GGAO as an Integrated Geodetic Site

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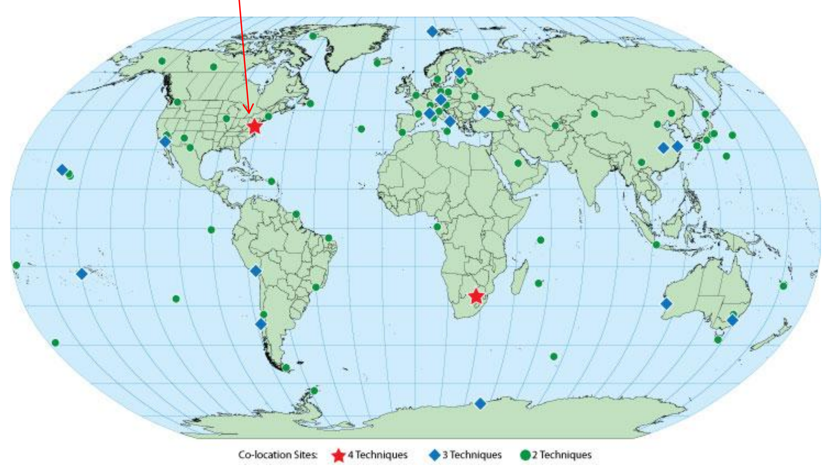
Introduction

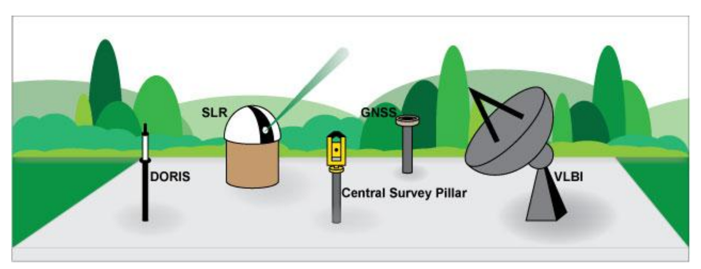
The **Goddard Geophysical and Astronomical Observatory (GGAO)** co-locates the four space-geodetic techniques of SLR, VLBI, GNSS, and DORIS. It is one of only two sites that integrate that many techniques at the same site.

Within the **Global Geodetic Observing System (GGOS)** it is suggested that globally up to 40 fundamental sites with all geometric techniques co-located are needed in order to provide the reference frame accuracy to support science at the 1-mm level and better. Hence, GGAO lends itself to serve as a test bed for an optimal configuration of these integrated geodetic sites.



The International Terrestrial Reference Frame (ITRF) is defined and maintained by the measurements of the space geodetic systems, taking advantage of the individual strengths of each technique.

NASA has contributed SLR, VLBI, and GNSS systems to the global network since the Crustal Dynamics Project in the 1980s.



Current Status of the Integrated Site at GGAO

GGAO co-locates the following techniques:

