

**SEISMOLOGICAL FACILITY FOR THE ADVANCEMENT
OF GEOSCIENCE (SAGE)**

**\$23,370,000
+\$1,070,000 / 4.8%**

**Seismological Facility for the Advancement of
GEosciences Funding**
(Dollars in Millions)

FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over FY 2021 Actual	
			Amount	Percent
\$22.30	-	\$23.37	\$1.07	4.8%

Brief Description

The Seismological Facility for the Advancement of Geoscience (SAGE) 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 seismic instrumentation, field training and support, and data services. SAGE provides the development, deployment and operation of modern digital seismic instrumentation and related geophysical instrumentation, including magnetotellurics and infrasound. The facility operates a global network of seismic stations; provides field and technical resources; supports data archiving, quality control, and distribution; and provides education and outreach activities that serve a wide range of audiences. SAGE deploys geophysical instruments globally—on the land, including in polar regions, and under the oceans.

Scientific Purpose

SAGE data and services advance fundamental studies in earthquake and fault processes, Earth structure and evolution, volcanoes and magmatic systems, glacier and ice sheet dynamics, and near-surface Earth processes, like landslides, hydrology, and sedimentation. Data from SAGE are also used for studies of solid earth geohazards research, as well as monitoring of natural and anthropogenic hazards, such as global real-time earthquake monitoring, and nuclear test ban verification.

Status of the Facility

SAGE is currently in year four of a five-year award, 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.

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

Major Facilities

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 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 operation, the current SAGE and Geodetic Facility for the Advancement of GEoscience (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 portfolio review is also an important input to an ongoing effort to plan seismic research and related infrastructure in the U.S. over the next decade, so that NSF's geophysical facility will address the science priorities highlighted in the decadal survey. Additionally, the portfolio review report, which was completed in FY 2021, 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.

Summary of COVID-19 Impacts

SAGE has continued to operate remotely during the COVID-19 pandemic, with most staff teleworking and data continuing to flow. Restrictions on travel and social distancing precluded decommissioning and removal of the Alaska Transportable Array (ATA) as had been planned during 2020. Instead, ATA operated in a "bare-bones" capacity and was removed in 2021.

Meeting Intellectual Community Needs

SAGE users include scientists who perform research using instruments and/or data provided via SAGE; educators who make use of teaching materials and training made available via SAGE; other Federal agencies and international groups that make use of resources and/or data provided via SAGE for multiple operational purposes; and interested members of the public and private sector.

SAGE 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 SAGE typically are funded by awards from NSF, the U.S. Geological Survey (USGS), and other agencies. NSF-sponsored users are usually supported by EAR, the Division of Ocean Sciences (OCE), or OPP.

The Earth's interior remains a major scientific frontier holding the key to understanding the origin of the planet. Recent developments in seismic sensor design and the acquisition, transmission, and storage of data have resulted in dramatic improvements in the resolving power of seismic imaging of the interior of the Earth. To serve the research needs of the broad Earth science community, SAGE is organized under three primary service areas: Instrumentation Services, Data Services, and Education and Public Outreach.

Demand remains high for data, equipment, and other resources provided by SAGE. In fiscal year 2021:

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

- The total amount of data downloaded from the SAGE Data Management Center increased by 11 percent compared to the same period in FY 2020.
- At least 70 field experiments used equipment and support provided by SAGE worldwide; and
- More than 150,000 classroom activities were downloaded by K-16 educational projects.

Governance Structure and Partnerships

NSF Governance Structure

SAGE, together with GAGE, 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 program activities.

The IPT membership includes a core group consisting of the SAGE and GAGE managing program officer (PO), a representative from the Division of Acquisition and Cost Support, and a liaison from the Large Facilities Office. The GAGE and SAGE PO serves as chair of the IPT. The IPT will remain 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

SAGE is managed and operated by the Incorporated Research Institutions for Seismology (IRIS), which is incorporated as a non-profit consortium representing 125 U.S. universities and non-profit organizations with research and teaching programs in seismology. Each voting member institution of the consortium appoints a member representative, who collectively elect the nine members of the IRIS Board of Directors. Board members, who serve three-year terms, vet all internal program decisions associated with SAGE management and operation, through consultation with IRIS staff and SAGE advisory committees (one for each major SAGE component and additional *ad hoc* working groups appointed for special tasks). The Board of Directors appoints a president of IRIS to a renewable two-year term. The president is responsible for IRIS operations, all of which are managed through the IRIS Corporate Office located in Washington, DC.

Partnerships and Other Funding Sources

The core SAGE facility is managed for NSF by IRIS, under a single award overseen by EAR. IRIS has received funding under the SAGE award for additional activities, including support for specific PI-driven research in Antarctica, organization of relevant workshops, and operation of regional seismic networks.

Besides its role in providing the observational data essential for basic Earth science research, SAGE also plays a significant role providing real-time seismic data to USGS and the National Oceanic and Atmospheric Administration for global earthquake, volcano, and tsunami monitoring, and international seismic monitoring of compliance with the Comprehensive Test Ban Treaty. The Global Seismographic Network (GSN) component of SAGE is managed as a partnership among USGS, NSF,

Major Facilities

and IRIS.

SAGE is heavily involved in partnership activities, many international in nature. Installation and operations of the GSN have put IRIS in contact with scientists, as well as government and non-government organizations, around the world. Many international GSN stations are designated as the official stations for nuclear test ban treaty monitoring in their host countries. SAGE also provides multi-use resources for other government agencies that have responsibilities for development of a nuclear test ban monitoring capability and for monitoring global seismicity. For these purposes, agencies in partnership with NSF have provided substantial support for accelerated development of the GSN, shared operation and maintenance of the GSN, and accelerated development of the Portable Seismology Instrument pool.

Funding

Total Obligations for SAGE

(Dollars in Millions)

	FY 2021	FY 2022	FY 2023	ESTIMATES ¹				
	Actual	(TBD)	Request	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028
SAGE O&M	\$22.30	-	\$23.37	\$23.37	TBD	-	-	-
GAGE O&M	14.56	-	14.55	14.55	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 management reviews. These include innovating SAGE's portable sensor pool to include additional nodal instruments for studies of processes in Earth's near surface, moving data services for the Facility to the cloud and recapitalization of aging instrumentation. A pilot cloud service program was initiated in 2020 in partnership with GAGE and the program plans to expand this capability over the existing award period. The program 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 SAGE facility on an annual basis. NSF conducted a full management review of SAGE in September 2021, and the panel commended IRIS for its strong overall performance in operating and maintaining SAGE. NSF reviewed the SAGE 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

The previous SAGE award is in a no-cost extension period to complete activities associated with ATA. The divestment of ATA began in FY 2020 and was completed at end of FY 2021. Final project closeout, including warehouse cleanout and equipment repairs, is underway and expected to be completed in the first half of 2022.

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 SAGE and GAGE. NSF envisions that a successor facility will provide access to a suite of geophysical instrumentation, data services, and education and outreach capabilities that sustain scientific progress and address future opportunities to advance understanding of Earth processes. 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 SAGE 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