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VLBI2010 in NASA's Space Geodesy Project

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Abstract

In the summer of 2011 NASA approved the proposal for the Space Geodesy Project (SGP). A major element is the development at the Goddard Geophysical and Astronomical Observatory of a prototype of the next generation of integrated stations with co-located VLBI, SLR, GNSS, and DORIS instruments as well as a system for monitoring the vector ties between them. VLBI2010 is a key component of the integrated station. The objectives of SGP, the role of VLBI2010 in the context of SGP, near term plans, and possible future scenarios will be discussed.

1. Introduction

NASA's Space Geodesy Project (SGP) is a new initiative that started at the end of the summer of 2011. SGP is a joint effort of the Goddard Space Flight Center (GSFC) and the Jet Propulsion Laboratory (JPL) with participation from the Smithsonian Astrophysical Observatory and the University of Maryland.

The long-range goal of the Space Geodesy Project is to build, deploy, and operate a next generation NASA Space Geodetic Network (NSGN) of integrated, multi-technique next generation space geodetic observing systems, along with a system that provides for accurate vector ties between them. This new NSGN will serve as NASA's core contribution to a global network designed to produce the higher quality observational data required to maintain the Terrestrial Reference Frame and to provide other data necessary for fully realizing the measurement potential of the current and coming generations of Earth Observing spacecraft.

A wide range of information ranging from science and technique descriptions to publications and multimedia presentations is compiled in the project's Web site at

`http://space-geodesy.nasa.gov/`.

Of particular interest to the VLBI community is the short video about the history of VLBI `http://space-geodesy.nasa.gov/multimedia/VLBIHistoryVideo.html`.

2. Recommendations from the National Research Council

SGP is part of NASA's response to the National Research Council report "Precise Geodetic Infrastructure: National Requirements for a Shared Resource" (`http://www.nap.edu/openbook.php?record_id=12954`). The report formulated the following recommendations:

- Deploy the next generation of automated high-repetition rate SLR tracking systems at the four current U.S. tracking sites in Hawaii, California, Texas, and Maryland;
- Install the next generation VLBI systems at the four U.S. VLBI sites in Maryland, Alaska, Hawaii, and Texas;

- Deploy additional stations to complement and increase the density of the international geodetic network, in a cooperative effort with its international partners, with a goal of reaching a global geodetic network of fundamental stations;
- Establish and maintain a high precision GNSS/GPS national network constructed to scientific specifications, capable of streaming high rate data in real time;
- Make a long-term commitment to maintain the International Terrestrial Reference Frame (ITRF) to ensure its continuity and stability;
- Continue to support the activities of the GGOS.

The SGP has taken on the task of making all or part of these recommendations a reality.

3. Project Schedule

The initial project is set up for two years. Within these two years, SGP will focus on accomplishing three main tasks.

1. `Network Design Studies:` Perform network simulations to find the optimal number and distribution of SGP sites for an improved global network of space geodetic stations;
2. `Prototype Station Development:` Complete the prototypes of the next generation SLR and VLBI instruments; implement an automated survey system for measuring inter-technique tie vectors; develop a generalized station layout considering RFI and operational constraints;
3. `Implementation Plan:` Establish a deployment and operations plan based upon site evaluations and prototyping results.

As major milestones of the project the prototype integrated space geodetic station shall be established by February 2013, the station performance verified by July 2013, and the implementation plan completed by July 2013.

4. NASA Prototype Station at GGAO

The Goddard Geophysical and Astronomical Observatory (GGAO) functions as a testbed for the prototype station as developed by NASA because GGAO co-locates the four space-geodetic techniques on site (VLBI, SLR, GNSS, and DORIS). Figure 1 provides an aerial view of the observatory and the four space-geodetic techniques. The NGSLR is semi-operational, while a VLBI2010 antenna was installed and is in the process of being equipped.