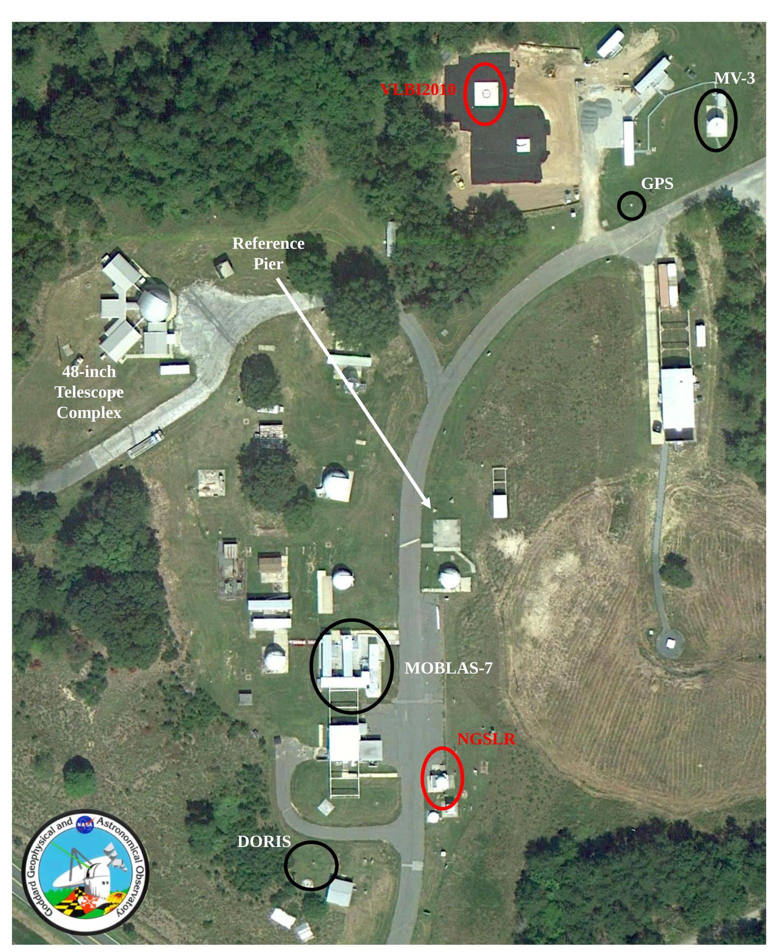
- GPS, DORIS, and legacy SLR and VLBI systems
- Next Generation SLR (NGSLR): semi-operational
- Next generation VLBI (VLBI2010): antenna installed and being equipped

GGAO will be the location for the prototype next generation multi-technique station as developed by NASA.

Next steps:

- Network simulations to determine operational and technical tradeoffs based on LAGEOS, GNSS, VLBI.
- Complete prototypes of SLR and VLBI instruments.
- Implement automated survey system to measure inter-technique vectors for co-location.
- Develop generalized station layout considering RFI and operational constraints.
- Begin site evaluation for network station development.

Aerial view of GGAO. The sites of the next generation instruments NGSLR and VLBI2010 are marked by red ovals.

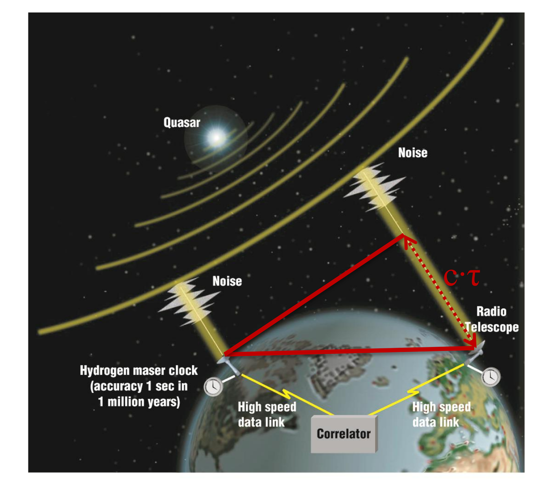


GGAO as seen from the NGSLR system. The panorama has an angular view of about 210°. The NGSLR radome is in the front center.

Next Generation VLBI (VLBI2010) at GGAO

Key characteristics of VLBI2010:

- Fast, small antennas.
- Unattended operations.
- More observations for troposphere and geometry.
- Broadband feed for multi-band observable.
- Higher speed recording for increased sensitivity.
- Modern digital backend electronics.



In place:

- 12-m Patriot antenna with 6 deg/sec azimuth rate.
- Proof-of-concept cryogenic COTS broadband feed
- DBE-1 (Digital Back End)
- Mark 5B Recorder
- UpDown Convertor (UDC) for flexible RF placement

Next months:

- Broadband Eleven Feed
- RDBE
- Mark 5C

Please see the poster EGU2011-13547 about VLBI2010 by D. MacMillan et al. in the same poster session.

