A View of ILRS Station Performance

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At the 2015 ILRS Technical Workshop in Matera Italy, the ILRS Governing Board instituted a new station pass performance standard 3500 passes per year, increased from the previous standard of 1500 passes per year. With the top priority of the ILRS being the reference frame, stations were asked to provide 200 passes each for LAGEOS and LAGEOS-2, and subsequently 200 passes on LARES and some sampling on Etalon-1 and -2. This increase acknowledges improvements over the past several years in technology, procedures, and increased experience and success in daylight ranging. Currently the network is tracking 23 LEO satellites, 3 LAGEOS/LARES, and 46 GNSS satellites. Network performance over a recent twelve-month period is shown in Figure 1. Fourteen stations have reached the 3500-pass total, and another three are getting close. Unfortunately, half of the stations are providing little data. Several stations, that have performed well in the past, are in the process be being moved and/or upgraded, so we expect production to increase in 2018.
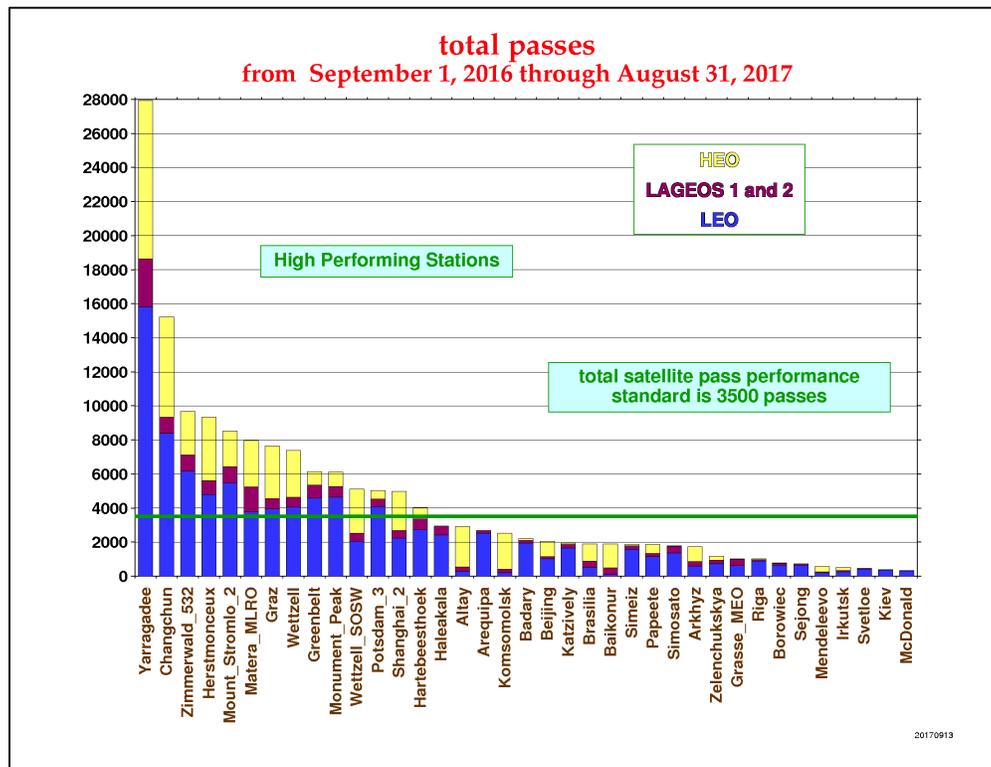

Figure 1. Total passes by station (from ILRS Monthly Report Card, September 01, 2016 thru August 31, 2017).

