Session 11 : 3060

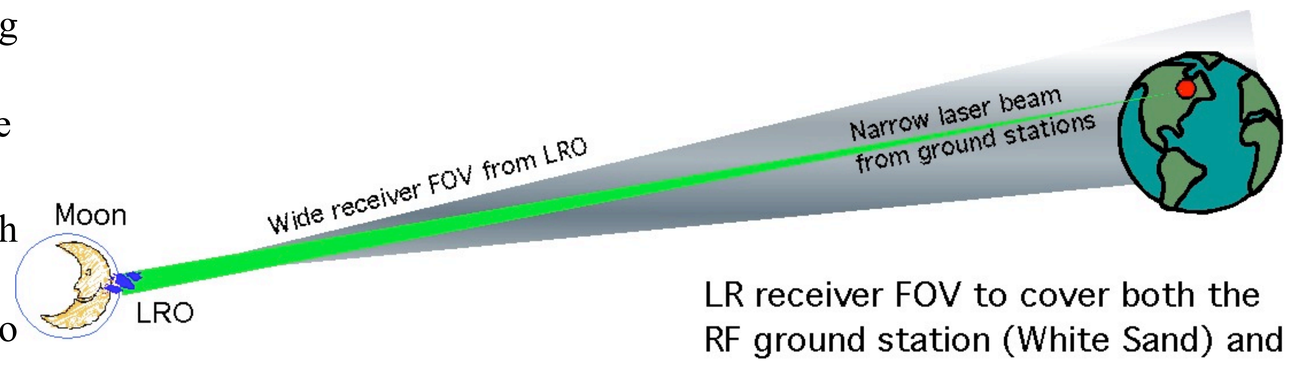
Time-transfer Experiments between Satellite Laser Ranging Stations via One-way Laser Ranging to the Lunar Reconnaissance Orbiter

Dandan Mao[1] (dandan.mao@nasa.gov), Xiaoli Sun[2], David Skillman[2], Jan McGarry[2], Evan Hoffman[3,4], Gregory Neumann[2], Mark Torrence[5], David Smith[6], Maria Zuber[6]

([1]Sigma Space Corporation, Lanham, MD 20706, USA; [2]Solar System Exploration Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA ; [3]GFZ German Research Center for Geoscience, Germany; [4]Honeywell Technology Solutions, Inc. (HTSI), Columbia, MD 21046, USA; [5]Stinger Ghaffarian Technologies, Greenbelt, MD 20770, USA; [6]Department of Earth, Atmospheric and Planetary Sciences, MIT, Cambridge, MA 02129, USA)

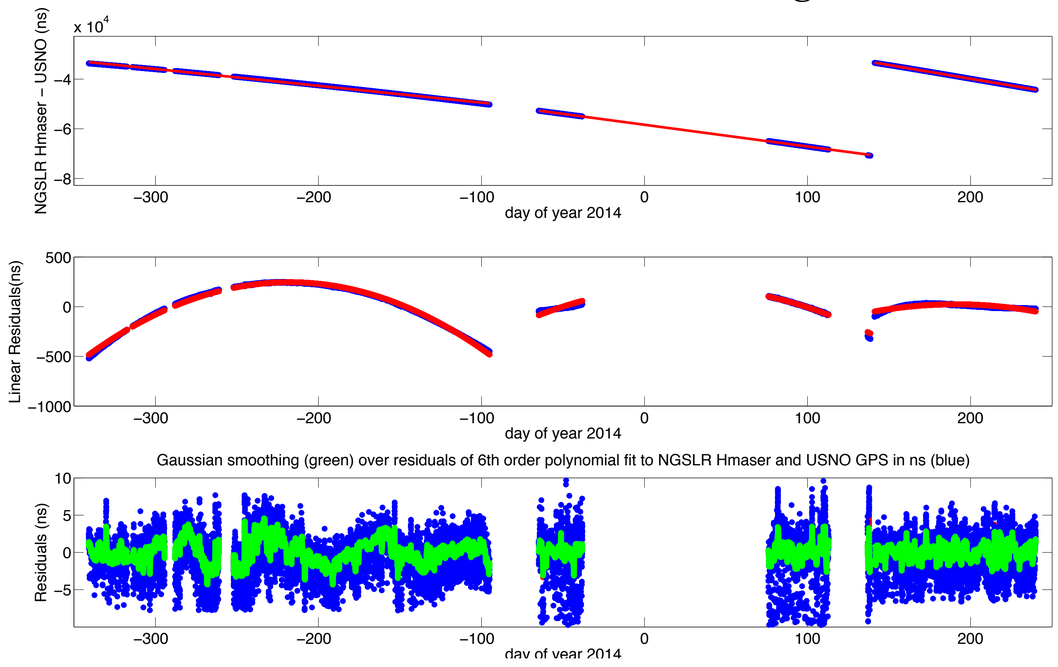
The Technique:

