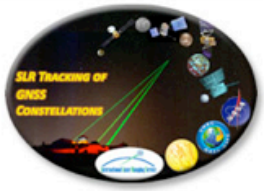
International Technical Laser Workshop on SLR Tracking of GNSS Constellations

50 Years of Satellite Geodesy and Geodynamics
On the Occasion of Prof. George Veis 80th Birthday



September 14-19, 2009
Metsovon Conference Center
Metsovo, Greece

National Technical University of Athens (NTUA)
Metsovion Interdisciplinary Research Center (MIRC) of the NTUA

Programme: ILRS Workshop on SLR Tracking of GNSS Constellations
50 years of Satellite Geodesy & Geodynamics

Sept. 14, Monday: **Impact of SLR Tracking on GNSS Constellations (**Position papers)

PP01:GPS, T. Springer

PP02: GLONASS, V. Vasiliev, V. Glotov

PP03: GALILEO, T. Springer

PP04: COMPASS, X. Wang

PP05: QZSS, M. Sawabe, S. Nakamura,

Status of SLR and the ILRS, M. Pearlman

Sept. 15, Tuesday: **Science from SLR and GNSS**

Sept. 17, Thursday: **PP 06: Scientific impact of SLR tracking of GNSS Constellations**
E. C. Pavlis

What is the benefit of tracking GNSS satellites with SLR?
D. Thaller, R. Dach, G. Beutler, M. Mareyen, B. Richter

An assessment of the value of SLR observations to GNSS
R. Govind

Collection and processing in TSNIMASH of GLONASS spacecraft ranging data obtained by Russian and global SLR network stations
V. D. Glotov, N. N. Parkhomenko

SLR Observations of COMPASS – G2
Y. Fumin, Z. Zhongping, C. Juping, C. Wanzhen, Z. Haifeng, W. Zhibo, M. Wendong

ESOC SLR Activities
T. A. Springer, C. Flohrer, M. Otten, D. Svehla, J. Dow

Two approaches to build time series of EOP from SLR data

F. Deleflie, D. Coulot, B. de Saint Jean, J.-M. Lemoine, P. Exertier, O. Laurain

PP 08: Operational issues
G. Appleby

Scheduling lessons learned from Lunar Laser Ranging
R Ricklefs

Operational 'Best Practices' for the NASA laser systems
H Donovan

Possible strategy for laser tracking the future GPS constellation
S Wetzel

Potential Scheduling Applications to the Tracking of the GNSS Constellations
C Clarke

GOCE orbit predictions for SLR tracking
A. Jäggi, H. Bock, W. Gurtner, R. Floberghagen

Towards 2kHz new SLR system in Metsähovi
K. Arsov, A. Raja-Halli, J. Näränen, M.Poutanen

Routine kHz tracking at Changchun and Shanghai
Z Zhongping, Y Fumin, *et al*

Navigation of the RadioAstron Mission
R. M. Bebenin, Y. N. Ponomarev, V. A. Stepanyants

Sept. 18, Friday: **PP 07: Technology Challenges**
M. Pearlman

Uncoated Cubes for GNSS Satellites
D. Arnold

Proposed Single Open Reflector for the GALILEO Mission
R. Neubert, J.Neubert, J. Munder, L. Grunwaldt

Target signature effects on laser ranging accuracy for the GIOVE satellites
T. Otsubo, P. Gibbs, G. M. Appleby

Relative signal strengths from SLR tracking of the different retroreflector targets onboard HEO satellites using the fullrate data set
M. Wilkinson, G. Appleby

Creation of the new industry-standard space test of laser Retroreflectors for GNSS constellations
S. Dell'Agnello, G. O. Delle Monache, D. G. Currie, R. Vittori, C. Cantone, M. Garattini, A. Boni, M. Martini, C. Lops, N. Intaglietta, R. Tauraso, D. A. Arnold, G. Bianco, M. R. Pearlman, S. Zerbini, M. Maiello, S. Berardi, L. Porcelli

Some conditions necessary to achieve submillimiter accuracy in SLR
M. A. Sadovnikov

HEO and Moon tracking at Grasse (MeO).
JM Torre, M Aimar, D Féraudy, M Furia, H Mariey.

First T2L2 results and time transfers
P Exertier, E Samain

Panel discussion

- The workshop brought together experts from the two communities to discuss all aspects of the theme:
    - focusing primarily on the science benefits,
    - tackling problems arising from the large number of GNSS clients,
    - considering the finite resources available to the ILRS

- It was acknowledged that there is great synergism between the two techniques and it should be fully exploited to the benefit of the larger community, in particular for space geodesy and Earth science

- The combined list of benefits to both techniques can be summarized in the following:
    - SLR tracking of GNSS satellites allows to connect the ILRS/SLR and IGS/GNSS reference frames in space ("space ties");
    - Validation and calibration of the GNSS orbit quality, passing SLR tracking through GNSS-based orbits and by comparison of GNSS orbits to independently determined orbits from SLR tracking;
    - Improvement of GNSS-based results by combining SLR and GNSS data at the observation level;
    - Improvement in the determination of the SLR contribution to the TRF by including laser ranging to GNSS satellites along with that to lower satellites (e.g. LAGEOS);
    - Improved scale contribution to ITRF from improved GM estimates based on SLR tracking of GNSS satellites (with indirect improvement of lower orbits as well, e.g. for LAGEOS);
    - Improving the orbits of LEO satellites with onboard sensors like radar and laser altimeters, sounders, SAR, InSAR, etc.

- From the GNSS point of view, the most important requirements on SLR are:
    - Continuous SLR tracking of all GNSS targets, or as network capacity permits, using optimized scenarios;
    - GNSS operators should follow strictly the ILRS recommendations for laser reflector array (LRA) designs to meet network requirements for best data yield;

- The SLR community should document unambiguously and maintain a publicly accessible data base of all known system biases for the ILRS network, past and future, with clear documentation even for non-SLR users;
- Extensive and timely (even near real-time) support of GNSS constellations, especially during the initial deployment phase and their "in-orbit validation" phases for models, hardware, software, operations, etc.

- From the ILRS point of view, important requirements are:

  - All of the GNSS operators should adhere to the adopted ILRS standard for the laser reflector arrays (LRA), so that ILRS can assure uniform tracking capability throughout its network and at all times and conditions;
  - An accurate calibration of all LRA designs prior to launch with a goal of a measurement of the vector to the center of gravity of the spacecraft to within a few millimeters (1-3 mm) and continuous monitoring of any changes while in orbit, due to fuel expenditure, attitude changes, etc. ;
  - A precise description of the spacecraft attitude routine while in orbit and during periods of SLR tracking in particular;
  - The ILRS must work with the separate GNSS constellation communities to develop a practical strategy to satisfy both the tracking requirements of the constellations and those for the development of the terrestrial reference frame;
  - The ILRS should continue the simulation activity on GNSS satellites in order to quantify trade-offs among competing options

- An overarching requirement is that the GNSS and SLR communities work together to facilitate communications so that planning can be done well in advance of any new GNSS deployments to best exploit the combination of techniques.