Fifteen stations are meeting the reference frame data requirement (see Figure 2) and another three to four stations should be operational in 2018. Nine stations are providing the bulk of the data on the altimeter satellites (see Figure 3).
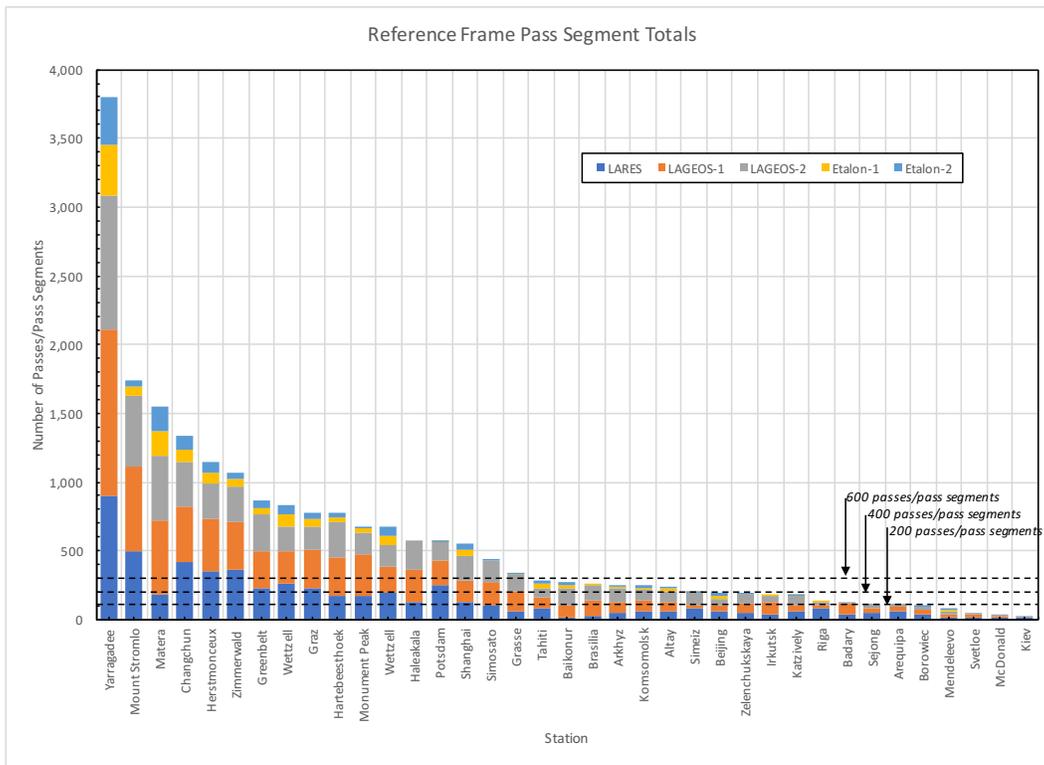

Figure 2. Total passes from reference frame satellites (LAGEOS-1, -2, LARES, and Etalon-1, -2) by station (September 01, 2016 thru August 31, 2017)

Figure 4 presents the tracking of LEO targets (with the exception of altimetry satellites) as a percentage of total LEO tracking. This plot shows a large amount of tracking time is still devoted to "easy" targets (e.g., Ajisai). Even though total data yield varies significantly, the distribution of tracking on this subset of satellites is still fairly consistent.

Figure 5 shows the pass yield for the stations on the GNSS satellites by constellation. Thirteen stations were able to achieve a minimum of 1000 passes in the year.

