GEODETIC FACILITY FOR THE ADVANCEMENT OF GEOSCIENCE (GAGE) — $14,550,000 / -$10,000 / -0.1%

Geodetic Facility for the Advancement of GEoscience Funding
(Dollars in Millions)

FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over FY 2021 Actual Amount	Percent
$14.56	-	$14.55	-$0.01	-0.1%

Brief Description

The Geodetic Facility for the Advancement of GEoscience (GAGE) is a distributed, multi-user facility that enables a diverse principal investigator (PI) community to make advances in understanding Earth processes that would otherwise not be possible, through broad access to geodetic instrumentation, field training and support, and data services. GAGE operates networks of Global Positioning System (GPS) and Global Navigational Satellite Systems (GNSS) instruments; provides geodetic and related geophysical instrumentation for field experiments; supports data archiving, quality control, and distribution; and provides education and outreach activities that serve a wide range of audiences.

Scientific Purpose

GAGE serves a broad spectrum of geosciences disciplines that use geodetic instrumentation and data, including Earth, atmospheric, and polar sciences. GAGE data support transformative advances in current understanding of the Earth system, including crustal deformation, plate boundary processes, landscape evolution, the earthquake cycle, volcano, tsunami, and hurricane hazards, continental groundwater storage and soil moisture dynamics. Data from GAGE real-time, high-rate GPS/GNSS observations also support the commercial surveying and engineering industries, particularly in the western U.S.

Status of the Facility

GAGE is currently operating in year four of a five-year NSF award to UNAVCO, and the capabilities provided by the facility have evolved based on input from a series of community engagement activities held in 2015, including an NSF-sponsored workshop entitled "Future Seismic and Geodetic Facility Needs in the Geosciences".[1] The Division of Earth Sciences (EAR) in GEO continues to evaluate NSF's geophysical facilities to best enable emerging research directions. In 2018, EAR commissioned a National Academies of Science, Engineering, and Medicine-led decadal survey that identified the top research priorities for the Earth sciences for the next decade. Released in July 2020, *A Vision for NSF Earth Sciences 2020-2030: Earth in Time*[2] reaffirmed the importance of NSF's seismic and geodetic facilities in advancing Earth science research over the next decade.

As part of the decadal survey process, a workshop entitled *Management Models for Future Seismological and Geodetic Facilities and Capabilities* was held to review the strengths and weaknesses of different

[1] www.iris.edu/hq/files/workshops/2015/05/fusg/reports/futures_report_high.pdf
[2] www.nap.edu/catalog/25761/a-vision-for-nsf-earth-sciences-2020-2030-earth-in

management models for NSF geophysical facilities.[3] Following the release of the workshop report, EAR announced that, at the time of the next competition for their management and operations, the current Seismological Facility for the Advancement of GEoscience (SAGE) and GAGE facilities would be consolidated into a single facility with a single operator.[4]

In FY 2020, after announcement of the consolidated facility, GEO commissioned a portfolio review from a subcommittee of its Advisory Committee to inform planning for a consolidated geophysical facility. The group reviewed possible geophysical instrumentation and sensor networks that a new facility might support to address the science priorities highlighted in the decadal survey. Additionally, the portfolio review report emphasizes the importance of developing partnerships in support of elements of SAGE and GAGE that are mission critical for other Federal agencies. EAR is working to define the best path forward for a future facility and undertaking efforts to expand existing federal partnerships.

In FY 2019, NSF issued a Dear Colleague Letter (NSF 19-072) to let the community know of the intent to divest 10 percent of the GPS/GNSS stations that comprise the Network of the Americas (NOTA) as part of GAGE. EAR received requests to adopt 95 of the 128 stations for continued operations, and all station adoptions were completed in July 2021. The remaining stations are expected to be removed from the ground by end of FY 2022.

Summary of COVID-19 Impacts

The impact of COVID-19 on GAGE has been relatively minor. While there is a backlog of maintenance issues at some NOTA sensor network stations, network uptime currently exceeds target performance levels. In 2021, UNAVCO shifted to a permanent hybrid work model, enabling most employees to work from home, except when individuals are required to work in the warehouse or when visiting field sites for maintenance. UNAVCO has not implemented operational changes other than requiring that employees comply with local, state, or federal masking guidelines for their work location.

