Plans and activities within the NASA SLR Operational Network towards meeting ILRS data requirements

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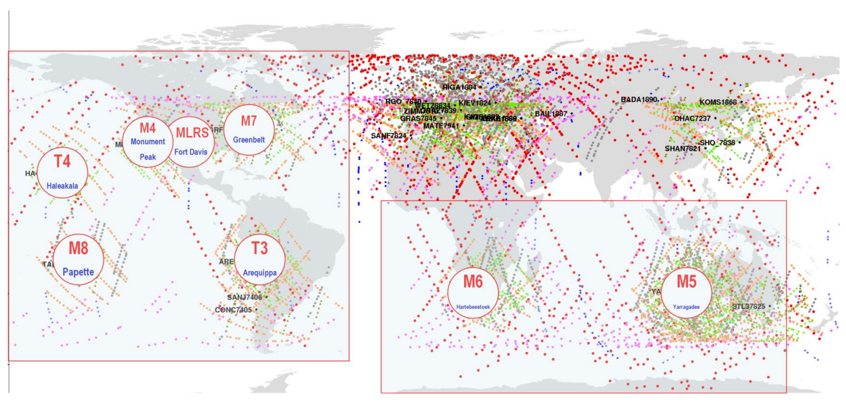
Abstract

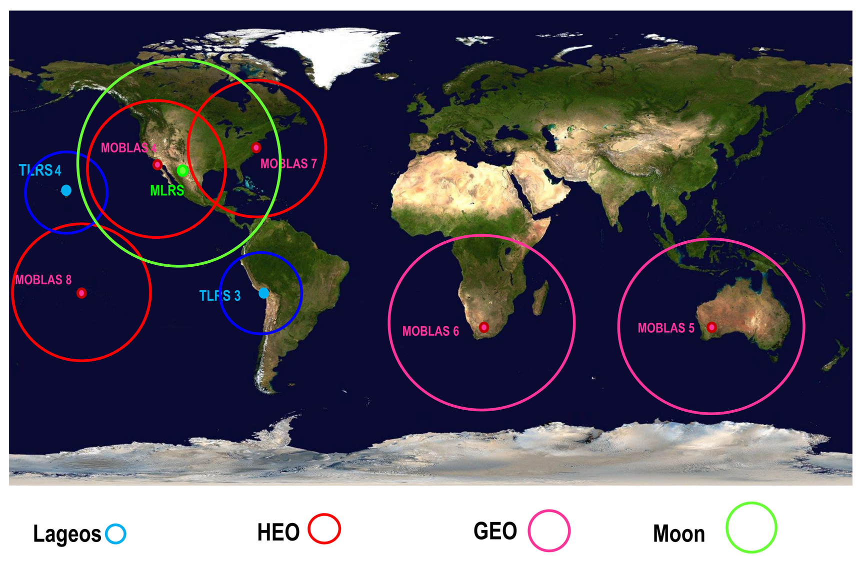
NASA's global SLR network maintains its critical presence in North and South America, Tahiti, Hawaii, South Africa, and Australia. These globally distributed legacy SLR stations need to sustain their operational performance over the coming years to provide ILRS support. Robust, cost-effective, and time efficient strategies are needed to maintain a healthy network to meet the ILRS data quality and quantity requirements at these unique long term geodetic locations. This requires a coordinated strategy that involves station engineering, operations, and continued collaborations with NASA's vital international and domestic partners. This poster will address the engineering and operations actions that are currently being employed and those that will be implemented in the near future to maintain station productivity. These unique SLR locations also participate in other scientific activities including space geodetic techniques. This poster will summarize the current network activities in engineering, operations, data collection, collaborations, site-specific activities, and plans.