Figure 6 shows the results from the 2017 three-month LAser Ranging to GNSS spacecraft Experiment (LARGE) Campaign. The LARGE campaigns are designed to help define an operational GNSS tracking strategy for the ILRS that addresses the many proposed requirements. Stations are asked to focus on three to four satellites from each GNSS constellation to reduce the number of targets. However, it was noted in this last campaign that the ILRS saw limited success since many stations continued to track the full complement of GNSS targets.
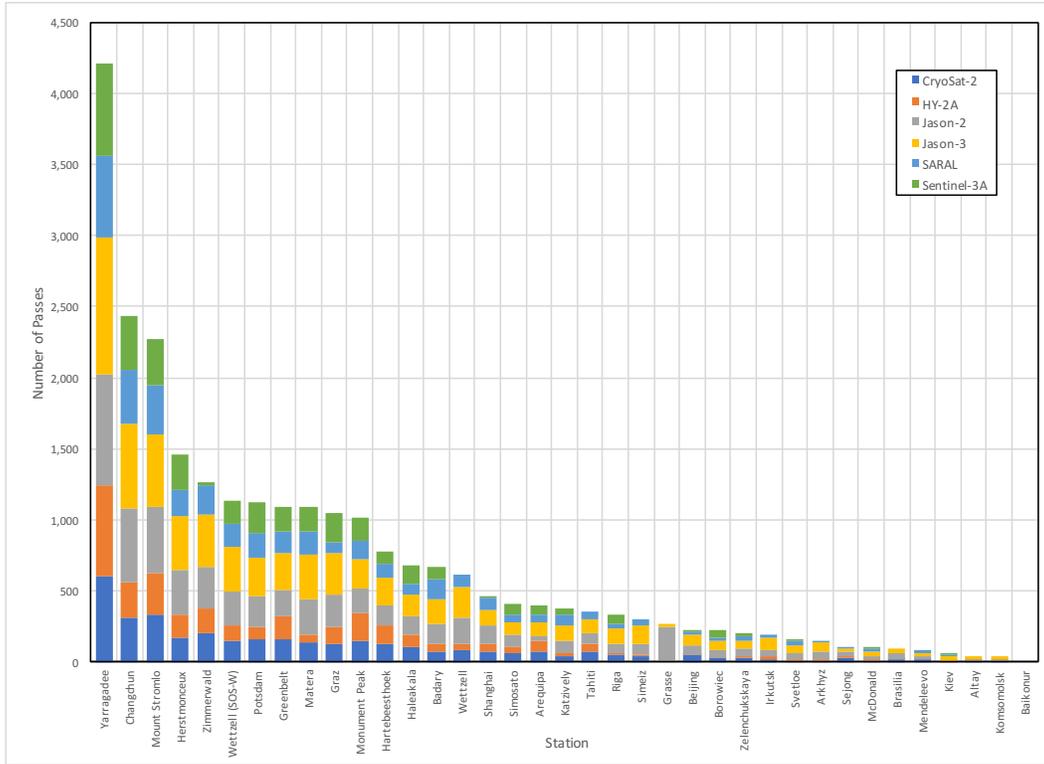
Figure 3. Total passes from altimetry satellites (Cryosat-2, HY-2A, Jason-2, -3, SARAL, and Sentinel-3A) by station (September 01, 2016 thru August 31, 2017)
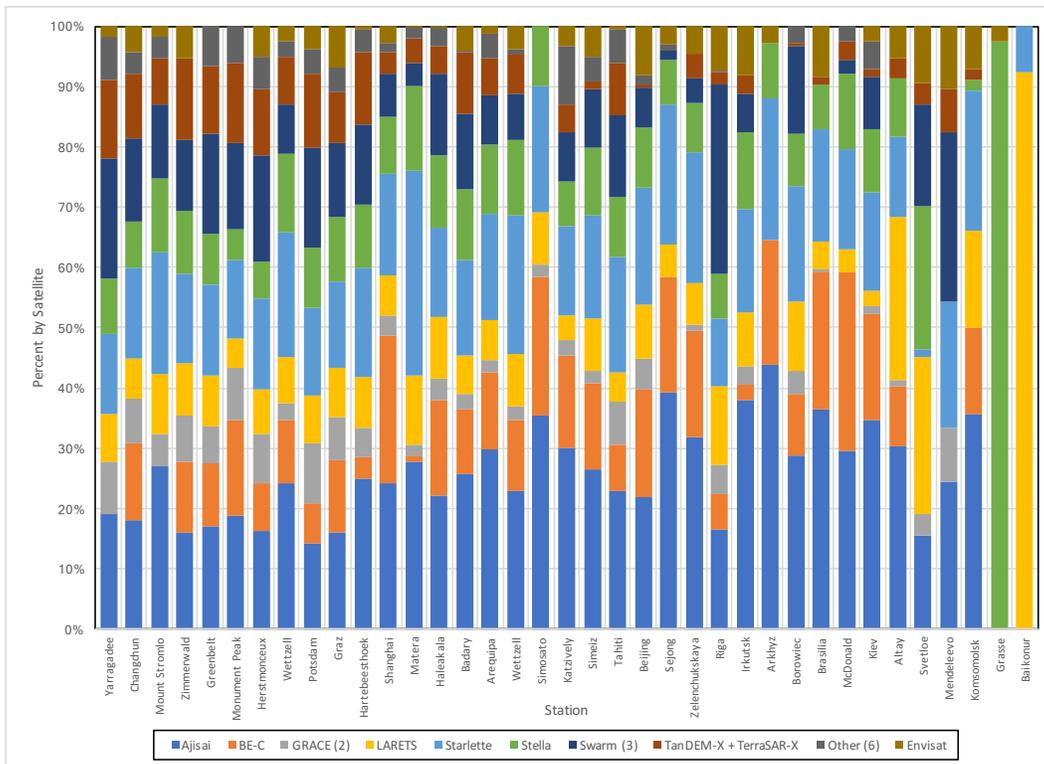

