

# SLR Automation for the New Space Geodesy Multi-Technique Sites

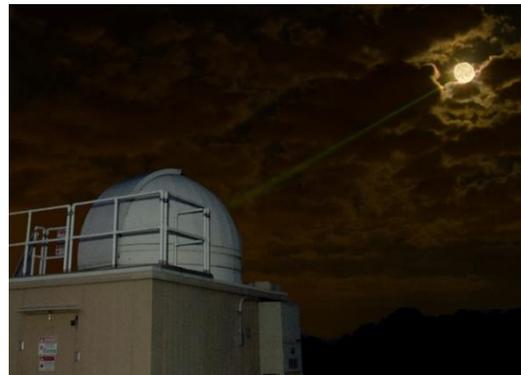
**Jan McGarry (NASA/GSFC)**

**Scott Wetzel (Honeywell)**

**Thomas Zagwodzki (NASA/GSFC)**

**Julie Horvath, Howard Donovan, Donald Patterson,  
Christopher Clarke, Anthony Mann (Honeywell)**

**John Cheek (Raytheon)**



## **Abstract:**

**The original design for NGSLR was for a completely automated stand alone system using an eyesafe laser. Since the original design 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

- The original design for NGSRL was for a completely automated stand alone system using an eye-safe laser.
- NGSRL is now part of a multi-technique site which includes VLBI, GNSS and DORIS. Coordination with the other techniques is needed.
- The requirement for daylight GNSS ranging has also been added, partly because of our participation in the multi-technique site.



# NGSLR originally planned automation

- **Operator decision making**

- closure of system due to weather conditions
- sun avoidance (prevent pointing telescope near sun)
- cloud cover (determine when to search and when to go to different target)

- **Scheduling onsite from predictions and SLR priority table**

- **Acquisition, signal processing and closed-loop tracking**

- star assisted pointing at night, search during day
- determine when successfully hitting satellite
- optimize signal response by calculating angular biases from quadrant info

- **Transmit / receive path optics configuration and control**

control all transceiver bench optics autonomously with SW decided configuration

- Laser divergence
- Receiver FOV
- Risley control (point-ahead)
- Focus
- Daylight / twilight filters
- Ground calibration configuration
- Star calibration configuration



# NGSLR originally planned automation (2)

- **Data processing and product delivery**
- **Remote monitoring**
- **Health and safety of system**
  - Remote monitoring and alerts
  - System security
  - HVAC monitoring
  - Prime Voltage monitoring
  - Interior & Exterior Cameras
  - Motion sensors, door/gate interlocks, smoke alarms, and vibration sensors
  - Smoke detectors, temperature and humidity sensors, and water sensors in the dome area as well as the electronics room
  - Emergency shutdown



# Automation Status

- Operator decision making software:
  - weather monitoring (including wind, visibility & precipitation) mature – decision process on using this information is not completely tested,
  - sun avoidance is tested and working for over almost 2 years,
  - cloud cover – needs testing and verification.
- Individual system scheduling complete.
- Signal processing and closed-loop tracking:
  - signal processing works well for LAGEOS and LEO, GNSS still needs work,
  - closed-loop tracking using quadrant detector information - still in development.
- Transmit / receive path optics configuration and control
  - control of most optics complete,
  - automated decision on configuration/settings is coded and partially tested,
  - code to put it all together based on SW decisions & scheduling – in progress.
- Data processing and product delivery: almost done.
- Health and safety of system: complete during replication.