NASA SLR Network – Global Coverage



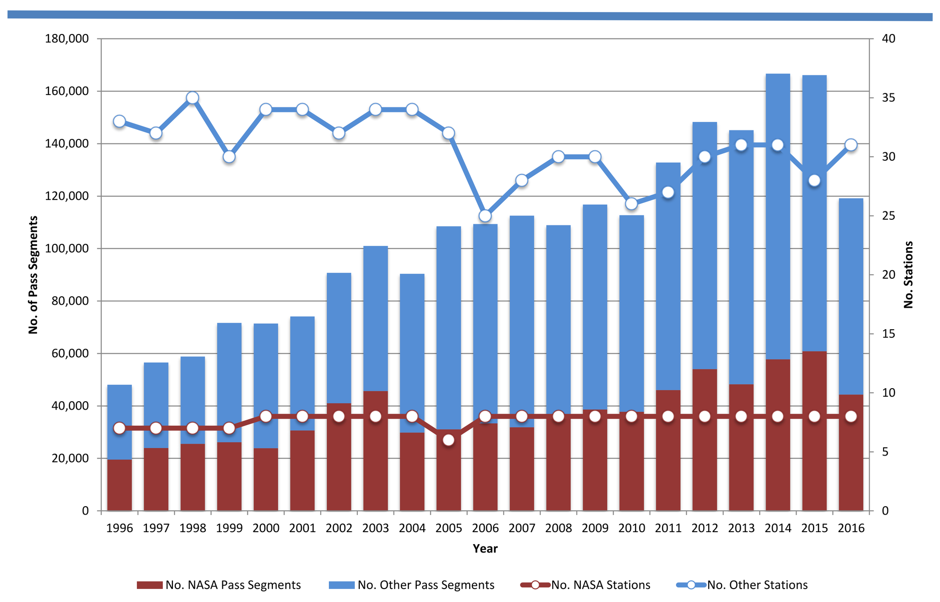
1. NASA SLR Network covers a significant part of the Globe providing >30% of the ILRS data;
2. Sites are unique with a long space geodetic history

NASA SLR – Current Ranging Capability

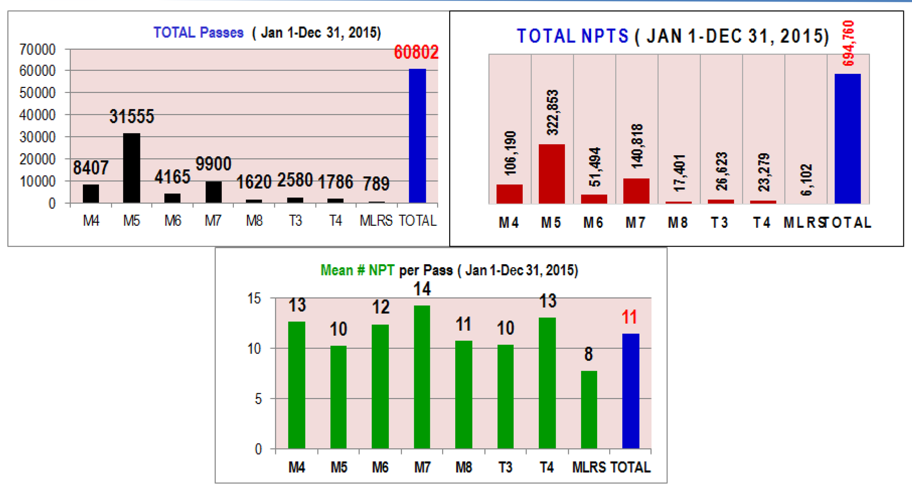


ILRS/NASA Yearly Data Yield

September 20, 2016 Update — Graph by Carey Noll



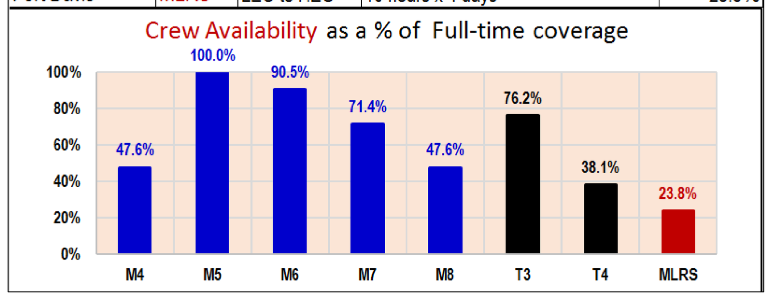
NASA SLR Network - 2015 Data Statistics



60,802 pass segments ; 694,760 Normal points

NASA SLR Network - Operations Optimization

Location	Station	Satellite Coverage	Operational Hours	Ops Crew Availability
Monument Peak	M4	LEO to HEO	16 hours x 5 days	47.6%
Yarragadee	M5	LEO to GEO	24 hours x 7 days	100.0%
Hartebeestoek	M6	LEO to GEO	24 hours x 5 days + 16 hours x 2 days	90.5%
Greenbelt	M7	LEO to HEO	24 hours x 5 days	71.4%
Tahiti	M8	LEO to HEO	20 hours x 4 days	47.6%
Arequippa	T3	LEO to Lageos	24 hours x 5 days + 8 hoursX 1 day	76.2%
Haleakala	T4	LEO to Lageos	8 hours x 6 days + 16 hours x 1 day	38.1%
Fort Davis	MLRS	LEO to HEO	10 hours x 4 days	23.8%



