NASA SLR Network GNSS Tracking - Current Performance and Future Plans

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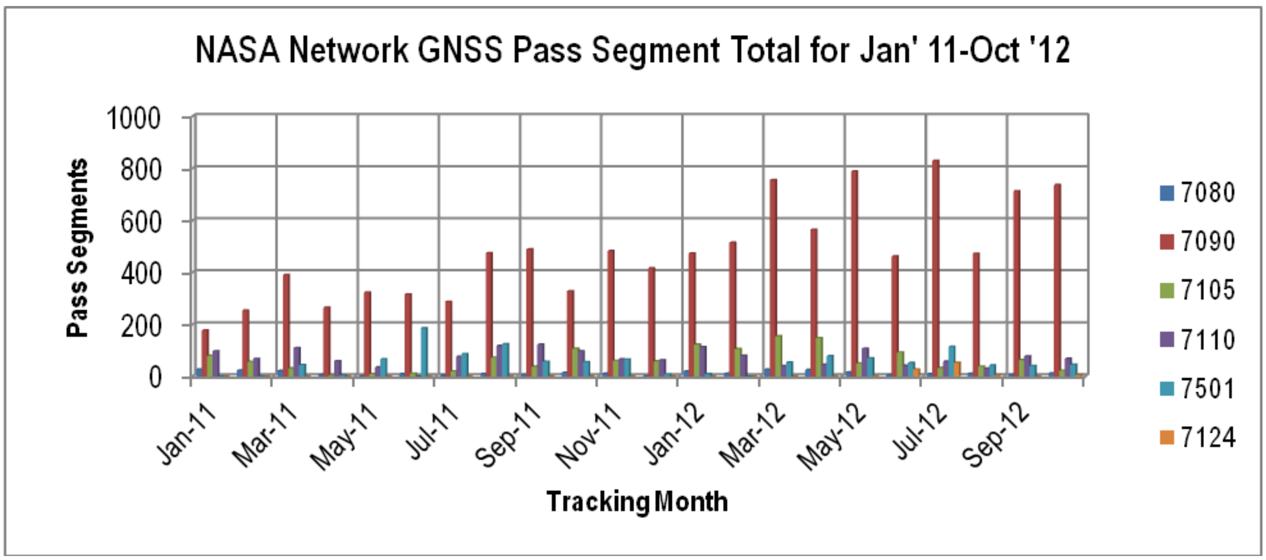
The NASA SLR network currently has six stations that are actively tracking GNSS satellites, viz., Monument Peak (7110), Yarragadee (7090), Hartebeesthoek (7501), Greenbelt (7105), Tahiti (7124) and McDonald Observatory (7080). The Tahiti station was modified in June, 2012 to allow High Earth Orbit (HEO) satellite tracking and the station tracks HEO as per the ILRS priority. The Yarragadee station has the highest GNSS tracking record in the NASA network. With its 24/7 tracking capabilities, Yarragadee also tracks the non-ILRS prioritized GLONASS satellites and the geosynchronous satellite, QZS-1. The rest of the NASA stations have fewer shifts and days of operation and generally conform to ILRS priority. Yarragadee tracks satellites in smaller pass segments producing fewer normal points per pass segment and more segments.

Several constraining factors limit the NASA network GNSS tracking capabilities. The larger beam divergence and telescope pointing errors limit the satellite link and hence the quantity of returns from these satellites. The atmospheric conditions are excellent at Yarragadee. At the other MOBLAS locations, where conditions are less than ideal, the daytime data collection is severely limited. MOBLAS stations also have a low (4pps) repetition rate due to the limitations of the Time Interval Counter. The low receiver detection efficiency and gain are also limiting factors. The chart below shows the GNSS pass segment totals for the NASA network from Jan 2011 through Oct 2012.



Engineering upgrade plans are in place to enhance the NASA stations capability to improve GNSS tracking beginning in 2013. Each NASA station will have an event timer installed that is capable of increased repetition rates with the goal of achieving higher normal point data quality. These stations can be operated easily at 10 Hz or more (limited by the laser pulse repetition rate). A Servo system upgrade will further enhance satellite acquisition, tracking, and pointing. The TLRS 3 and 4 stations (at Arequipa (7403) and Haleakala (7119)), will also be upgraded to achieve HEO night tracking by increasing the TX-RX link and pointing accuracy.

NASA's Next Generation Satellite Laser Ranging (NGSLR) System Experience Ranging to GNSS Satellites

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NGSLR successfully ranged to GLONASS and ETALON satellites in its eye-safe configuration (per pulse transmit energy of < 100 microJoules). Tracking with this low energy level was extremely difficult and was only successful at night when the satellite was above 60 degrees elevation [1].

Since the installation of the NASA 1 milliJoule laser and the Hamamatsu 40% QE MCP-PMT [2], ranging to GNSS satellites is much easier. Nighttime acquisition has a fairly high success rate, daylight ranging has been demonstrated on several passes, and we have ranged down to 40 degrees elevation. The newest GLONASS satellites are the easiest to acquire. However, to achieve the highest success rate at acquisition and tracking we still need a clear sky and a good recent star calibration. Acquisition during the day remains more difficult than at night. In the various configurations at NGSLR, we have now successfully ranged to both Galileo satellites, both ETALON satellites, and multiple GLONASS satellites. We have tried many times to range to GPS but have never been successful. The table below shows the GNSS successful tracking with the 1 milliJoule laser configuration during the period April to June 2012.

The return rate from most GNSS passes is about 0.1%. This is an order of magnitude lower than our theoretical calculations indicate is possible. We believe part of this reduced return rate is due to pointing errors.

We have recently installed a Photonics Industries laser at NGSLR which is capable of transmitting 2.8 mJ per pulse. With about 3 times more transmit energy and gains from reducing the pointing errors, we expect in the future to regularly achieve a 1 % return rate from GNSS satellites.

Satellite	SIC	DOY	HH:MM	#obs	RR%	#NPTS	# segs
ETALON-2	4146	094	02:15	5374	0.2	8	3
ETALON-2	4146	102	01:55	3026	0.1	6	3
ETALON-2	4146	147	02:55	759	0.1	2	1
Galileo-101	7101	090	01:36	8010	0.3	5	1
Galileo-102	7102	097	00:34	573	<0.1	3	1
Galileo-102	7102	168	00:44	1210	<0.1	5	1
GLONASS-109	9109	093	23:00 DAY	4644	0.1	12	1
GLONASS-115	9115	094	18:15 DAY	778	0.1	3	1
GLONASS-122	9122	090	02:08	11181	0.8	12	1
GLONASS-122	9122	152	01:55	2293	0.1	6	1
GLONASS-122	9122	153	00:16	589	<0.1	4	1
GLONASS-123	9123	108	02:40	2568	0.1	4	1
GLONASS-123	9123	139	01:35	1046	0.1	4	1
GLONASS-123	9123	147	02:14	409	0.1	4	2
GLONASS-123	9123	150	18:27 DAY	3767	0.1	9	1

References:

[1] "NGSLR: sharing eye-safe kilohertz SLR with transponder ranging,", J. McGarry, T. Zagwodzki, T. Varghese, J. Degnan, J. Cheek, C. Clarke, P. Dunn, A. Mallama, A. Mann, D. Patterson, R. Ricklefs, "Proceedings of the 16th International Workshop on Laser Ranging," October 13-17, 2008, Poznan, Poland.

[2] "NGSLR's measurement of the retro-reflector array response of various LEO to GNSS satellites", J. McGarry, et al, in this Proceedings.