Accomplishments

This report covers the first year of this award and covers activities from April 1, 2013 through March 31, 2014.

What are the major goals of the project?

In recent years, Terrestrial Laser Scanning (TLS) has established itself as a valuable scientific tool for Earth science research. TLS uses Light Distance and Ranging (LiDAR) technology and is also referred to as ground-based LiDAR or tripod LiDAR. The primary capability of TLS is the generation of high-resolution 3-dimensional (3D) imagery of surfaces and objects over scales of meters to kilometers with sub-centimeter to centimeter resolution and precision. This allows for accurate mapping of geologic features, and determination of change of these features over time.
via repeated measurements. The incorporation of GPS measurements with TLS observations provides georeferencing of TLS data in an absolute reference frame. The addition of digital photography yields photorealistic 3D images. TLS systems are portable and suitable for a wide spectrum of user applications in a variety of environments. TLS resources at UNAVCO are currently overextended because of steadily increasing demand for support and the recent retirement of the sole UNAVCO Polar TLS instrument.

The project - Acquisition of Next Generation Terrestrial Laser Scanning Systems for Community Earth and Polar Science Research – was funded through the NSF EAR-IF program to acquire two new terrestrial laser scanning (TLS) instrument systems for the UNAVCO community equipment pool. These TLS systems will be shared resources managed by UNAVCO Facility and integrated into UNAVCO’s ongoing support for NSF Polar (PLR) and Earth science (EAR) projects. The new TLS instruments will be critical resources for the Geodetic Imaging group within the Geodetic Infrastructure program under the Geodesy Advancing Geoscience and EarthScope (GAGE) Facility Cooperative Agreement (EAR-1261833) from 2013-2018. Considering the expense of TLS equipment and the expertise needed for successful operation, this approach represents the most cost effective means of maximizing return on investment and making this technology accessible to the NSF EAR and PLR research communities. Related services also provided by UNAVCO EAR and PLR include access to the GPS instrument pool, pre-season project planning, logistical support, field support and training, data management and archiving, post-season follow-up and research and development work for supporting new applications.

What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?

**Major Activities:**
In May 2013, the first TLS system was acquired under this award. A Riegl VZ1000 laser scanner, integrated camera system, associated accessories, and field computer were acquired from Riegl USA. Funds from this award were also utilized to upgrade one of UNAVCO’s existing Riegl VZ400 systems to add a digital compass and hardware support for the integration of an RTK GPS antenna directly into the scanner. This upgrade represents an important modernization of UNAVCO’s existing TLS system, and ensures that the TLS remains useful to the EAR and PLR communities.

During summer and fall of 2013, the new TLS system was used to support six TLS projects – three in the US and three in Antarctica. See “Significant Results” section for a summary of these activities.

**Significant Results:**
The newly acquired Riegl VZ1000 TLS system was used to support six TLS projects during the summer and fall of 2013 – below is a summary of these projects:

*Icy Debris Fans, Alaska (PI: Craig Kochel, Bucknell College, NSF EAR-1224720):* UNAVCO’s Riegl VZ1000 was used to document landform evolution and depositional processes responsible for creating ice-dominated mass wasting landforms (icy debris fans) in areas where distributary
glaciers have decoupled from high-level icecaps during recent climate warming. A direct measurement of these landforms is very challenging due to terrain/hazards; accordingly, TLS surveys can provide quantitative data on rates of dynamic morphosedimentary processes and landform change. These are newly discovered landforms, and the PI anticipates that the research will provide transformative perspectives on the nature of landform evolution in rapidly deglaciating alpine environments.

Geodesy for Evaluation the Impact of Sea Level Rise on NASA Centers and Facilities (PI: Steve Nerem, University of Colorado, NASA NNX12AF56G): The goal of this project is to assess the impact of sea level rise on NASA Centers and Facilities. UNAVCO’s Riegl VZ1000 was used at NASA facilities at Wallops Island and Langley to capture very accurate and high-resolution topographic data and to generate accurate ties to proximal tide gauges. These topographic data will be used to assess impacts of sea level rise on NASA facilities, and to propose possible mitigation strategies.

A Multidisciplinary Exploratory Study of Alpine Cairns, Baranof Island, Southeast Alaska (PI: William Hunt, University of Nebraska-Lincoln, NSF PLR-1230132): This multidisciplinary project investigating the origins of a series of historic cairns on Baranof Island, Alaska, used UNAVCO TLS support and the Riegl VZ1000 TLS system to generate a 10 cm resolution digital elevation model (DEM) of the area where the cairns are found. The DEM will allow archaeologists to accurately position the cairns in the proper topographical context, helping them determine historic and geographic significance. High-resolution imagery for the majority of the scans sites was also collected.

