Support of EarthScope GPS Campaigns at the UNAVCO Facility

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ABSTRACT

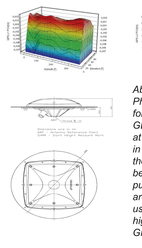
In order to support portable GPS deployments funded by the NSF's EarthScope Science panel, PBO has purchased 100 campaign GPS systems. Based Topcon GB-1000 equipment, the systems have been designed for stand-alone temporary or semi-permanent deployment that will be used for densifying areas not sufficiently covered by continuous GPS, and responding to volcanic and tectonic crises. UNAVCO provides support for all aspects of these projects, including proposal and budget development, project planning, equipment design, field support, and data archiving. Ten of the 100 systems have been equipped with real-time kinematic (RTK) capability requiring additional radio and data logging equipment. RTK systems can be used to rapidly map fault traces and profile fault escarpments and collect precise position information for GIS based geologic mapping. Each portable self-contained campaign systems include 18 Ah batteries, a regulated 32 watt solar charging system, and a low-power dual frequency GPS receiver and antenna in a waterproof case with security enhancements. The receivers have redundant memory sufficient for storing over a year's worth of data as well as IP and serial communications capabilities for longer-term deployments. Monumentation options are determined on a project-by-project basis, with options including Tech2000 masts, low-profile spike mounts, and traditional tripods and optical tribrachs. Drilled-braced monuments or masts can be installed for "semi- permanent" style occupations. The systems are being used to support several projects, including the University of Nevada Reno's current 34-unit deployment to monitor the motion of the Colorado Plateau and the ongoing Rio Grande Rift experiment, run by the Universities of Colorado, Utah State, and New Mexico, which has seen the construction of 25 permanent monuments in 2006 and 2007 and a 26-site campaign reoccupation in 2008.

UNAVCO provides support for equipment, project planning and budgeting, proposal writing, and training in all aspects of GPS campaigns. Field engineer support for assistance in deployment and monument construction is also available, although the PI is responsible for travel and material costs. Data collected will be archived at the UNAVCO Facility, and processing of the data through PBO analysis centers can be arranged by special request. Contact support@unavco.org for more information, and go to our website (http://www.unavco.org) to submit an online request for support.

EQUIPMENT

100 GPS systems are available for UNAVCO-supported EarthScope campaigns. Each campaign system includes a Topcon GB-1000 receiver with 1 GB each of internal and redundant external memory, Topcon GPS antenna, 18 Ah battery, 32 watt solar panels, and a solar charge regulator. In 2010 absolute phase center calibrations for the Topcon PG-A1 w/ground plane antenna were performed at the Geo++ robot facility in Hanover, Germany, and the type-mean results have been made available to the public by Topcon. The equipment is housed in a waterproof case, with optional exterior security bracket and lock. The system is designed for stand-alone deployment, with power requirements supplied by the solar-charged batteries. 1 GB of internal memory can store a year's worth of data; IP and serial communication capabilities are also available. Ten systems are equipped with real-time kinematic (RTK) capability for such uses as rapid fault mapping and GIS-based geologic mapping.

Above: EarthScope-funded campaign GPS system prototype. All equipment can be contained in the waterproof case, excluding antenna monumentation. Clockwise from top-center: 18 Ah 12 volt battery, optical tribrach, Topcon GB-1000 GPS receiver, Topcon antenna, solar charge regulator.



Above: In 2010 Absolute Phase Center Calibrations for both GPS and GLONASS were performed at the Geo++ robot facility in Hanover, Germany, and the type-mean results have been made available to the public by Topcon. These are the preferred PCV's for use in the majority of high-precision GPS and GNSS.

Above: Campaign GPS station on the Olympic Peninsula, WA. Low profile antenna mounts were used to reduce the amount of equipment to be transported into remote areas. 32 watt solar panels provide the power necessary to run the Topcon GB-1000 GPS receiver for the duration of the experiment. (Univ.'s of WA and AZ)

Right: EarthScope campaign GPS station on the Oregon coast. Topcon GB-1000 receiver, solar charge regulator, and 18 Ah battery are protected within the waterproof case. (University of Oregon)

Several Topcon GB-1000-based Real Time Kinematic (RTK) systems are available for use on EarthScope-funded projects. Useful for cm-level precision mapping for a variety of purposes, these systems are portable, relatively simple to operate, and include Topcon software for reducing and plotting the data. UNAVCO has detailed documentation posted on our website, and also offers a one- or two-day training course that can be given on request either at our Boulder facility or at your location to larger groups.

MONUMENTATION

Monumentation options include:

- Tech2000 masts
- traditional tripods/tribrachs
- low-profile spike mounts
- single mast
- full-scale DDBM's or SDBM's

Above: One of 29 Topcon GB-1000 GPS stations deployed across the Olympic Peninsula, WA, as part of a Universities of Washington and Arizona (PI's Dan Johnson, Ken Creager, Rick Bennet) project to monitor the September 2005 Cascadia Episodic Tremor and Slip event. The antenna monumentation consisted of a galvanized steel rod driven 2-4 feet below the ground surface.

Above: Station CHRS on the island of Hawaii, deployed immediately following the October 15, 2006 M6.7 Kiholo Bay earthquake by investigators of the University of Hawaii and USGS/Hawaii Volcano Observatory. This and four other stations will be used to determine the post-seismic deformation field associated with the event.

