SCHEDULING THE NASA SGSLR NETWORK

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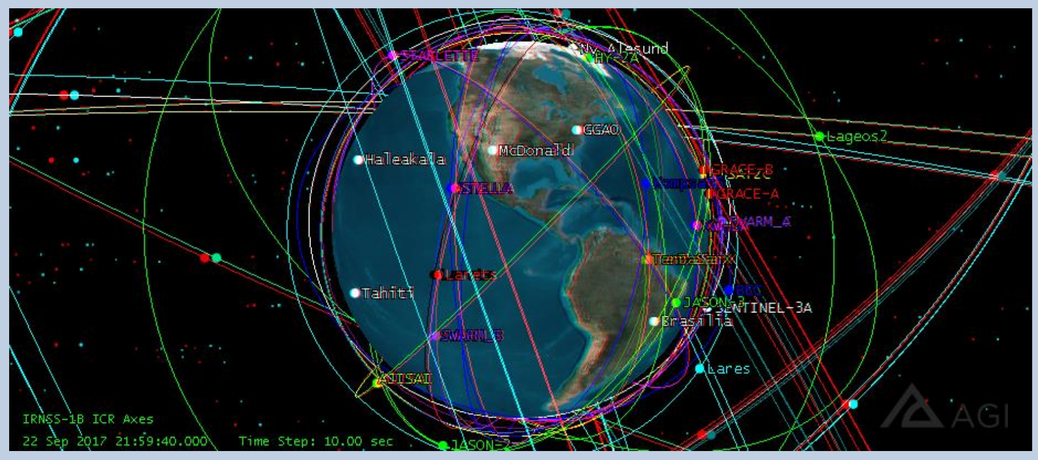
Abstract: Over a decade ago, Honeywell Technology Solutions Inc (HTSI, now KBRwyle) developed an intelligent SLR scheduling software package during the development of the Matera Laser Ranging Observatory. This package offered a broad advanced capability to produce prioritized SLR schedules using multiple optimizations, including evolving satellite priority based on mission data requirements. HTSI further developed this software package for NASA and installed it at the NASA Data Operation Center to be used for all routine scheduling for participating NASA operational stations and the NGSLR. Although a number of the software's capabilities were used in scheduling the NASA stations, much of the broader capability, including coordinated Network scheduling, was left unused due to of the lack of system automation as well as the lack of satellite scheduling interferences. As the satellite roster continues to increase with the launch of multiple navigation constellations, experimental satellites, and Earth observers, it is important to work toward scheduling networks rather than individual stations, in order to fully meet the ILRS performance requirements. In addition, with the increased automation of SLR stations, the ability to make full use of this scheduling capability is finally being realized. NASA and KBRwyle plan to further develop this Network scheduling tool to intelligently schedule the next generation Space Geodesy Satellite Laser Ranging (SGSLR) Network. This poster will explore the current NASA scheduling capabilities as well as our vision for the future of the SGSLR Network scheduling.

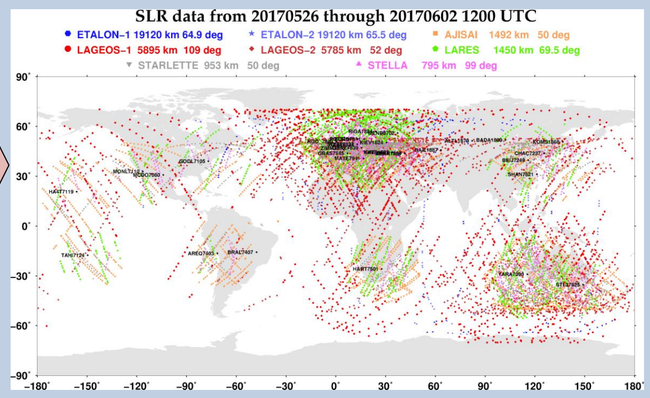
Current NASA Scheduling: The number of ILRS supported targets has greatly increased in the last 10 years, and the station scheduling has become increasingly difficult to satisfy mission and analysis requirements. The NASA/KBRwyle scheduling package, when fully utilized with the new NASA SGSLR systems, will provide dynamic scheduling for each individual SGSLR system as well as provide Network scheduling coordination for the entire SGSLR Network. The scheduling software, originally developed for the Matera Laser Ranging Observatory, was continually enhanced and developed for NASA in anticipation of the automated Next Generation SLR (NGSLR) system, and now for the future SGSLR Network.

The NGSLR, during its operational lifetime, automatically ingested and followed the ILRS prioritized schedule. The NASA/KBRwyle scheduler uses multiple dynamic inputs as well as user assigned inputs to generate a schedule that maximizes satellite mission requirements, ILRS tracking requirements, ILRS Analyst orbit requirements, and SGP SGSLR data volume requirements. The scheduler will use the ILRS priorities to develop an initial schedule as well as station specific information such as horizon visibilities and restricted zones, or satellite specific information such as day/night only tracking. The software then uses multiple features to enhance and optimize a system schedule.