Figure 4. Total passes from LEO satellites (no altimetry) by station (September 01, 2016 thru August 31, 2017) as a percentage of total LEO tracking.
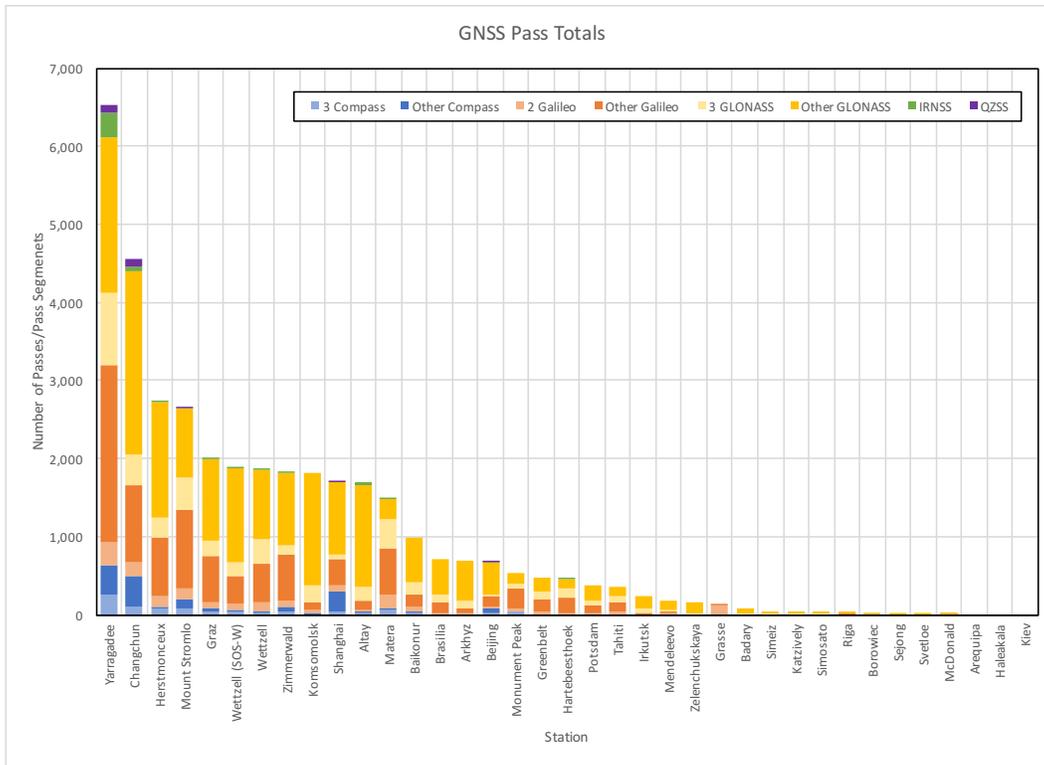
Figure 5. Total passes from GNSS satellites (Compass, Galileo, GLONASS, IRNSS, and QZSS) by station (September 01, 2016 thru August 31, 2017) for high priority satellites and all satellites by constellation
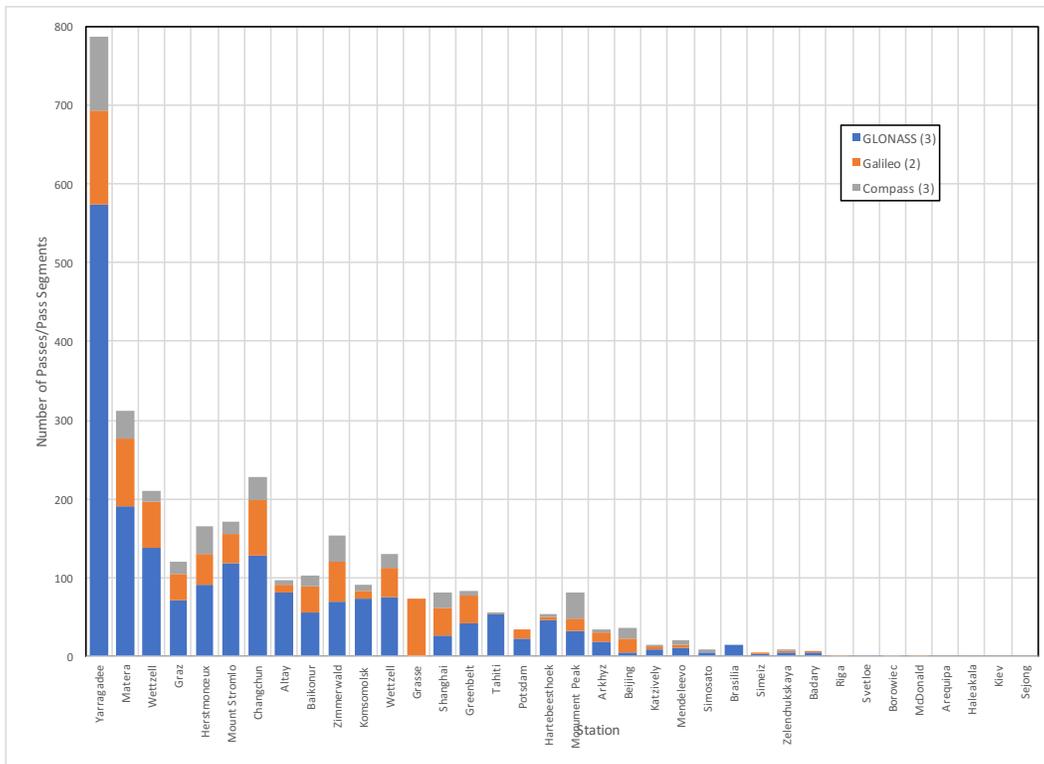