NASA SLR Network – Station News

1. **Moblas 4**, Geospatial Lightning Monitor (GLM) beacon site for NASA/NOAA GOES- R satellite, Jan – June 2017
2. **Moblas 7:** (a) GLM beacon site for NASA/NOAA GOES- R satellite, Jan – June 2017 (b) Planning to participate in ACES Time transfer experiments
3. **Moblas 5:** (a) Nearby Maritime Safety System Antenna Operational (b) Planning to participate in ACES Time transfer experiments (c) New UPS for the site in place (d) Fiber infrastructure upgrade expected in the near future
4. **Moblas 6:** (a) Russian SLR station to be located in the proximity of Moblas 6; perpetual intercomparison possible; (b) LLR station build in progress; (c) New VLBI planned;
5. **Moblas 8:** Trailer Renovation; Evaluation of new GGOS site by CNES/NASA

NASA SLR Network – Station News

1. **TLRS 3:** (a) New Institute of Astronomy and Aerospace Pedro Paulet (IAAPP) established (b) Academic program in Geodesy/research planned; (b) Super computer capability established; (c) GNSS analysis effort initiated, SLR analysis planned; (d) Satellite Image analysis for environmental studies is underway (e) Continue to formulate study project on nearby volcano Misti
2. **TLRS 4:** (a) Large DKIST Solar telescope established nearby and impacting SLR tracking
3. **MLRS:** New NASA GGOS site planning is underway

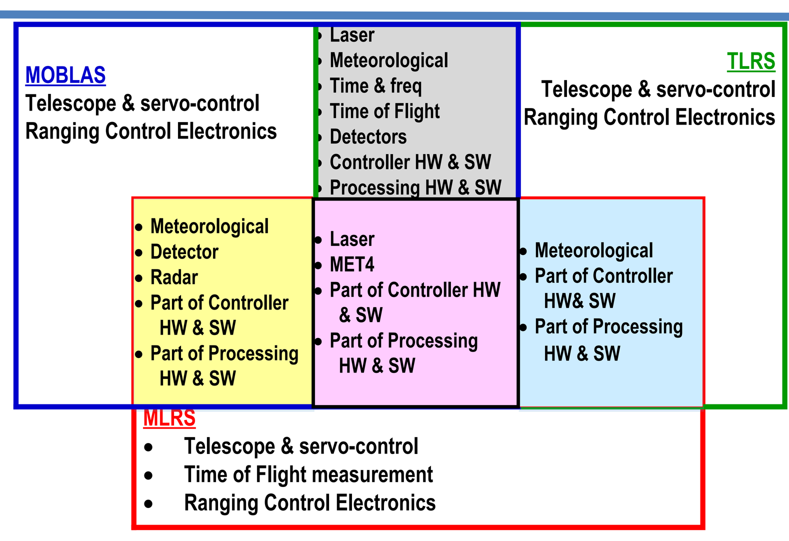
NASA SLR Network - Operations Summary

1. Operational hours restricted by the available funding within NASA and NASA partners
2. Having qualified station crews remains vital for the successful collection of data
3. Full staffing at **Moblas 5**
4. 90% staffing at **Moblas 6**
5. No additional funding resources for expanding shift coverage at M4 & 7, T4, and MLRS
6. Local Labor rules prevents single person operations at night; Moblas 8 at Tahiti
7. Best efforts are used to compensate for smaller crews;
   1. T3 Peru shifted crew resources to take more data over the weekends
   2. MLRS, Moblas 8 crews are flexible to accommodate weather etc.