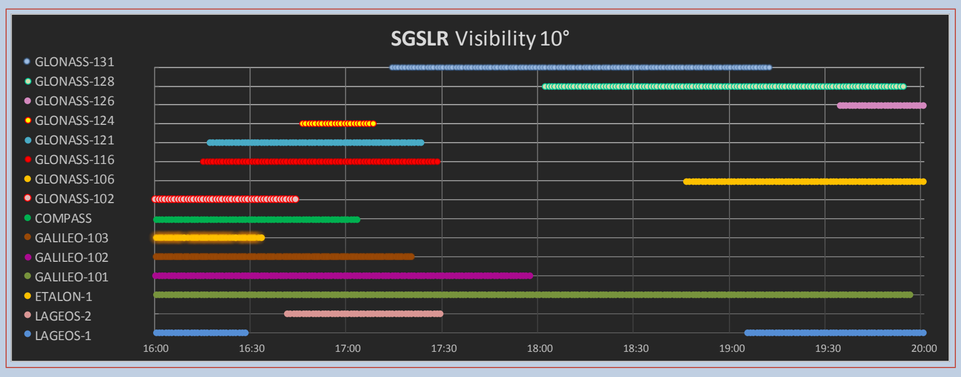


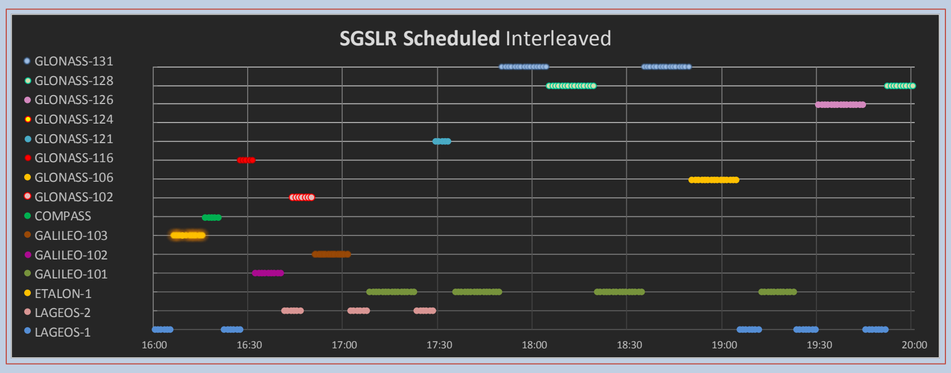
Over 70 Satellites on the Current ILRS tracking roster
~28 Satellites in 2007

Recently tracked Global SLR data
A satellite's position and the amount of data recently tracked are among the criteria that may be considered when changing the priority of a satellite. In this way, recently tracked data can be used to change satellite priorities for all SGSLR station schedules, for individual stations or station located in clusters depending on geographic location.

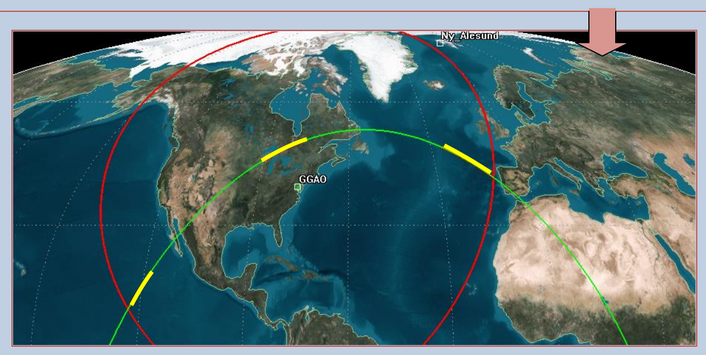


Interleaving Optimization
When using the interleaving optimization for a satellite the schedule will alternate between that satellite and lower priority satellites at a given time interval. The use of interleaving optimization will help avoid scheduling scenarios where one satellite of a group of similarly prioritized satellites is scheduled a disproportionate amount of time. As an example, see satellite visibilities vs a schedule of interleaved passes shown below. The schedule alternates between the optimized satellites and the other satellites in five-minute or fifteen-minute intervals. The resulting schedule produces a more even distribution between the satellites and each satellite's complete arc is more fully covered.