- **VLBI2010 at GGAO.** The key characteristics of the next generation VLBI system are fast and small antennas, unattended operations, increased number of observations, broadband feeds (for multi-band observables), higher speed recordings (for sensitivity), and modern digital backends, among other things. In the spring of 2012 the following equipment was in place at GGAO:
  - 12-m Patriot antenna with 5°/s azimuth slew rate;
  - Cryogenic QRFH (QuadRidgeFlaredHorn) feed and LNAs from Caltech;
  - ORCA (Optical Receiver/Splitter/Amplifier);

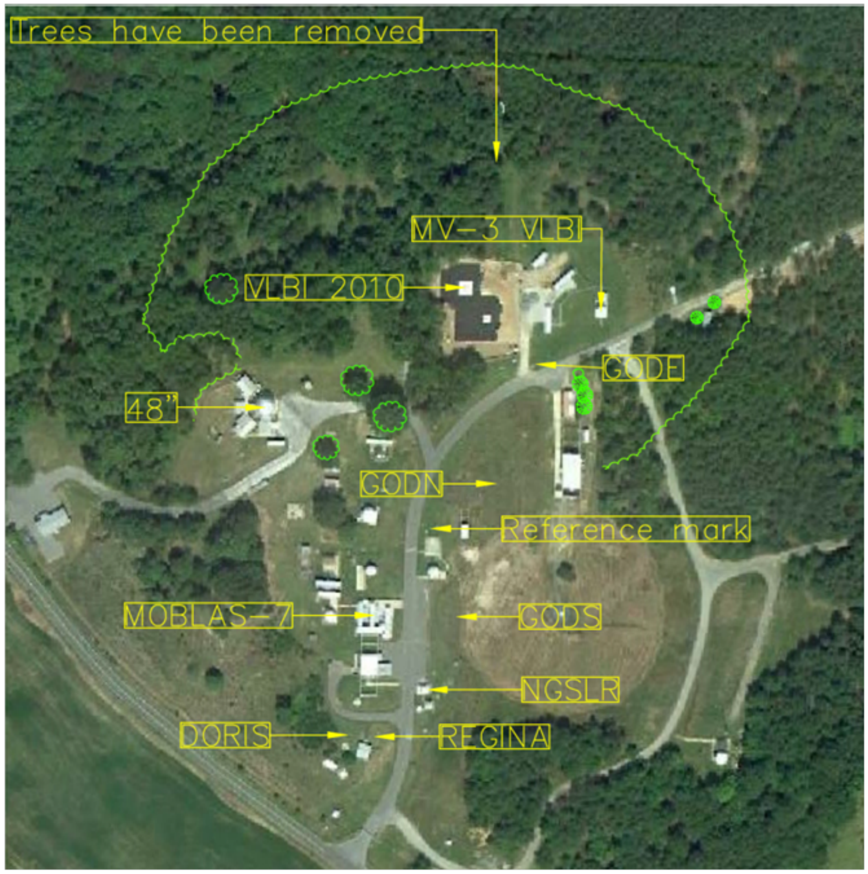

Figure 1. Aerial view of GGAO and its four space-geodetic techniques.

Figure 2. GGAO's 12-m Patriot antenna.

- UDC (UpDown Converter) for flexible RF placement;
- RDBE (ROACH-board Digital Back End);
- Mark 5C recorder;
- Sigma Tau maser;
- Optical fiber from antenna to rack for RF.

• **NGSLR at GGAO.** The next generation SLR has a high repetition rate single photon detection laser ranging system capable of tracking cube corner equipped satellites in Earth orbit. The concept of NGSLR was developed by J. Degnan (GSFC, retired) in the 1990s. The technical development continues at Goddard. The system has demonstrated tracking of Earth orbit satellites with altitudes from ∼1,000–20,000 km. The completion of the NGSLR prototype will occur during the Space Geodesy Project.