- Two or more ground stations perform simultaneous one-way laser ranging to LRO, LRO time-tags all received laser pulses to the on-board clock
- Each ground station time-tags its laser emission times to its own time base
- Radio frequency (RF) tracking provides the spacecraft ephemeris
- A hydrogen maser or a cesium clock provides a stable time base for each of the ground stations
- An All-View GPS receiver compares the primary ground station clock to the near-by USNO master clock via the GPS satellites with most of the common view atmosphere effects canceling out
- Solve for the difference between two ground station epoch times and hence transfer the time from the primary station to the remote station(s)



LR receiver FOV to cover both the RF ground station (White Sand) and all possible laser tracking stations

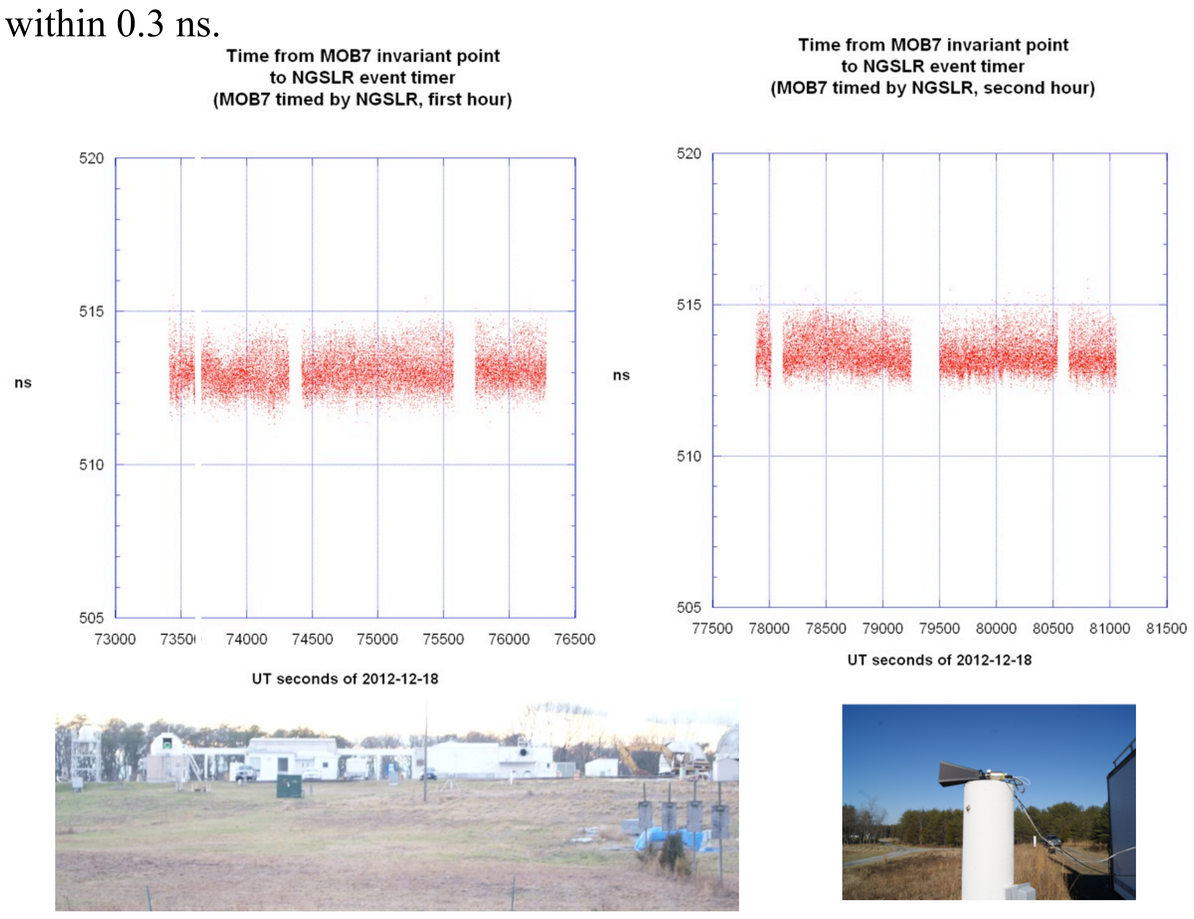
Monitoring the Station Time with an All-View GPS Receiver