The VLBI observable is the difference in the arrival time of a radio signal (from a quasar) at two different radio telescopes. The measured time delay, using the speed of light, can be interpreted as a distance. The distance is the component of the baseline toward the source (quasar). By observing many sources, all components of the baseline can be determined.

Next Generation SLR (NGSLR) at GGAO

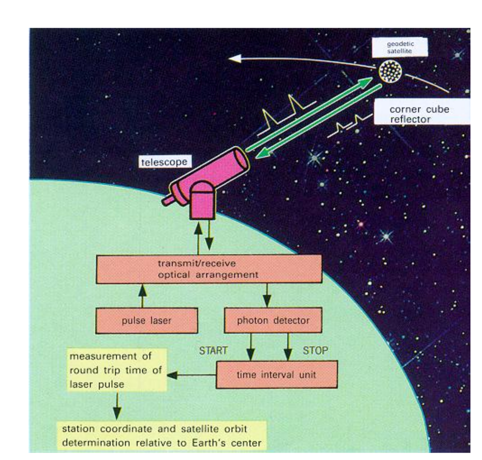
Key characteristics of NGSLR:

- A high rep rate, single photon detection laser ranging system capable of tracking retro-reflector equipped satellites up to 20,000 km.
- Daylight as well as night-time automated tracking and ranging.
- Also capable of planetary transponder ranging and potentially of laser communication.

In place:

- Successfully ranges to satellites from Low Earth Orbit to GNSS satellites.
- Agrees ±2 cm with network standard MOBLAS7.
- GSFC-developed variable mJ laser capable of both eye-safe and daylight GNSS tracking.
- Currently also performing uplink-only ranging to the Lunar Reconnaissance Orbiter (LRO).

SLR measures the time of flight of a laser pulse as it travels between a ground station and a satellite equipped with retro-reflectors. The two-way travel time determines the distance to the satellite.



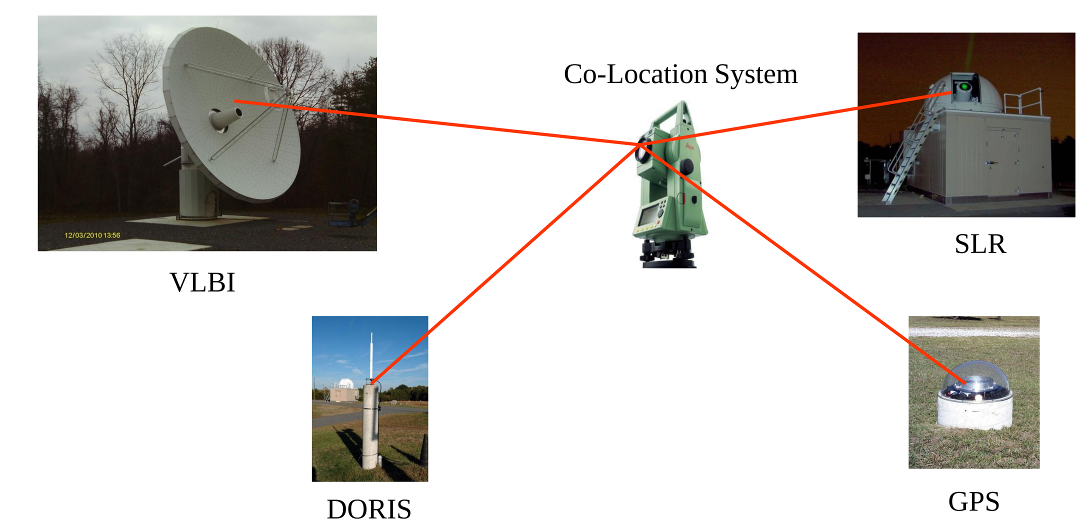
Co-location Monitoring at GGAO

Key characteristics:

- System needs to be simple enough for site personnel to set up and operate.
- Automatic, rapid, and computer-driven.
- Done regularly: daily or weekly.

