Operational Challenges of SLR Tracking of GNSS Constellations

Summary of Session to Discuss Position Paper 8

Graham Appleby summarized his Position Paper on Operational Challenges for SLR tracking of GNSS constellations. The main points raised are summarised below.

- The populating of the GNSS constellations with satellites with retroreflector arrays will pose a challenge for the ILRS network. However, with operational and technical improvements, coupled with carefully planned tracking strategies, the network and the ILRS infrastructure can meet the challenge.
- Pass interleaving has become routine for some stations, permitting satellites simultaneously in view to be tracked. In particular, short segments of a GNSS satellite passes can be interleaved with satellites at all altitudes.
- The present network has considerable unused capacity in terms of time when tracking is not underway. Even the Yarragadee station with nearly continuous coverage and nearly perfect weather only tracks about 1/3 time. As autonomous operations become more common, we anticipate that stations will be tracking many more passes.
- The network productivity on the GNSS satellites has steadily increased due in part to improved technology and additional satellites, but dedicated campaigns have shown that improved tracking techniques, better predictions, and more experience have all played an important role. Currently 12 – 15 stations provide nearly all of the GNSS SLR data. As more stations go through upgrading and as new stations become operational, production will improve.
- Aircraft safety has been a historical issue with SLR. The introduction of radars and new optical and infrared sensors have made this routine at most stations; some groups are also working on eye safe laser systems that operate at emitted energy densities below the eye safety threshold.
- Through the years the ILRS data flow has been streamlined, to the point now where most normal point data is available to the users within 1 - 2 hours of acquisition, making near real-time applications practical.
- Recently, the ILRS has been tasked to track satellites with optically vulnerable payload under some orientations. The ILRS has introduced a hierarchy of restricted tracking constraints, including a web-based go-nogo key with which satellites missions can command the SLR stations to cease operations on their satellite.
- Many stations are undergoing hardware and software upgrades that will improve ranging capability, including increased daylight ranging, a critical aspect of accurate orbit determination.
- An ever present issue with the ILRS network is funding; operations and upgrades can only continue if adequate funding is available. The ILRS and its parent organizations such as the IAG must continue to stress the importance of SLR to the science community and to insist that its data users give proper recognition and credit for ILRS support. It would also seem reasonable that the benefit to the GNSS Missions of laser tracking should be recognized by some funding mechanism especially if that benefit falls outside the purely scientific.

Following the presentation of the Position Paper a number of related presentations were given, summaries of which follow here.

- Randy Ricklefs described some of the operational issues with lunar ranging and lessons learned;

- Buddy Donovan gave a review of best practices used in the NASA Network and the benefit that can be derived from careful maintenance and calibration; he used the example of the improvement in performance at the Yarragadee station after recent maintenance procedures; he stressed the importance of simple, but carefully implemented procedures.

- Scott Wetzel discussed some ideas for an operational plan for GNSS tracking, recognizing that the number of targets will increase dramatically as the GNSS complexes become populated; strategies need to be implemented that will sample all of the array-carrying satellites while at the same time provide continuity on at least some satellites to support the ITRF development and maintenance.

- Chris Clark described a system being developed by NASA for complex scheduling for multi-target, multi-constraint conditions that might be applicable for GNSS tracking; with many satellites being tracked and interleaving of passes of several satellites at one time, the bookkeeping will become quite complicated.

- Adrian Jaggi described the new IAUB daily predictions that have dramatically improved SLR data acquisition on GOCE. While the predictions were scheduled to stress the European stations, all regions have benefited. Plans are underway to further enhance the service by adding a second prediction cycle each day focused on the other areas.

- Kirco Artov described the progress being made at the Metsahovi site on a new SLR system based on a 2 kHz laser and novel application of commercially available hardware. As an interim measure, they are presently rebuilding their old mount with new mechanical and electrical components. They are also using inexpensive but powerful computer components from commercially available computer games in their command and control systems.

- Zhongping Zhang reported on the progress made with the new kHz laser at the Changchun station with great improvements in data volume and daylight ranging. This is very significant since all of the Chinese stations are going this route with the expectation that the whole networks will see dramatic improvement.

- Roman Bebenin described the RadioAstron VLBI mission which could fly in late 2009 or early 2010 into a highly eccentric orbit from a few hundred kilometers altitude out to near lunar distance. This terminal, coupled with a terminal on the Earth will provide a variable VLBI baseline out to a distance of about 300,000 km. The retroreflector array has been positioned and optimized for ranges in the neighborhood of 150,000 – 180,000 kilometers. The spacecraft will be visible at 12 – 14 magnitude, so visual acquisition will be quite practical with a modest CCD and telescope, and all the LLR-capable stations are to be invited to contribute to the ranging effort.