MIDGE: Minimally Invasive Direct Glacial Exploration of Biogeochemistry, Hydrology and Glaciology of Blood Falls, McMurdo Dry Valleys (PI Jill Mikucki, University of Tennessee, NSF PLR-1144178): The Riegl VZ1000 was used to create a digital terrain model of the ice surface surrounding Blood Falls and to accurately define elevation profiles along Ground Penetrating Radar lines. This project is a multidisciplinary study of the biological, hydrologic, and glacier
dynamics at Blood Falls, an enigmatic feature at the toe of the Taylor Glacier. Blood Falls is characterized by a periodic release of subglacial brine that oxidizes on the ice surface and crates an orange-red icefall.

Demographic Consequences of Environmental Variability and Individual Heterogeneity in Life-history Tactics of a Long-lived Antarctic Marine Predator (PI: Robert Garrott, U. Montana, NSF PLR-1141326): The Riegl VZ1000 was used on this project together with one of UNAVCO’s Riegl VZ400 instruments. The PI is developing a novel methodology for efficient volume estimation of individual Weddell seals during the annual pupping season. In previous attempts, the movement of seals between repeat scans has limited the usefulness of LiDAR to accurately determine seal volume. A proof-of-concept survey was attempted during the 2013-2014 season to capture a full coverage seal scan by deploying two scanners in unison. The method is promising for estimating seal volumes more accurately and more quickly than traditional time intensive survey methods, thereby increasing both the frequency and number of seal volume estimates. These mass measurements (derived from volume) are critical data of population dynamic research on the Weddell Seal, one of the longest running mammal population studies.

Mt. Erebus Volcano Observatory: Operations, Science and Outreach (MEVO-OSO) (PI Phil Kyle, New Mexico Tech, NSF PLR-1142083): UNAVCO’s Riegl VZ1000 was used on the crater rim of Mt. Erebus to scan the active lava lake at the bottom of the crater. LiDAR scans of lava lake level are used to correlate infrared and gas emission data with eruptive events and volatile flux. Because the lake level is changing minute-by-minute, quick repeat scans are needed to characterize the periodic rise and fall of the lava lake level surface.
Key outcomes or other achievements:

**What opportunities for training and professional development has the project provided?**
As part of the new VZ1000 scanner acquisition, Riegl USA staff came to Boulder in September 2013 to conduct a three-day training session on Riegl scanner operation, software techniques for data processing and analysis, and instrument care and calibration procedures. Six UNAVCO staff participated in the training.

**How have the results been disseminated to communities of interest?**
Outreach to the UNAVCO community to make them aware of this new TLS resource has primarily been through presentations at national meetings, for example the GSA Annual Meeting in Denver and the Fall AGU Meeting in San Francisco. PIs soliciting UNAVCO TLS project support are also briefed on instrument resources during consultations with the Geodetic Imaging Project Manager. The UNAVCO Geodetic Imaging website and knowledge base have been updated with information on the new instrumentation, as well.

**What do you plan to do during the next reporting period to accomplish the goals?**
UNAVCO will publish a request for proposals (RFP) in the first half of 2014 to acquire the second instrument that was funded by this award. The UNAVCO Terrestrial Imaging Geodesy Working Group (TIGWiG) and community members will be asked to provide guidance on the technical requirements in the RFP before it is made available for manufacturers to access.
Products

Within the Products section, you can list any products resulting from your project during the specified reporting period, such as:

Websites:
http://facility.unavco.org/kb/questions/511/UNAVCO+Resources%3A+Terrestrial+Laser+Scanning+%28TLS%29
http://facility.unavco.org/kb/questions/792/UNAVCO+Summary+of+RIEGL+VZ-1000
http://facility.unavco.org/kb/questions/797/TLS+Battery+Box+Set+Up+for+Riegl+Scanners
http://facility.unavco.org/kb/questions/796/Targets+Used+With+Riegl+Scanners
http://facility.unavco.org/kb/questions/791/TLS+Field+Gear+for+Riegl+Scanners
http://facility.unavco.org/kb/questions/786/Riegl+TLS+Field+Operation+Manual+and+Workflow

Other Products:
Riegl TLS Field Operation Manual and Workflow - Manual developed by UNAVCO staff to document our best-practices for Riegl terrestrial laser scanner field operation, data collection, and initial data processing. This document is for a tie-point based workflow, using the Riegl VZ1000, VZ400, and Z620 scanners.