NASA SLR – Network Sustainment

- **Engineering Sustainability Issues**
  1. Obsolescence
  2. Sustaining/ Maintaining hardware/software in remote locations
  3. System Down-time
  4. Cost of Material, Labor, and Logistics
  5. Lack of HW, SW Standardization
- **Monitor and Improve Station Data Performance (in particular; biases)**
  1. Work with analysts to understand station specific biases
  2. Establish what is Internal to the station vs External to the station

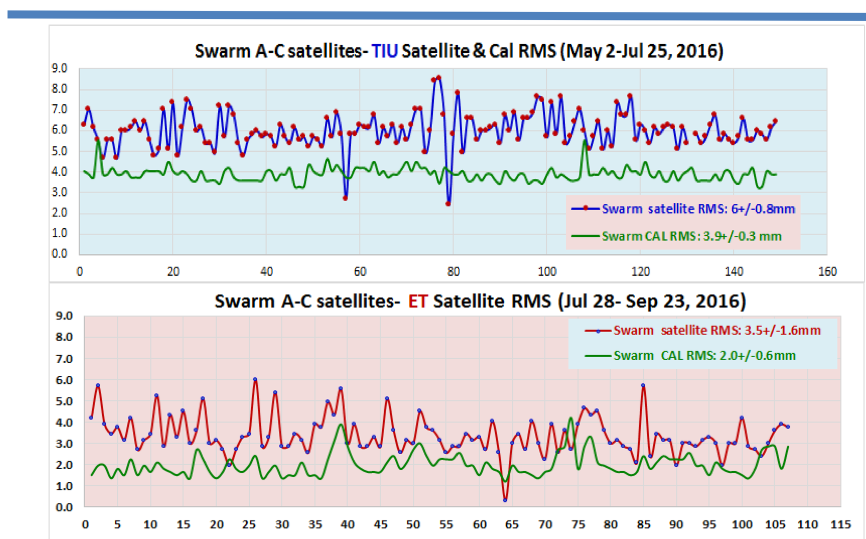
NASA SLR: Station Similarities and Differences



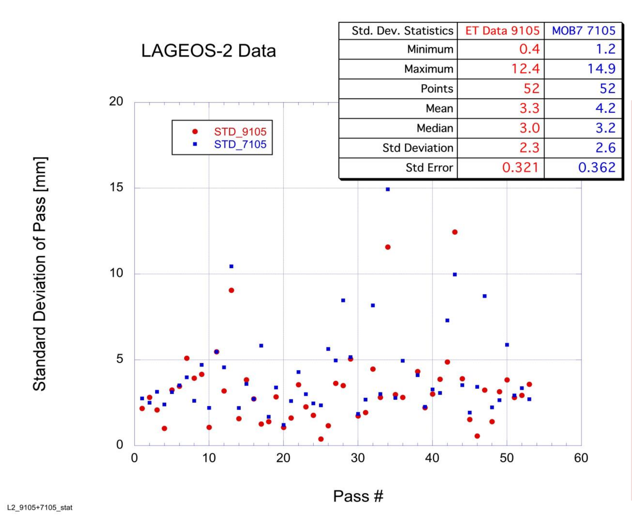
NASA SLR – Time of Flight Measurement

- Time Interval Unit (TIU) has been failing across the network; 30 year old technology; an obsolete but most critical part of the Data chain
- NASA needed reliable, stable, accurate replacement to perform epoch and time of flight measurement; event timer chosen
- Event Timer is now operational in Moblas 7 with higher precision and accuracy than TIU
- Event Timer is being implemented across the network in a manner that allows concurrent data taking with the TIU. This allows for seamless and robust transition/test/analysis with a "virtual" quarantine that eliminates any urgency to hurry testing/analysis due to quarantine "blackout"
  - This concurrent testing ongoing now in M6 and T4, remainder of stations are immanent
  - This could provide insight into any past network or station bias due to TIU
- Ranging Performance Improvement as well as potential for higher volume of data especially for Lageos, HEO, GEO satellites;

M7 Satellite and Cal RMS – Before & After



Pavlis – ASC L2 Analysis- ET vs TIU



Std. Dev. Statistics	ET Data 9105	MOB7 7105
Minimum	0.4	1.2
Maximum	12.4	14.9
Points	52	52
Mean	3.3	4.2
Median	3.0	3.2
Std Deviation	2.3	2.6
Std Error	0.321	0.362

"The bottom line is that the ET performs much better and provides a much tighter scatter of the pass std. dev. compared to the standard setup. Note that there are a lot fewer "outliers" within these sample cases for the ET data (not more than 3) in either satellite data set, compared to many from the standard setup. I think this is going to be a significant improvement when all sites are equipped with such systems!"

NASA SLR: Improvement Goals

1. Network sustainability
2. Station Reliability and data stability
3. Improved Data Performance – Data Quality (Precision & Accuracy) and Quantity
4. Reduced cost of operation for Engineering, Logistics, Travel