SLR Automation for the New Space Geodesy Multi-Technique Sites

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ABSTRACT

The original NGSLR plan was for a completely automated stand alone system using an eye-safe laser. Since then the requirement for daylight GNSS ranging has been added, and NGSLR is now part of a larger multi-technique facility which includes VLBI, GNSS, and DORIS. Because of this the automation needs have also changed. NGSLR must now interface with and potentially automate much of the Laser Hazard Reduction System (LHRS). Daylight GNSS tracking has made the signal processing and automated closed-loop tracking more challenging. Automated real-time coordination between VLBI and SLR has now become a requirement, and automated surveys between all of the systems are being planned. A brief discussion of the status of NGSLR automation will be presented along with some preliminary thoughts on near term station automation design work.

Background

NASA's Next Generation Satellite Laser Ranging System (NGSLR) was originally designed to be a completely autonomous satellite laser ranging system, with the capability of ranging to low Earth orbiting satellites and LAGEOS during both night and day [1] [2]. Ranging to satellites at altitudes higher than LAGEOS was to be a night-time only requirement with daylight ranging a best effort.

NGSLR is now part of the new NASA Space Geodesy Project's Multi-Technique Fundamental System which includes Very Long Baseline Interferometry (VLBI), Global Navigational Satellite System Receivers (GNSS), and Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS). Coordination between NGSLR and the other techniques as well as daylight ranging to the high altitude GNSS satellites [3] have both become a requirement.

Planned Automation

To operate completely autonomously NGSLR needed to transmit at eye-safe laser energies (60 microJoules at 300 picosecond pulsewidth) because of Federal Aviation Administration (FAA) regulations in the United States regarding hazardous laser transmissions skyward. To maintain a similar return rate to existing NASA systems and to facilitate system automation, the laser pulse repetition frequency (PRF) was chosen to be 2 kHz.

The software was designed to make all of the decisions that are normally made by the system operator, including closing the system for inclement weather, determining what to track based on cloud cover, determining when signal is being received from the satellite, and closing the tracking loop to optimize the signal response.

In addition it was planned for the software to continuously monitor the sun angle and prevent the telescope from getting within 15 degrees of the sun. The software was to configure all of the hardware including optics on the transceiver bench and was to completely control switching from satellite tracking to ground calibration to star calibration. The transceiver bench controls include:

- Laser divergence
- Receiver FOV
- Risley point-ahead
- System focus
- Daylight / twilight filters
- ND filters
- Shutters for camera and detector
- Blocks for laser

As in other NASA systems the data processing was to occur automatically after each pass with the standard SLR products delivered within two hours of data collection.

A Remote Access Terminal (RAT) was designed to provide the interface for a human to monitor and control the system, either locally or remotely. The RAT laptop was not required when the system was running autonomously.

The original system design included hardware and software to monitor the health and safety of the system. The Health and Safety subsystem as planned consisted of:

- Remote monitoring and alerts
- System security
- HVAC monitoring
- Prime voltage monitoring
- Interior and exterior cameras
- Motion and vibration sensors, door/gate interlocks
- Temperature and humidity sensors
- Water sensors
- Emergency shutdown

Automation Status

Much of the operator decision making software is written and tested. The weather monitoring software and hardware is mature. The cloud cover monitoring station is complete and the decision software to make use of the sky information is in progress. The real-time signal processing algorithm works well for LAGEOS and LEO in both night and day. Closed loop tracking automation is in progress.

The system scheduling software is finished and in use for many years, and the data processing and product delivery is nearing completion. The sun avoidance software is tested and has been operationally working well for almost two years. Software to control all the optics in the system is nearing completion, and control of the system configuration settings is underway.

The Remote Access Terminal software is mature and has been in use for many years. Currently monitoring and control of the system requires access from within the Goddard firewall.

The Health and Safety subsystem will still be needed for completely autonomous operation, however, this subsystem is not in the NGSLR prototype as the current plans are for semi-autonomous operation. This is due to FAA requirements to have an operator present during all non-eye-safe laser operations.

New Requirements for GNSS Daylight Ranging

Because of the daylight GNSS requirements, NGSLR will require the use of a laser with a minimum of 1 milliJoule per pulse output at a pulse repetition frequency of 2 kHz which is non-eye-safe. Ranging with this laser will require the use of an aircraft avoidance radar and its associated beam blocks and ND inserts. This system, called the Laser Hazard Reduction System (LHRS), will require a new interface which will give the software the ability to both monitor and control the LHRS.

GNSS daylight ranging poses challenges for the signal processing. The high daylight noise rates combined with the low signal return rates will likely require an upgraded signal processing technique. The current software can find signal with return rates as low as 0.0005 per shot, but to date GNSS ranging has generally been less than this.

New Automation for the Multi-Technique Site

The multi-technique site will need to automatically coordinate the day to day scheduling to provide seamless non-conflicted operations between all of the system, to support remote or unmanned operations of each technique, to maximize performance and reduce cost, and to allow for site surveys between systems to monitor site ties.

Coordination between VLBI and SLR

Some analysis has been performed on the coordination of VLBI2010 and NGSLR where damage to the VLBI2010 receiver could occur if the two systems were pointed at or close to each other. In 2010 a study was performed to determine the overload threshold of VLBI2010 Broadband receiver from RFI from the SLR LHRS [4]. Currently NGSLR has implemented a telescope mask to restrict pointing its radar within the calculated damage region of VLBI2010.

Real-time knowledge of the antenna and telescope pointing will allow for the highest individual system performance while protecting the VLBI2010 system from damage. The real-time pointing avoidance model used on Mauna Kea and Maui [5] will be reviewed as a potential starting point for this work.

Conclusion

Requirements for NGSLR have changed over the past decade. Continued evolution of NGSLR into the Fundamental Station concept will improve the science product but introduces new challenges. NGSLR automation and fulfilling the Fundamental Station requirements will be the major tasks to be completed at Goddard under the newly awarded Space Geodesy Proposal**.**

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