The UNAVCO Riegl TLS manual is detailed enough to guide a user through the standard data collection workflow; accordingly, we recommend it as a resource for UNAVCO community members working with UNAVCO all Riegl scanners.

Download:
http://facility.unavco.org/kb/questions/786/Riegl+TLS+Field+Operation+Manual+and+Workflow

Impacts

What is the impact on the development of the principal discipline(s) of the project?
UNAVCO is the geodetic facility for NSF supporting scientific investigations that include the study of earthquake processes, mantle properties, active magmatic systems, plate boundary zone deformation, intraplate deformation and glacial isostatic adjustment, global geodesy and plate tectonics, atmospheric science, global change, and polar processes. A summary of several projects supported with the newly acquired TLS system is in the Accomplishments section of this report, which point to the breadth of science disciplines that have been supported using the new TLS instrument. In the first approximately six months of UNAVCO ownership, the new Riegl VZ1000 TLS system has supported projects in volcanoanology, glacial dynamics and climate change, biological sciences, sea-level rise and coastal processes, and archeology. With technical capabilities such as full waveform data capture, we anticipate that the TLS system acquired in year one of this project will have considerable impact on the core Earth and Polar science disciplines as well as other NSF-supported disciplines such as ecology.
**What is the impact on other disciplines?**

As noted above, initial use of the new TLS system includes projects outside of UNAVCO’s core disciplines, including biology and archeology. With technical capabilities such as full waveform data capture, we anticipate that the TLS system acquired in year one of this project will have considerable impact on other disciplines such as ecology.

**What is the impact on the development of human resources?**

As noted in the training section of this report, UNAVCO staff received specific training in the use of the new TLS system. This training is part of a larger effort to cross-train staff, and to develop core expertise in laser scanning technology and applications at UNAVCO.

UNAVCO also invests in a large and visible education and community engagement program. An annual TLS introductory short course at the Geological Society of America meeting typically is filled to capacity, and provides important training to the UNAVCO community on TLS technology and its application to various Earth science applications. UNAVCO’s program to bring TLS systems to undergraduate level geology field courses is growing annually. In 2014 alone, approximately 100 students were introduced to TLS technology, field data acquisition, and data processing and analysis at four field camps and one graduate neotectonics seminar field trip.

**What is the impact on physical resources that form infrastructure?**

The TLS systems acquired under this award will be important physical resources that form the backbone of UNAVCO’s TLS EAR and PLR PI support program. These new systems bring additional technical capabilities and modernize UNAVCO’s TLS instrument pool.

**What is the impact on institutional resources that form infrastructure?**

See discussion above regarding impact on UNAVCO EAR and PLR PI communities.

**What is the impact on information resources that form infrastructure?**

See Products section for new informational resources developed under this award.

**What is the impact on technology transfer?**

The UNAVCO facility and community are significant users of geodetic instrumentation such as GPS and Terrestrial Laser Scanning. Interactions with vendors ensure availability of equipment to meet scientific needs. Data collection and processing methods are disseminated via technical publications, conference presentations, and the UNAVCO website (www.unavco.org). All data acquired by the instrumentation is freely accessible via UNAVCO’s data archive and can be leveraged by any federal, state, and local agency, and industry.
What is the impact on society beyond science and technology?

UNAVCO's Education and Community Engagement activities are focused upon providing resources and opportunities for education at multiple levels. UNAVCO has an active internship program called "RESESS," which is a paid undergraduate research internship, learning community, and mentoring program. RESESS students have received training in TLS data acquisition and processing methods, and used it in their summer research projects. One intern (M. Carnicle) used her knowledge of TLS in subsequent fieldwork in Italy. UNAVCO offers short course and other training courses to help graduate students and scientists learn more about geodesy, the applications of geodesy, and Earth Science. It also provides resources that use data and modern teaching techniques to use in teaching or after-school programs. The outreach activities by UNAVCO staff reach an audience beyond the scientific community. UNAVCO also reaches out to policy makers and decision makers to inform them of UNAVCO activities and UNAVCO-supported scientific discoveries.

Changes / Problems

If not previously reported in writing to the agency through other mechanisms, provide the following additional information or state, "Nothing to Report", if applicable.

Changes in approach and reason for change: None

Actual or Anticipated problems or delays and actions or plans to resolve them: None

Changes that have a significant impact on expenditures: None

Significant changes in use or care of human subjects: None

Significant changes in use or care of vertebrate animals: N/A

Significant changes in use or care of biohazards: N/A