Figure 6. Total passes from LARGE GNSS campaign (January 15 through April 15, 2017) by station

Figure 7 shows an approximation of the minutes of tracking from each station over a year. Estimates were determined by ascribing to each normal point the normal point interval (e.g., two minutes for a LAGEOS normal point) and then summing up the total time for each station for all of the satellites tracked. This specification gives some advantage to the high repetition rate stations, but we note the out of the twelve more prolific stations, six are legacy stations with low repetition rates. By this technique, lonely nine stations appear to be tracking 10% of the time; fourteen are working at 5%. The legacy station at Yarragadee appears to the tracking nearly half the time.
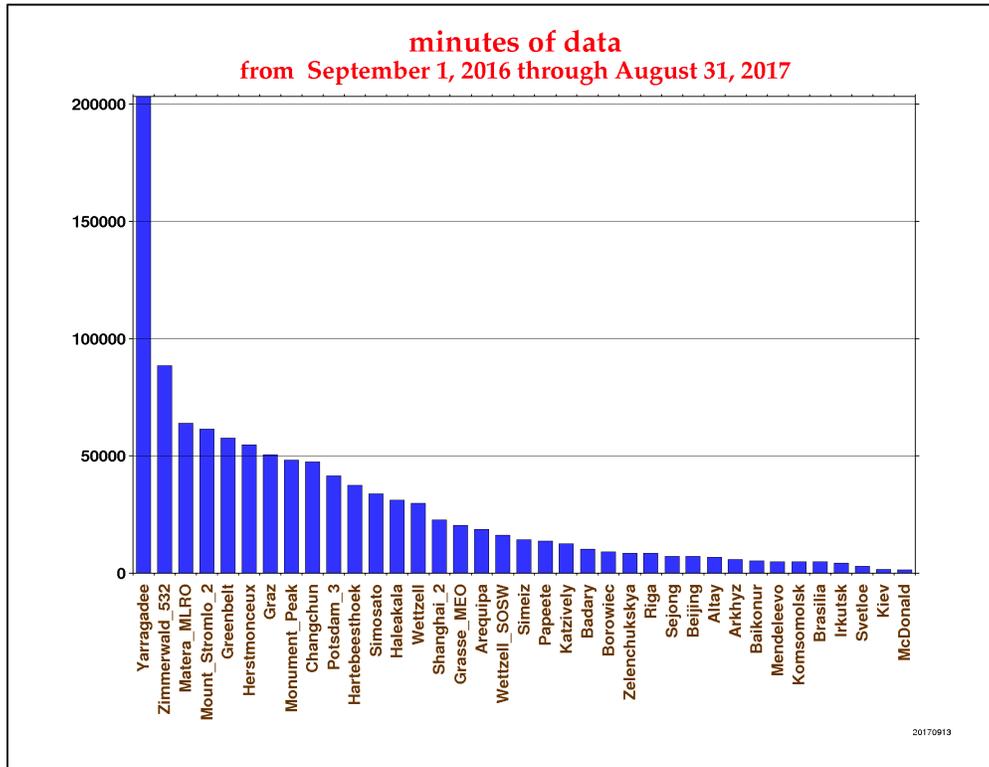