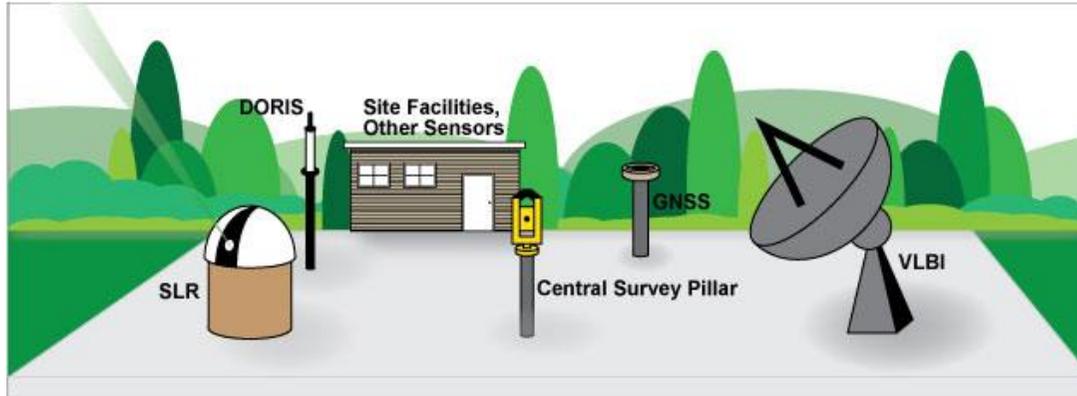


# Changes to automation needed for daylight GNSS

- **Laser Hazard Reduction System (LHRs) interface and control**
  - must use radar now for GNSS tracking due to high transmit power
  - requires interface and (mostly) autonomous control of LHRs by SW
  - intelligent automated reset
- **Signal processing challenges**
  - GNSS data rates are low and difficult to pick out
  - very difficult to use quadrant information to do closed-loop ranging for GNSS satellites – data rate too low. Need different technique or higher SNR.



# Changes needed for multi-technique site



## Multi-technique site:

A geodetic observatory  
Fundamental Station defines  
terrestrial reference points in  
the space and time domain.

The techniques include SLR,  
VLBI, GNSS, DORIS.

