS encourages the NICT Koganei Station to continue contributing to Satellite Laser Ranging, as a GGOS Core Site, a key station for Time Transfer and co-located GNSS Tracking, and other international activities.
- Recognizing the overall advantages of kHz SLR and considering the increasing number of GNSS targets, we urge all SLR stations to exploit every possibility to upgrade to kHz repetition rate operations.
- The ILRS congratulates Dr. Giuseppe Bianco on his appointment as the Director of the ASI Center for Space Geodesy (CGS).
- Recognizing the **great success** of the 2015 ILRS Technical Workshop, the participants express their **sincere appreciation** to:
  - ASI and e-GEOS for organizing and hosting the Workshop, and
  - Pippo Bianco, Cinzia Luceri, and the Local Organizing Committee for their meticulous organization that enabled this very successful event.