Figure 7. Total minutes of data by station (from ILRS Monthly Report Card, September 01, 2016 thru August 31, 2017).

Several centers estimate station data quality by computing NP RMS using a range bias and sometimes a time bias to accommodate un-modeled system biases. Result from an analysis performed by Toshi Otsubo is shown in Figure 8. Most of the stations are down at the level of a few mm's. The range bias issue was discussed in Session 2 of the workshop. There is a very strong correlation between the high data producing stations and those with low NP RMS.

There are significant data gaps in the ILRS network performance. Figure 9 shows a depiction of the data yield for altimeter, other LEO, reference frame and GNSS satellites by regional area. The large number of well performing stations in Europe and Australia are very apparent. The distribution is also a result of local priorities for the tracking (e.g., high priority of GLONASS for Russian stations).
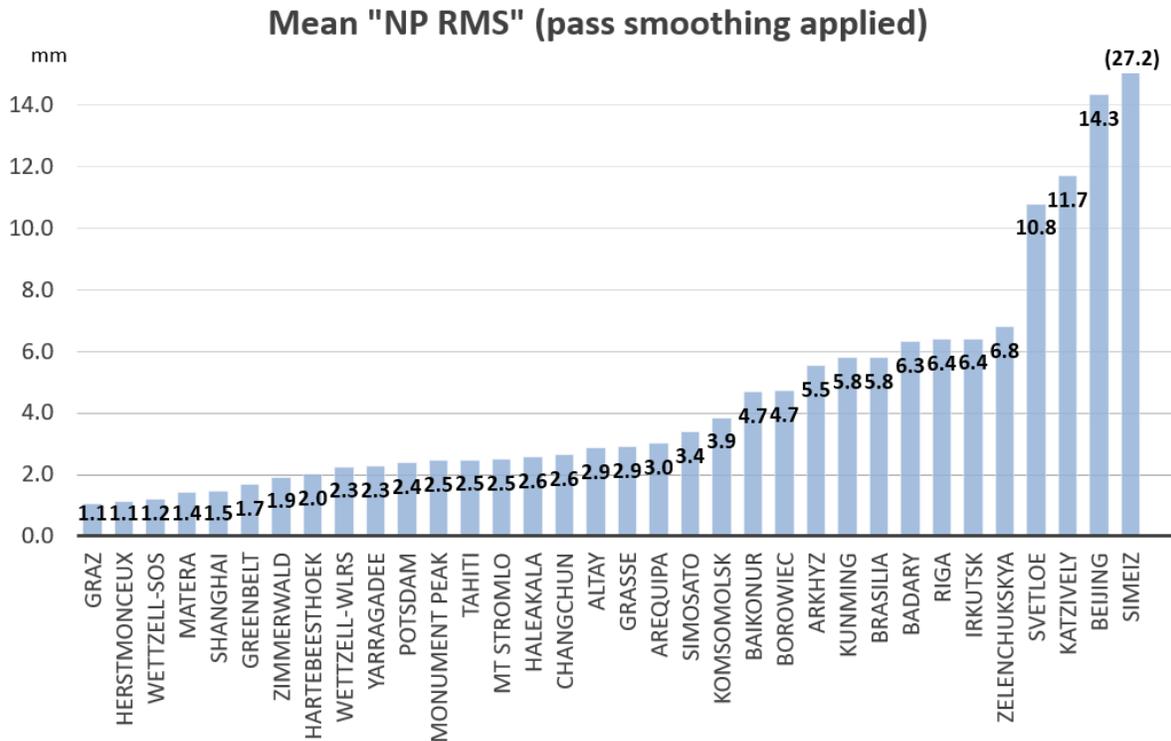
Mean "NP RMS" (pass smoothing applied)