Meeting Intellectual Community Needs

To serve the research needs of the broad Earth science community, GAGE is organized under three primary service areas: Geodetic Infrastructure, Geodetic Data Services, and Education and Community Engagement. GAGE users can access data and many educational products via the internet at no cost. Scientists making use of equipment, training, and other resources provided by GAGE typically are funded via awards from NSF, the U.S. Geological Survey (USGS), the National Aeronautics and Space Administration (NASA), and other agencies. NSF-sponsored users are typically supported by EAR, the Division of Ocean Sciences (OCE), and OPP. Funds permit ongoing operations and maintenance of continuous GPS regional networks, deployment of portable geodetic instruments and use of data managed by GAGE Data Services to solve major Earth science problems.

Demand for data, equipment, and other resources provided via GAGE remains high. In FY 2021:

- On average, there were approximately 8000 individual verified users accessing the GAGE real-time GPS/GNSS data streaming service at any given time.

[3] www.nap.edu/catalog/25536/management-models-for-future-seismological-and-geodetic-facilities-and-capabilities

[4] www.nsf.gov/pubs/2020/nsf20037/nsf20037.jsp

- Field experiments using equipment and field engineering assistance continue at an average annual level of approximately 100 projects.

GAGE facilitates three different summer internship programs at the community college, undergraduate, and graduate school levels that primarily focus on students from groups that are underrepresented in the Geosciences. The GAGE summer internship programs have consistently produced scientific and professional benefits for these students at different educational stages. In 2021, the programs were held in a hybrid format due to COVID-19, with a mixture of online and limited in-person activities. The program participants demonstrated strong growth in knowledge and awareness of geoscience career paths, as indicated in pre- and post-participation survey results. Interns also enhanced their technical skills across all of the programs, including computational and scientific communication skills. These findings have been consistent across in-person, virtual, and hybrid offerings of the program, indicating that the program has successfully adapted its career programming to a variety of formats.

Governance Structure and Partnerships

NSF Governance Structure

GAGE, together with SAGE, is overseen by a single Integrated Project Team (IPT) whose charge is to: 1) establish a collaborative team with a broad spectrum of expertise and perspective to help address current facility challenges and identify potential barriers to project success; 2) ensure effective and timely communications regarding facility activities and issues across NSF organizations by sharing knowledge and information on a regular and recurring basis; and 3) provide a formal mechanism to coordinate agency-wide oversight, take effective action, and remain accountable in support of the program of activities.

The IPT membership includes a core group consisting of the GAGE and SAGE managing program officer (PO), a representative from the Division of Acquisition and Cost Support, and a liaison from the Large Facilities Office LFO Liaison. The GAGE and SAGE PO serves as chair of the IPT. The IPT remains active through the planned five-year duration of the GAGE and SAGE awards. The IPT chair is responsible for uploading all IPT documentation into the official electronic records for the GAGE and SAGE awards. The IPT may periodically be assisted by other NSF staff as expertise is needed (e.g., Office of the General Counsel staff, Office of the Director staff).

External Governance Structure

The GAGE facility awardee, UNAVCO, Inc., is a 501(c)(3) nonprofit corporation governed by a nine-member Board of Directors elected by the UNAVCO institutional member representatives. The UNAVCO consortium currently has 119 full voting member institutions, representing nearly all U.S. university and nonprofit organizations with a major commitment to research and teaching programs in geodesy and related geoscience fields, and 111 non-voting associate member institutions. Six of the Board members are drawn from member institutions, and three serve as directors-at-large. Board members, who serve two-year terms, vet all internal program decisions associated with GAGE management and operation through consultation with UNAVCO staff and GAGE advisory committees (one for each major GAGE component and additional *ad hoc* working groups appointed for special tasks). The board appoints a president of UNAVCO to a renewable two-year term. The president is responsible for UNAVCO operations, which are managed through the UNAVCO Corporate Headquarters in Boulder, CO, and at three regional offices in San Clemente, CA; Portland, OR; and

Anchorage, AK.