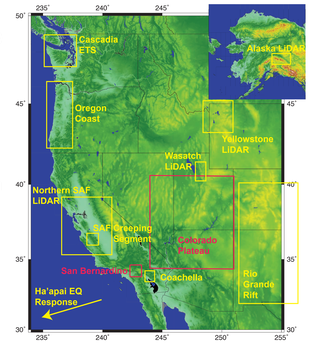
Above: Ground control station from the GeoEarthScope northern San Andreas Fault system airborne LiDAR survey. Topcon GB-1000 receivers recorded 1 Hz data collected by tripod-mounted choke rings over existing first-order benchmarks. Data was used to determine the locations of the aircraft and scanner to improve the resolution of the LiDAR images. The stations were manned by UNAVCO personnel and by USGS volunteers while missions were being flown.

UNAVCO Facility staff designed special enclosures and systems to provide support for semi-permanent installations in the Rio Grande Rift network (*right*). Monumentation included shallow-drilled braced monuments and shallow foundation masts. The systems are comparable to those of permanent PBO stations but portable to allow removal and reuse by future EarthScope projects.

RECENT PROJECT HIGHLIGHTS

From 2005-2011, UNAVCO has supported eleven EarthScope GPS projects using the Topcon GB-1000 equipment pool.

- 29-unit, 3 month monitoring the September 2005 Cascadia Episodic Tremor and Slip event
- Coachella Valley, CA: measuring groundwater-induced subsidence
- Oregon Coast: determining interseismic strain
- San Andreas Fault creeping segment
- 5-station emergency response to the 2006 Ha'apai earthquake on the island of Hawaii
- High-rate ground control for the 2007 GeoEarthScope LiDAR survey along 1000 km of the northern San Andreas Fault system.
- High-rate ground control for 2008 GeoEarthScope LiDAR surveys in Utah, Yellowstone NP, and Alaska
- Rio Grande Rift campaign, 26 points re-occupied in Colorado and New Mexico
- Rio Grande Rift semi-permanent network of 25 stations in CO and NM, operating through 2011
- San Bernardino campaign, 25 points occupied each summer from 2009-2011
- Colorado Plateau Campaign - 34 new GPS monuments in AZ, southern UT and southeastern NV



Above: Supported EarthScope campaigns between 2005 and 2008.

San Bernardino Campaign

- Investigating disagreements between geologically and geodetically estimated slip rates for the San Bernardino and San Gorgonio Pass sections of the San Andreas fault.
- Professor Sally McGill (California State University, San Bernardino) leads a team of undergraduate students and high school teachers (accompanied by some of their students) in an annual, week-long campaign to collect new survey-mode GPS data. During each summer from 2009-2011 the team collects 4 to 5 days of GPS data from 25 sites.

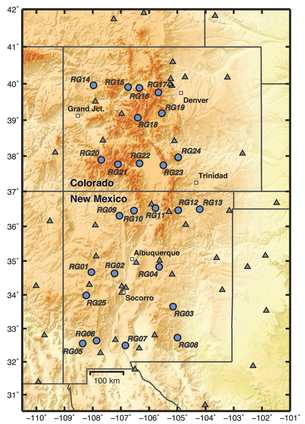
Left: From left to right, these students are Jimmy Nguyen, Miguel Santos and Clariza Munguia, from Hesperia High School, Hesperia, California. The 2010 participants included 10 high school teachers and 22 high school students, representing 9 different high schools. There were also 8 undergraduates involved.

Colorado Plateau Project

Above: Two campaign sites located on the Colorado Plateau in southwestern United States. EarthScope-funded campaign GPS systems are deployed for measurements at 34 new GPS monuments that were installed in Arizona, southern Utah and southeastern Nevada.

- Professors Corné Kreemer and Rick Bennett installed 34 new GPS stations in Arizona, southern Utah and southeastern Nevada.
- GPS measurements are conducted to establish how the crust of the Colorado Plateau moves relative to stable North America.
- Interpretation of the horizontal velocities tells the investigators whether the area moves as a coherent block or is internally deforming.
- These stations complement and densify the long-running continuous GPS stations of NSF EarthScope's Plate Boundary Observatory.
- Many of the new GPS stations are installed in National Parks and Monuments, as well as in State Parks. The investigators provide educational material to inform the parks on the active tectonics of the region and the aim of the project. The goal of these outreach activities is to educate the parks' visitors that the geologic wonderland they are in is actively

Ongoing Project: Rio Grande Rift Semi-permanent network



Above: The 25-station Rio Grande Rift Network (blue circles) infills PBO (gray triangles) and other existing permanent stations to bring the total number of stations available to study the rift to over 60.

As part of the ongoing Rio Grande Rift project operated by the Universities of Colorado and New Mexico, UNAVCO oversaw the design and construction of 25 high-stability GPS monuments.

These stations will be operated through at least 2011 to provide the first-ever high-precision measurements of extension across the rift. Installation of the network by UNAVCO personnel was completed between August 2006 and June 2007. PI's are Anne Sheehan (CU), Tony Lowry (now at USU), Steve Nerem (CU), and Mousumi Roy (UNM).

Above: Equipment enclosure designed for RGR sites - durable yet easy to move.

Above, left: Single mast monument with light-weight pelican case for equipment. Installation is done using hand-carried tools (no generator!), or horse/ATV pack. (RG23 - Great Sand Dunes Natl. Park, CO)

Below: Short drilled-braced monument with Jobox style equipment enclosure, constructed for semi-permanent site RG06 (Faywood, NM) of the Rio Grande Rift network.

Site selection and reconnaissance for all Rio Grande Rift stations were done by the Universities of Colorado and New Mexico, and permitted through UNAVCO. Stations will be operated and maintained by CU and UNM staff for the duration of the project.

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