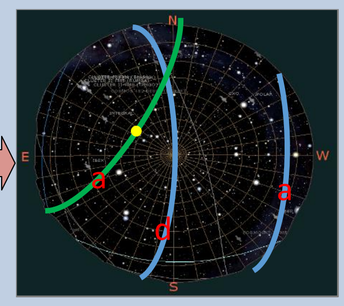


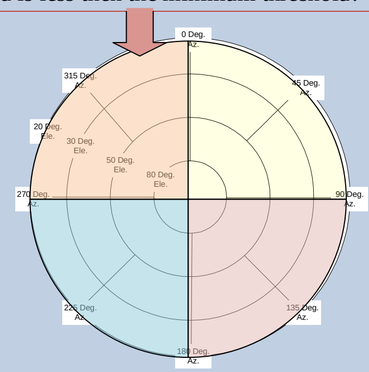
AOS, PCA, LOS Optimization:
For years the SLR analysts have suggested that getting data at the beginning, PCA, and ending of a satellite pass is the best possible data for generating satellite orbits. The NASA/KBRwyle scheduler allows for AOS/PCA/LOS optimization and can raise the priority of a satellite at the beginning, end, and the PCA of a pass.



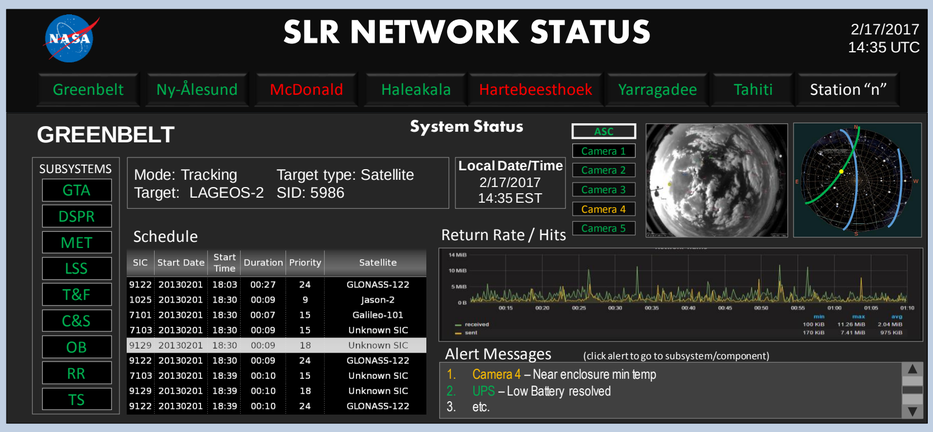
Geodetic Sky Coverage Optimization:
Geodetic optimization is used to assist in scheduling complete sky coverage for a satellite. Using geodetic optimization the sky is divided into sections based on azimuth and elevation. A minimum number of minutes per section is specified and a number of days of previously tracked data is considered. The priority of a satellite will be raised if the number of minutes previously tracked plus the number of minutes the satellite is scheduled to be tracked is less then the minimum threshold.

Ascending/Descending Optimization:
Ascending/Descending optimization is used to assist in obtaining even distribution data in ascending and descending nodes. Ascending/Descending optimization operates similarly to geodetic optimization. When using ascending/descending optimization for a satellite, the a minimum number of minutes per node is specified and the number of days of previously tracked data is considered. The priority of a satellite will be raised, if the number of minutes previously tracked in addition to the number of minutes the satellite is scheduled to be tracked is less then the minimum threshold.