Partnerships and Other Funding Sources

The GAGE facility is primarily supported by EAR, with additional NSF support from OPP. Externally, NASA provides $1.15 million in support via interagency transfer each year. Beginning in FY 2021, GAGE received $930,000 from the USGS via interagency transfer for support of ShakeAlert, their earthquake early warning program, and NSF expects this partnership with the USGS to continue through the end of the GAGE award period. Additionally, UNAVCO will be leveraging the GAGE award to partner with commercial entities in support of autonomous vehicle navigation. That activity is expected to generate program income in FY 2022 of about $500,000, which will be used to support recapitalization of aging infrastructure.

Besides its role in providing the observational data essential for basic Earth science research, GAGE also provides real-time geodetic data in support of the missions of other agencies. GAGE provides O&M support for 58 NASA-funded stations and the GNSS network that enable satellite orbit and clock corrections and the refinement of the International Terrestrial Reference Frame (ITRF). The ITRF is the foundation for high-precision global Earth science. The National Oceanic and Atmospheric Administration (NOAA) utilizes data from GAGE for its management of the national reference frame for oceanic vessel navigation and support of survey professionals. USGS, NASA, NOAA, and other state and local agencies also utilize the GAGE portable geodetic station pool for support of field projects.

Funding

Total Obligations for GAGE

(Dollars in Millions)

	FY 2021	FY 2022	FY 2023	ESTIMATES[1]				
	Actual	(TBD)	Request	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028
GAGE O&M	$14.56	-	$14.55	$14.55	TBD	-	-	-
SAGE O&M	22.30	-	23.37	23.37	TBD	-	-	-
Consolidated Facility O&M[2]	-	-	-	-	TBD	TBD	TBD	TBD
Total	**$36.86**	**-**	**$37.92**	**$37.92**	**TBD**	**TBD**	**TBD**	**TBD**

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends September 2023.

[2] NSF is currently planning for GAGE and SAGE to be consolidated into a single geophysical facility in FY 2025.

NSF is currently implementing recommendations from the 2019 and 2020 reviews. These include innovations in multi-constellation instrumentation for more precise measurements of Earth's surface to improve studies of near-surface processes (e.g., water storage and flux); moving data services for the Facility to the cloud; and recapitalization of aging instrumentation. EAR is evaluating different strategies and scales of aging instrumentation and plans to phase in recapitalization over the existing award period.

Reviews

NSF externally reviews components of the GAGE facility on an annual basis. NSF conducted a full management review of GAGE in September 2021, and the panel commended UNAVCO for its strong overall performance in operating and maintaining GAGE. NSF reviewed the GAGE instrumentation services programs in late June 2020 and the data services programs in September 2019. Both reviews

noted the outstanding management and the critical services these programs provide to the research community. As per the reviews' recommendations, EAR, in collaboration with SAGE, GAGE and the NSF Office of Advanced Cyberinfrastructure, is implementing a pilot program to move facility data services to the cloud. NSF plans to conduct a management review of the education and outreach program in FY 2022.

Renewal/Recompetition/Termination

In 2020, NSF announced that it is preparing for a competition for a future cooperative agreement to support a single, unified geophysical facility as the successor to GAGE and SAGE. NSF plans to evolve the different components of GAGE and SAGE through the competition for the unified facility to enable the community to advance the scientific priorities in the *Earth in Time* decadal survey. NSF is considering the recommendations contained in the portfolio review, as well as the interagency context in which the unified facility will operate, to formulate a strategy for continued support of this important community research resource. Divestment is not being considered at this time.

While the GAGE award was initially planned to end in 2023, NSF announced in a Dear Colleague Letter (NSF 21-097)[5] issued in June 2021 that it will extend the current awards for operations of both SAGE and GAGE to ensure continuity of services until 2025. This extension will allow NSF to work with agency partners to thoughtfully respond to the recommendations in the portfolio review.

[5] www.nsf.gov/pubs/2021/nsf21097/nsf21097.jsp?org=EAR