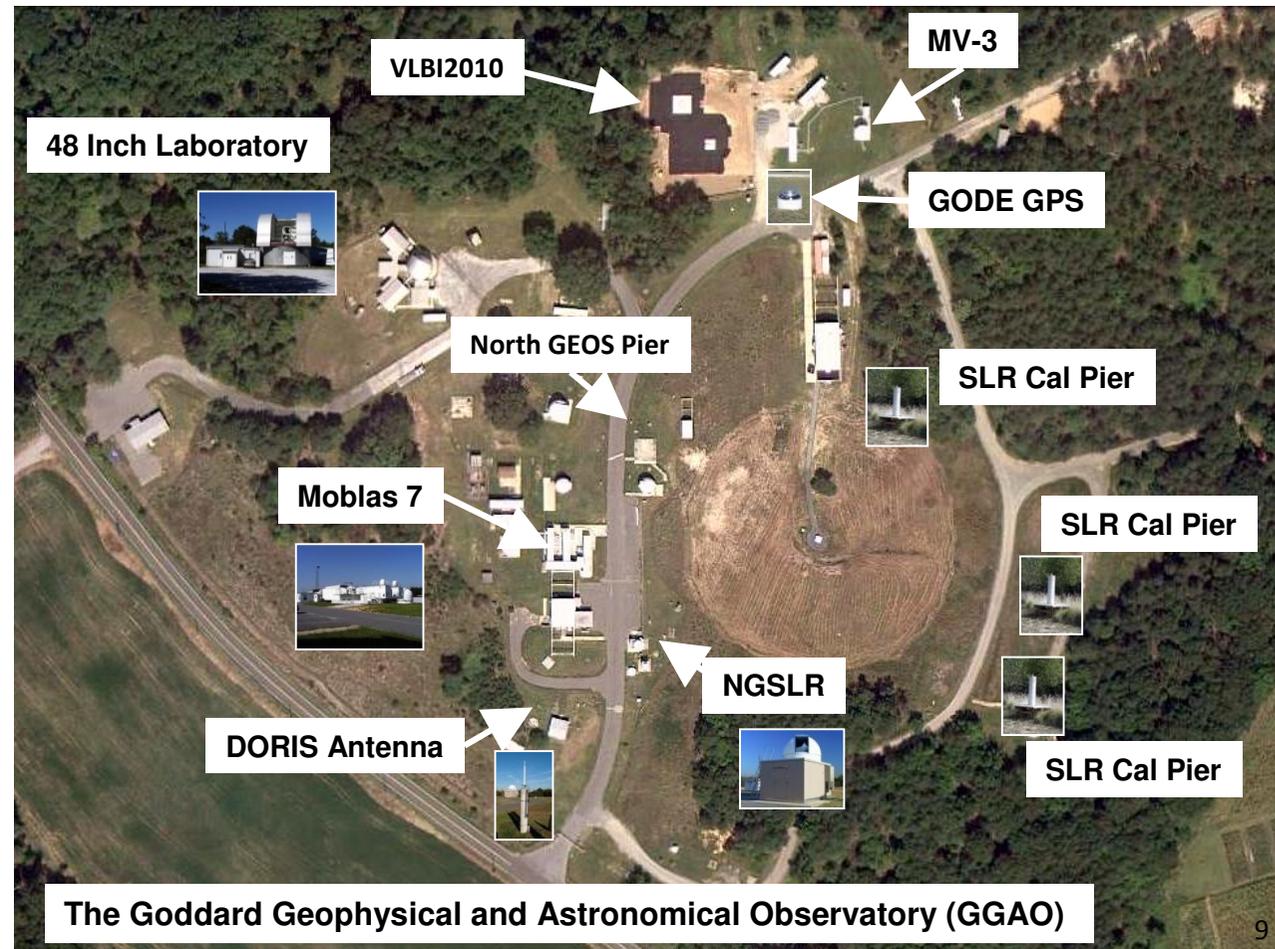
- **Automation is needed:**

- to coordinate the day to day scheduling, acquisition and delivery of data products, seamless non-conflicted operations, & communications
- to support remote or unmanned operations of each technique to maximize performance and reduce costs
- for frequent site surveys to monitor site ties.



# NASA GSFC GGAO Fundamental Station

- GSFC GGAO currently one of only a few Fundamental Stations in the SLR community.
- SLR (NGSLR), VLBI (VLBI2010) and GPS facilities being developed and integrated into the Fundamental Station concept.
- These techniques will be tied with a survey technique developed to monitor the site ties on a regular basis.



# Coordination between VLBI and SLR

- Avoid operational conflicts between the SLR LHRS and the VLBI2010 broadband receiver.
- In 2010, study was performed to determine overload threshold of VLBI2010 Broadband receiver from RFI from the SLR LHRS. (**Chris Beaudoin, MIT, Howard Donovan, Irv Diegel, HTSI**)
- Real-time knowledge of each antenna pointing is crucial to develop a most likely automated de-confliction process.
- Possibly utilize existing model used on Mauna Kea / Maui (reference Dan O’Gara presentation).
- Both systems could be run or monitored by a single operator at the central control room or remotely at the Central Facility.