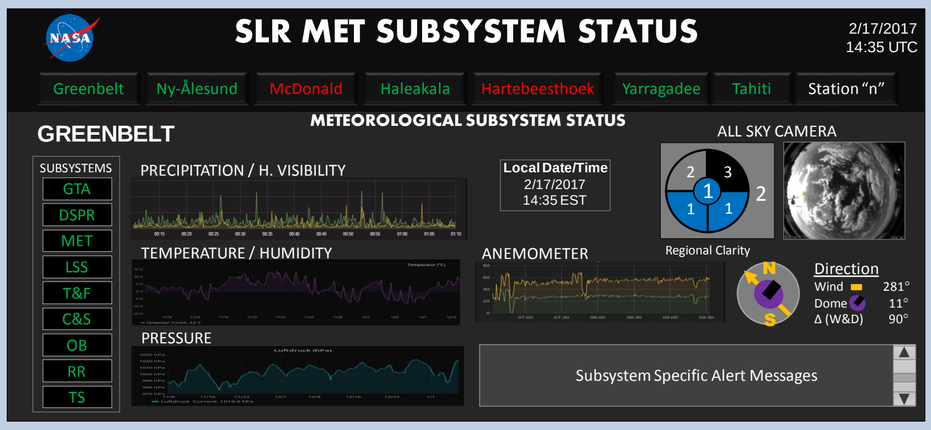




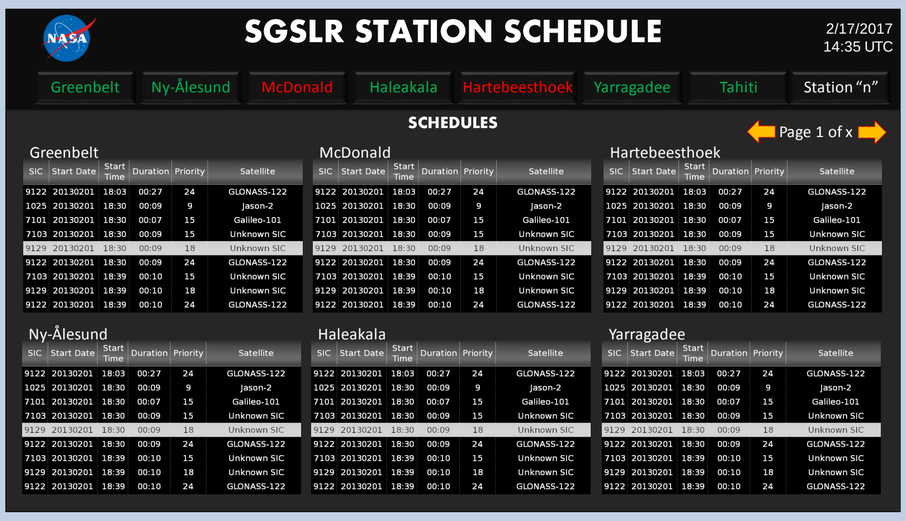
Space Geodesy Network Operations Center: The future SGSLR systems will be operated and monitored from a central facility at Goddard Space Flight Center called the Space Geodesy Network Operations Center (SGNOC). The SGNOC will provide for remote operations capability prior to implementation of full automation, system monitoring, engineering data trending, and operations coordination. The NASA Data Operations Center will be moved to the SGNOC such that all functions are performed at the same central facility location, including NASA system scheduling. This provides an increased redundancies to the Operations Center as well as provides for a robust network and minimal downtime. The SGNOC will also provide public views of the NASA Network near real-time operations and tracking status such that all ILRS members can see system status at any given time.

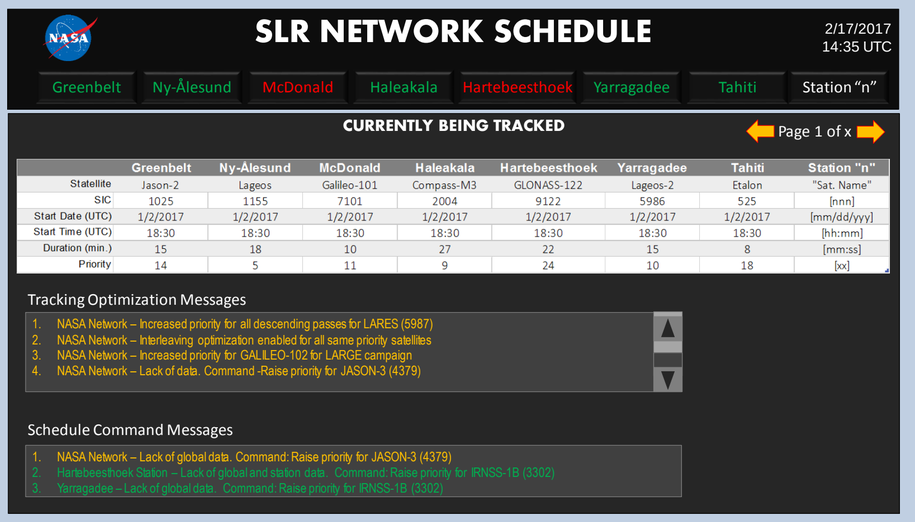


Example of SGNOC Monitoring display: The SGNOC will display many layers of real-time and non real-time data and engineering information coming from each of the SGSLR systems. The information will inform an operator if there are any issues at any site at any time. Real-time alerts will appear on all display pages to immediately alert personnel to any system issue, and messages will be sent automatically to a distribution of NASA SLR operations personnel.



NASA SGSLR Network Scheduling: The SGNOC will generate schedules for all systems in the NASA Network and will coordinate schedules based on ILRS priorities, geographic location, mission requirements, restricted tracking requirements, recent tracking and scheduling optimization inputs. The SGNOC will schedule the SGSLR systems multiple times every day to take advantage of all optimization features, including the database of recently tracked data. The SGNOC will also command stations to increase or decrease satellite priorities based on real-time information coming from the global ILRS dataset. Commands will be pushed to the Network or to individual stations to automatically change satellite priorities. The SGNOC will also provide alerts about tracking performance on the public facing page to encourage all ILRS systems to increase/decrease tracking priorities based on the most recent ILRS tracking.





The NASA/KBRwyle scheduler will provide optimized scheduling of an ever increasing number of ILRS satellites, which will improve productivity of the integrated network of SGSLR systems

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