Figure 8. Mean normal point RMS for LAGEOS-1 and -2 (July 2016 through June 2017); a simple smoothing function (RB only or RB+TB) are applied to see the scatter of each NP.
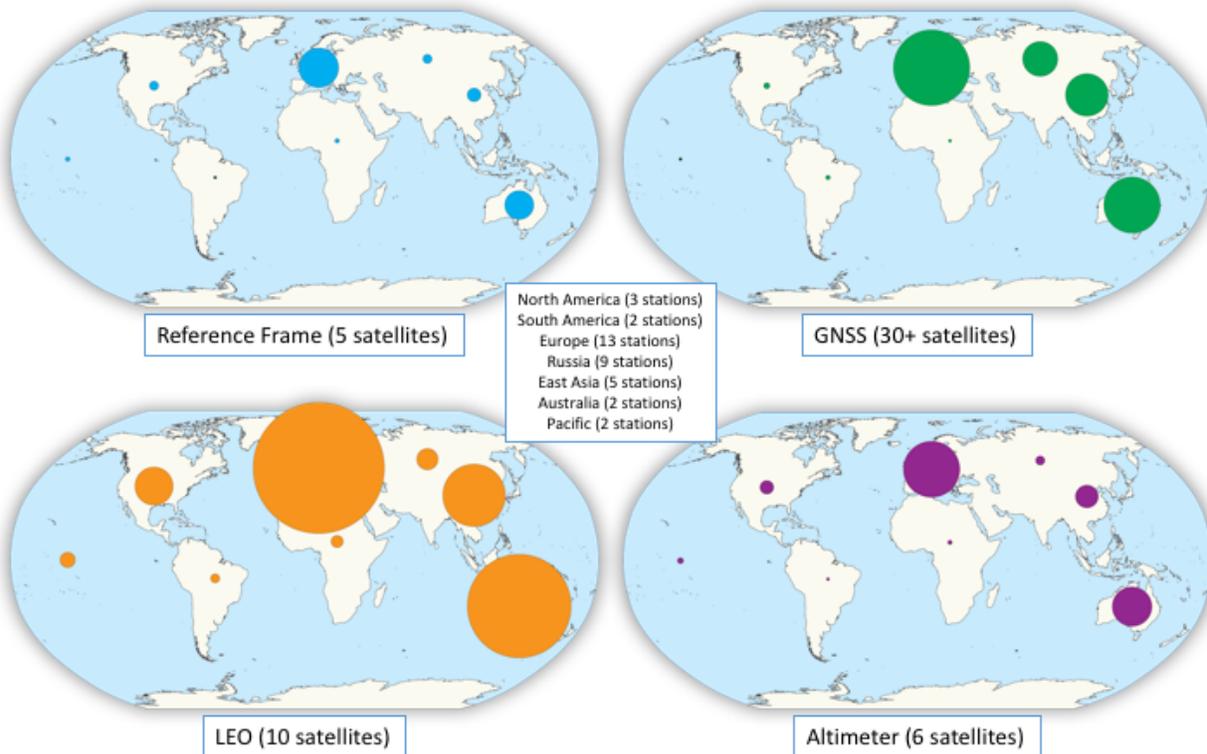

North America (3 stations)
South America (2 stations)
Europe (13 stations)
Russia (9 stations)
East Asia (5 stations)
Australia (2 stations)
Pacific (2 stations)

Reference Frame (5 satellites)

GNSS (30+ satellites)

LEO (10 satellites)

Altimeter (6 satellites)

Figure 9. Graphical representation of tracking by satellite category and geographic region.

Some observations:

- Less than half of the stations are meeting or coming close to the 3500-pass target.
- Less than half of the stations are meeting or coming close to the 600-pass level target for the reference frame.
- Less than half the stations are averaging more than one pass per day on the altimeter satellites.
- We need to characterize stations on the basis of performance; perhaps rating some as reference frame stations and perhaps other categories.
- We need to limit tracking on lower priority satellites and give stations more "credit" for tracking the higher priority satellites.
- We also need to examine reducing the number if GNSS satellites tracke at one time.