- Monitoring the station time to sub-nanosecond at the Next Generation Satellite Laser Ranging (NGSLR) at NASA GSFC with an absolute accuracy of ~1ns and a stability mainly governed by the station clock, 4e-15 for the hydrogen maser and 1e-13 for the cesium clock source.
- NGSLR station H-Maser time referenced to USNO master clock via All-View GPS receivers
- ~1 ns precision and accuracy since Jan 2013.
- Similar method is used to reference the clock at the McDonald Laser Ranging Station (MLRS) in Ft. Davis, Texas.

Verification and Validation with Ground Targets:

Three tests performed with two ground targets in an LRO like configuration from two ground stations, NGSLR and MOBLAS-7, both at NASA GSFC, and the results agreed to within 0.3 ns.



Three tests performed:
2011-11-30, Pier C, 10 minutes
2012-12-18, Pier C, 1 hour
2012-12-18, Pier B, 1 hour

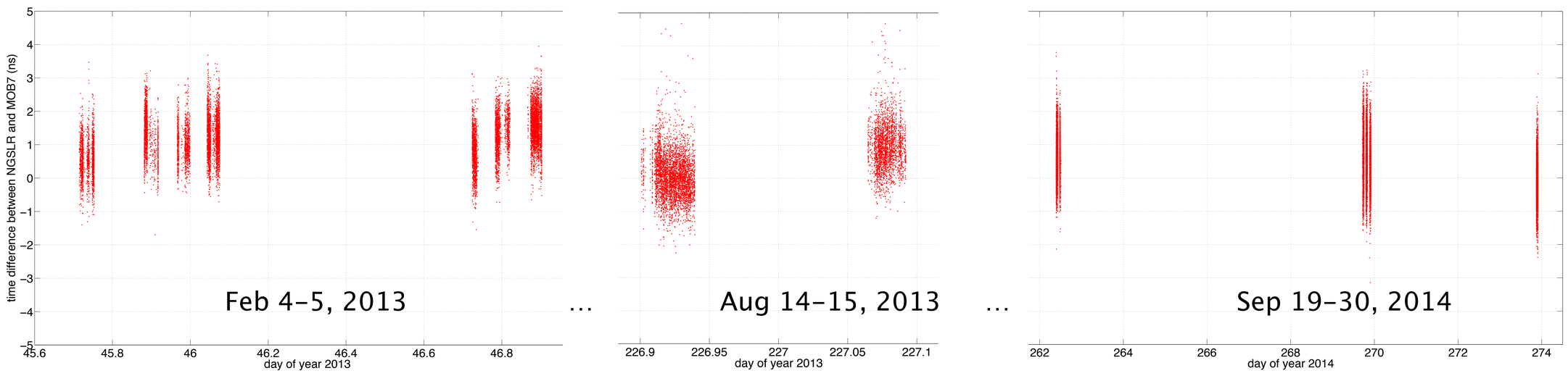
Pier_C

Test 1, 2011-11-30:
M7-Invariant Point to NGSLR event timer = 513.27 ns
Test 2: 2012-12-18:
M7-Invariant Point to NGSLR event timer = 513.00 ns

Pier_B

Test 1, 2012-12-18
M7-Invariant Point to NGSLR event timer = 513.296 ns

Results of time transfer via LRO between NGSLR and MOBLAS-7 at NASA GSFC



Transferring time between two SLR stations to within ~1ns and repeated after 6 months, then 13 months.

Work in Progress:

- Time transfer tests between NGSLR in Greenbelt, Maryland to the McDonald Laser Ranging Station (MLRS) in Ft. Davis, Texas, have been conducted. Test data are under analysis.