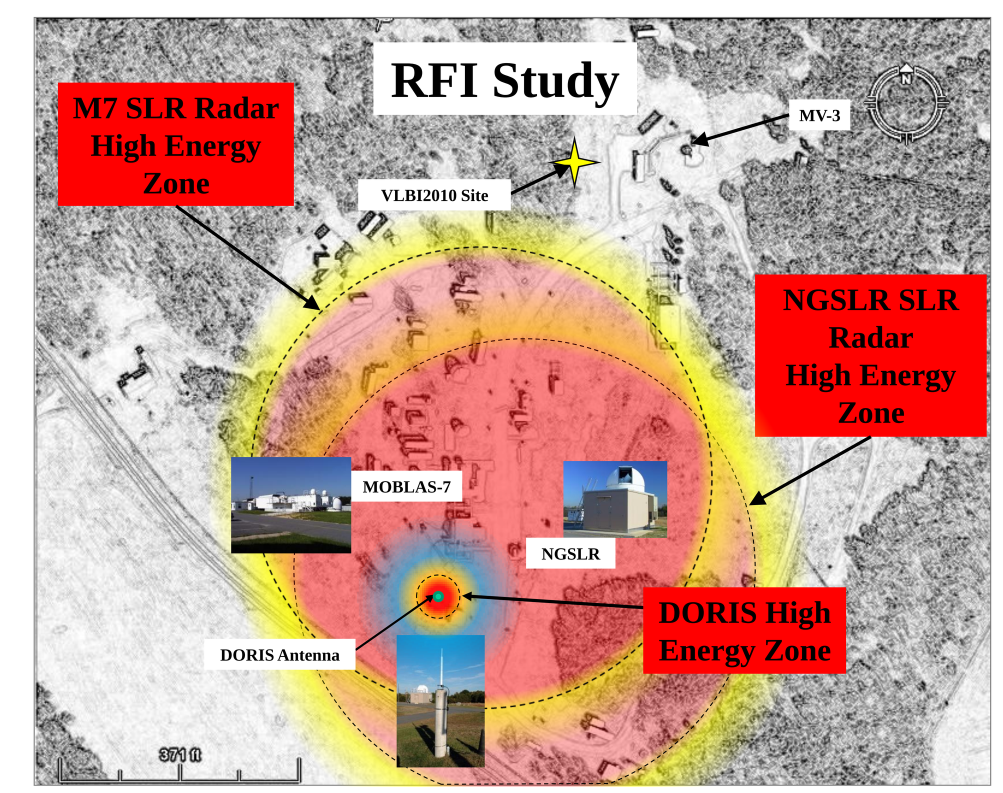
Demonstrated:

- Automated VLBI reference point determination using Leica TCA2003 robotic total station.



As a first step towards an automatic monitoring system, an automatic measurement procedure was developed. Both the total station and the VLBI antenna can be controlled from a Matlab-coded control program. Running specific observational programs, data was collected that indicate that the reference point of the VLBI antenna can be automatically determined with an accuracy of 1 mm or better.

Radio Frequency Interference (RFI) Mitigation



For a successful operation of the four space instruments in parallel, it is essential that the techniques do not interfere with each other or that interference can be sufficiently mitigated. In this respect, the electro-magnetic compatibility of the VLBI2010 and legacy VLBI systems with DORIS and the aircraft-avoidance radar of SLR/NGSLR are most critical.

We undertook signal simulation studies as well as actual signal measurements and we will continue this into the future. While the legacy VLBI system can operate without any mitigation strategies, for the broadband VLBI2010 system such strategies need to be implemented.

Currently suggested RFI mitigation strategies:

- separate VLBI2010 from DORIS/NGSLR by >100 m
- place a reflective or absorptive barrier between the transmitter and VLBI2010 (natural or man-made)

Outlook

The development of the next generation SLR and VLBI systems will be continued. We plan to investigate further the generalized station layout considering RFI and operational constraints. Long-term plans include site evaluations for a generalized network station deployment of up to 10 stations and creation of a possible implementation plan.