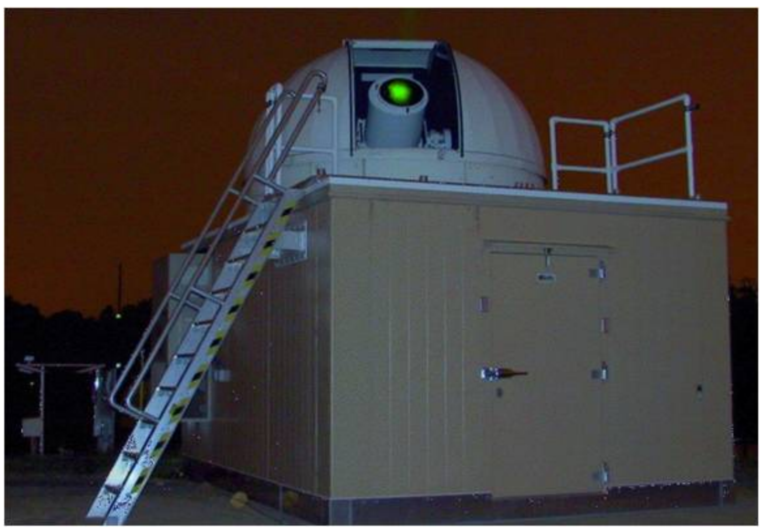

Figure 3. GGAO's NGSLR system.

The features of the NGSLR system include:

- 1–2 arcsecond pointing/tracking accuracy;
- Tracking CCR equipped satellites to 20,000 km altitude, 24/7 operation;
- Reduced ocular, chemical, and electrical hazards;
- Semi-automated tracking features;
- Small size, compactness, low maintenance, and increased reliability;
- Lower operating/replication costs.

• **GNSS at GGAO.** New GNSS equipment (Javad Delta TRE_G3TH receivers) for GPS, GLONASS, and Galileo has been installed using two new deep-drilled braced monuments (GODN and GODS). The long established GODE station will be retained.

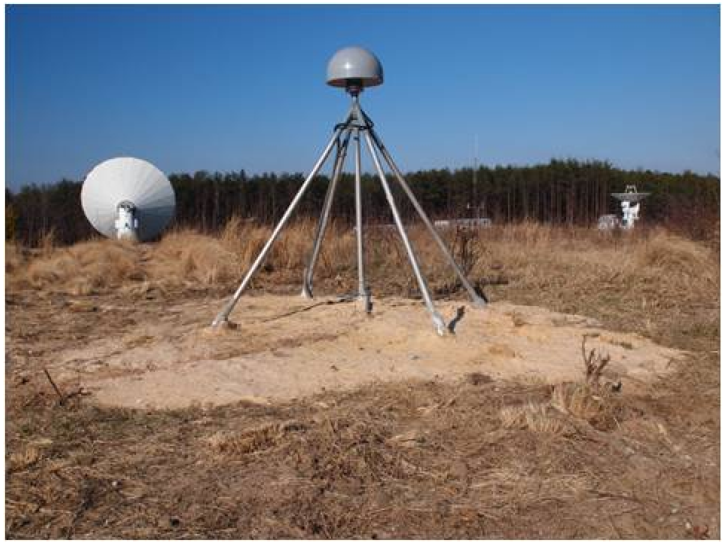

Figure 4. Deep-drilled braced monuments for GPS, GLONASS, and Galileo.

5. Co-location Monitoring at GGAO

The key characteristics of the co-location system at GGAO comprise:

- A need for sufficient simplicity that site personnel can set up and operate the system;
- Automatic, rapid, and computer-driven control;
- Regular operation: daily or weekly.

Using a Leica TCA2003 robotic total station an automated VLBI reference point determination has been demonstrated.

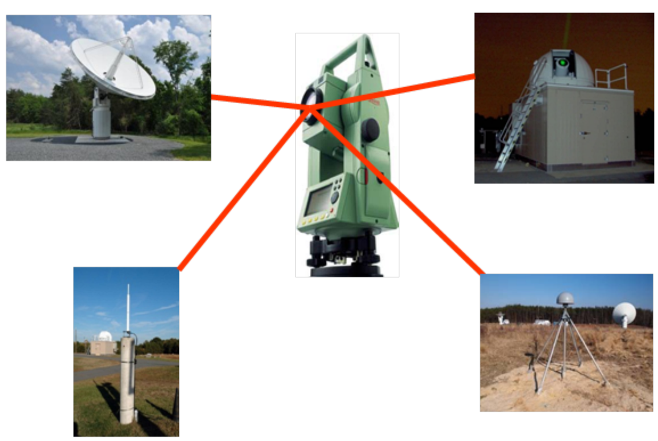

Figure 5. Automatic co-location monitoring system based on the use of robotic total stations to determine the tie vectors between VLBI, SLR, DORIS, and GNSS.