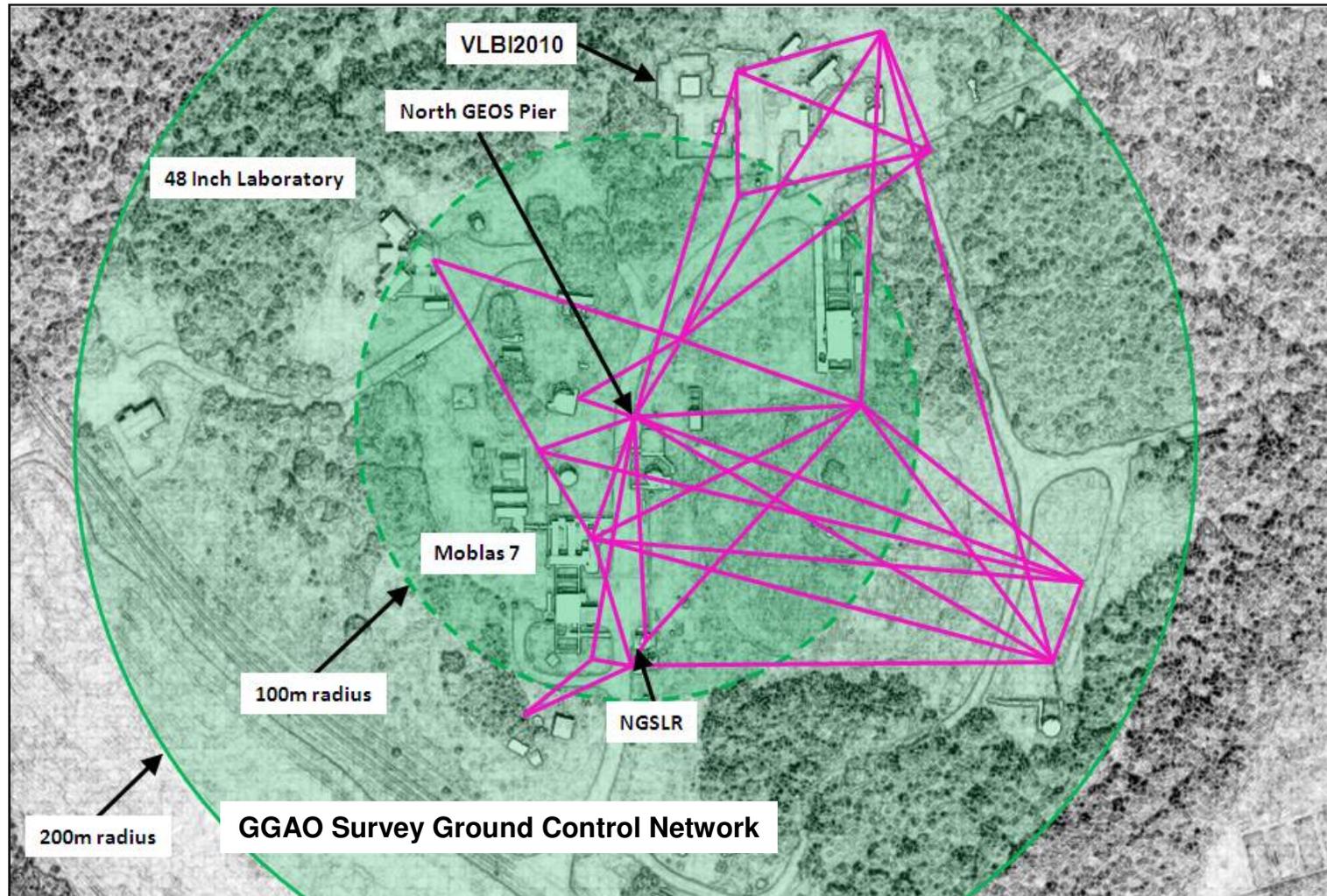


# Automated Station Survey

- Avoiding local motions from being aliased in the data products, monitoring of ground stability and slight local motions is essential to properly interpreting the space geodesy data.
- **Traditional first order geodetic surveys are expensive and infrequent.**
- Errors in site ties may not be resolved in a timely manner, introducing bias
- **Fundamental Station concept provides for frequent survey, and site tie development / monitoring being explored with use of robotic survey equipment.** Utilizing international cooperation to share thoughts, tools, etc.
- Study at GSFC in 2009 began the development of automated survey capability.
- Minimum set of ground targets at each system, and survey markers optimized for mutual line of site measurements.
- **Frequent monitoring of these positions** and those relative to the data techniques will ensure rapid understanding of local motions.
  - **Should be part of site scheduling, same as preventive maintenance and calibration**
  - Should be made available for incorporation to ITRF
  - May require some break in SLR tracking but best if no break



# Monitoring the GGAO Site Ties



# Summary

- Requirements for automation at NGSRL and GGAO have evolved over the past 10 years.
- Addition of daylight GNSS has added more to monitor and control and presents some issues for automation.
- Continued evolution to the Fundamental Station improves the science product but introduces new challenges.
- Working to complete NGSRL automation while developing strategies needed to fulfill Fundamental Station requirements.

