



This document is being submitted in response to the request for a summary of our facility's accomplishments, products, and/or publications. The content below highlights the accomplishments and impacts of the GAGE Facility over the period 2013 – 2018.

Geodesy Advancing Geosciences and EarthScope: GAGE Final Project Report

Reporting period: 01 July 2017 - 31 December 2018

Appendix B: Impacts

1. What is the impact on the development of the principal discipline(s) of the project?

UNAVCO manages GAGE, the geodetic facility of the NSF, and supports geoscience research and education using geodesy. GAGE supports all aspects of the scientific research process including instrumentation and equipment support, data archiving and dissemination, and broader impacts support. Scientific investigations supported 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. Details of projects supported are given in the accomplishments section of this report.

2. What is the impact on other disciplines?

The GAGE Facility supports cutting edge, interdisciplinary science using geodesy within the broader realm of science, technology, engineering, and mathematics (STEM). In addition to the core discipline of geodesy, the instrumentation, data, tools, and data products provide scientific researchers from a wide variety of geoscience disciplines to leverage GAGE services. This provides a plethora of disciplines with cutting edge technology to support scientific investigations.

In addition, geoscience applications are included in STEM education materials and distributed at both the K--12 level and in higher education. The inclusion of geodetic data into education materials is transforming instruction. It provides students with an unprecedented opportunity to be immersed in the science using real -world data. This is critical in training the next generation of scientists at the university level and is an emerging focus of K--12 education with the development and adoption of the Next Generation Science Standards (NGSS).

3. What is the impact on the development of human resources?

The GAGE facility supports a highly popular short course series each year whereby community experts teach a short course in their disciplinary expertise. The courses provide training in cutting edge scientific techniques and software for processing and analyzing data from the data archive. Students participate in these professional development training sessions through financial support of the GAGE facility. During this past year technical short courses and educational-focused workshops were supported by the GAGE facility reaching hundreds of participants including researchers, university faculty, graduate students, post-doctoral scholars, undergraduate students, and K--12 faculty. When possible, courses are offered in a hybrid format (synchronous online and face-to-face), in essence doubling the capacity of courses and enabling us to reach a broader - global - audience.

Staff provided mentoring support for three summer research internships. The Research Experiences in Solid Earth Science for Students (RESESS) program serves underrepresented minorities in geosciences. Eight undergraduate students participated in the program in 2018. A science colloquium featuring the research of each student providing students a professional environment to develop their research presentation skills. The Geo-Launchpad internship program is a work-experience internship for Colorado community college students. UNAVCO hosted four students who worked at the U.S. Geological Survey in Lakewood, Colorado. They worked under the supervision of USGS staff, providing staff with both the opportunity to engage with community college students and learn more about the work the GAGE facility



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conducts and supports. Staff engineers directly mentored four Geo-Launchpad interns. UNAVCO also supports the UNAVCO Student Internship Program (USIP) where interns from undergraduate and graduate programs conduct work directly on UNAVCO-GAGE scope of work. Eight USIP interns worked under the supervision of six staff, some of whom do not have regular management responsibilities.

UNAVCO supports the maintenance of a GPS/PBO focused museum display at the Pacific Science Center in Seattle, Washington. The exhibit highlights the EarthScope Plate Boundary Observatory network in the Pacific Northwest with its upgraded real-time data streaming capabilities. The museum hosts over a half million visitors annually. *Monitoring a Shifting Earth* is a hands -on exhibit designed to reach a broad audience, including students either on field trips or after- school programs, families, and senior groups. The exhibit offers a regional perspective on the processes responsible for earthquakes and tsunamis in the Seattle area. Museum visitors explore and learn about basic plate tectonics concepts and natural hazards relevant to the Pacific Northwest, how the GPS in a smartphone compares to a high-precision GPS receiver used by the EarthScope Plate Boundary Observatory, and how land near the coastline is being squeezed inland and building potential energy that could be released as an earthquake, resulting in strong ground shaking and tsunamis. Additionally, visitors learn about the role that the upgraded PBO GPS network is expected to play in hazard mitigation with a combined real -time GPS and seismometer earthquake early warning system.

Geodetic-focused education materials provided through the UNAVCO website and the Science Education Research Center (SERC) at Carleton College were accessed by K--12 teachers and college faculty and incorporated into their classes. The implementation of these materials into the classroom impacts several thousand undergraduate students per year.

UNAVCO staff provided exposure of the GAGE facility- work through outreach to local community groups, rotary clubs, park service professionals and interpreters, K--12 students and teachers, and undergraduate students. Outreach activities include science cafes, formal and informal presentations, participation in community organized science fairs, and field camps and field education experiences.

4. What is the impact on physical resources that form infrastructure?

As described in the accomplishments, the equipment, engineering, data, and educational resources provided by UNAVCO in management of the GAGE facility ensure high quality data are acquired, archived and curated. UNAVCO is a leader in NSF facilities in leveraging emerging technologies and best practices, including transforming the physical resources to support the community including cloud computing, virtual machines, online short course instruction, and an expanded online database for engineers and researchers.

5. What is the impact on institutional resources that form infrastructure?

As described in the accomplishments, equipment, engineering, data and educational resources provided by the GAGE facility ensure high quality data are acquired, archived and curated.

6. What is the impact on information resources that form infrastructure?

Same as above.

7. What is the impact on technology transfer?

UNAVCO staff, under GAGE, provided support for community networks including the Caribbean network (Continuously Operating Caribbean GPS Observational Network, COCONet) and Mexican GPS-Meteorological Observational Network (TLALOCNet). Regional Data Centers and Regional Mirror Data Center Sites provide additional community capacity in the Caribbean as a result of UNAVCO training and assistance with infrastructure development. Software developed for the Regional Data Centers (Dataworks) is available to any group having data to share.



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8. What is the impact on society beyond science and technology?

Outreach efforts have a broad impact on a large segment of society, beyond our key research and academic stakeholders. Some instrumentation is installed on private property. Outreach efforts with property owners have expanded their knowledge of the value of geodetic data in issues of local relevance such as water availability and earthquake early warning. A museum display in Seattle focuses on the how the hazards of earthquakes and tsunamis are better understood through GPS and the Plate Boundary Observatory. This improves public knowledge about the basic of GPS and the value of GPS to earthquake early warning and tsunami warning. A wall calendar for 2019 with the focus of “Earth Hazards” presents the practical applications of geodesy and a focus on why the science matters. Over 6,000 calendars were distributed to the public.

Through social media (Instagram, Pinterest, YouTube, Facebook and Twitter) UNAVCO has reached tens of thousands of individuals beyond our core stakeholders. Instagram posts share the work of GAGE in a visual manner with the ability to tag and search easily. Pinterest is used by a high percentage of K-12 educators, thereby increasing our reach to the next generation of scientists with visual representation of what science supports. YouTube videos provide explanations and show animations of complicated scientific concepts related to GAGE supported science. Videos are also available of seminars focused on community science. The UNAVCO Twitter feed reaches an audience interested in science news, policy, and geo--related opportunities. The UNAVCO Facebook page engages a broad spectrum of the geoscience- interested public through geoscience news, interesting facts, summaries and photos of GAGE activities in support of the community, and geo--focused humor. Communications are framed in “plain English” and easy to understand terms to reach the broadest audience. The combination of these media channels has resulted in more people than ever being aware of and engaged in the conversation about GAGE supported science.