

SEISMOLOGICAL FACILITIES FOR THE ADVANCEMENT OF GEOSCIENCE AND EARTHSOPE (SAGE)

\$24,160,000
-\$1,040,000 / -4.1%

Seismological Facilities for the Advancement of Geosciences and Earthscope Funding

(Dollars in Millions)

FY 2017	FY 2018	FY 2019	Change over	
			FY 2017 Actual	Percent
Actual	(TBD)	Request	Amount	
\$25.20	-	\$24.16	-\$1.04	-4.1%

The Seismological Facilities for the Advancement of Geoscience and EarthScope comprise a distributed, multi-user, national facility for the development, deployment, and operational support of modern digital seismic instrumentation to serve national goals in basic research and education in the earth sciences, earthquake research, global real-time earthquake monitoring, and nuclear test ban verification. SAGE is managed and operated for NSF by the Incorporated Research Institutions for Seismology (IRIS), a consortium of 125 U.S. universities and non-profit institutions with research and teaching programs in seismology, 21 educational affiliates, three U.S. affiliates, and 128 foreign affiliates. SAGE was formed in late FY 2013 from the seismic components of the EarthScope facility and seismic facilities previously managed by IRIS. The FY 2019 Budget Request will enable SAGE to provide key services for the geoscience research community, including global and regional observing networks, field and technical support for experiments worldwide, data management and distribution systems, and other related activities.

Total Obligations for SAGE

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	ESTIMATES				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Operations & Maintenance	\$25.20	-	\$24.16	\$24.16	\$24.16	\$24.16	\$24.16	\$24.16

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

- The Global Seismographic Network (GSN) consists of over 150 permanently-installed broadband digital seismic stations, most of which have real-time data access. GSN stations provide critical data for a range of global Earth science research, and support key national security needs such as nuclear test-ban treaty verification and natural hazards warning and response. GSN is operated in partnership with the U.S. Geological Survey (USGS).
- Portable Seismology (PS) includes a pool of over 5,200 portable seismometers that are made available to the Earth science research community for a wide range of principal investigator-driven experiments largely funded through the NSF merit review process to study a wide range of Earth processes.
- Polar Support Services (PSS) supports the development of specialized seismic equipment for use in harsh environments and provides instrumentation, training, and field support for experiments in the polar regions.
- The Transportable Array (TA) is a continental-scale seismic observatory designed to provide a foundation for multi-scale integrated studies of continental lithosphere and deep Earth structure. Over 1,700 TA stations operated across the lower 48 states and southern Ontario and Quebec, Canada,

between 2004 and 2015. The full 280-station TA network is now deployed in Alaska and western Canada. These stations collect data for use in studies of natural hazards including earthquakes, volcanoes, and tsunami; the plate tectonic process that have formed Alaska; Earth's magnetic field; and Earth's changing climate.

- The Magnetotelluric (MT) component exploits the natural variations in Earth's magnetic and electric fields to provide information on the distribution and composition of fluids in Earth's crust and upper mantle, which gives constraints on Earth's structure that are complementary to those resulting from seismology.
- Instrumentation Services-Coordinated Activities include efforts to develop the next generation of seismic instrumentation for large-scale scientific experiments; global-scale geophysical networks; and training courses to distribute best practices to partners worldwide.

Data Services

SAGE Data Services (DS) manages an archive of over 450 terabytes of seismic, magnetotelluric, and other data from all SAGE components, the EarthScope program, and numerous affiliated networks; operates automated and manual systems to ensure the quality of all data stored in the archive; and provides systems to give the national and international research community timely access to these data. In the last quarter of FY 2017, more than 20,000 unique users downloaded over 136 TB of data from the SAGE archive. These data enable the wide range of Earth science studies described above.

Education and Public Outreach

The SAGE Education and Public Outreach (EPO) program enables audiences beyond seismologists to access and use seismological data and research, including student internships, and programs for under-resourced educational institutions.

Besides its role in providing the observational data essential for basic Earth science research, SAGE supports community activities including scientific and technical workshops that bring together the international seismic community and publications designed to communicate SAGE activities and results to the community. SAGE also provides real-time seismic data to the USGS and the National Oceanic and Atmospheric Administration (NOAA) for global earthquake, volcano, and tsunami monitoring, and enables international seismic monitoring of compliance with the Comprehensive Test Ban Treaty.

SAGE is heavily involved in partnership activities, many international in nature. Because GSN stations are hosted by a variety of local organizations, installation and operation of the GSN has put IRIS in contact with scientists, as well as governmental and non-governmental organizations, from around the world. Many international GSN stations are designated as the official stations for nuclear test ban monitoring in their host countries. For all these purposes, Federal 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 PS instrument pool.

The EarthScope, Geophysics, GeoPRISMS, and Tectonics Programs in the Division of Earth Sciences (EAR); the GeoPRISMS and Marine Geology and Geophysics Programs in the Division of Ocean Sciences (OCE); and the Geology and Geophysics Program and the Glaciology Program in the Antarctic Research Section of OPP provide most of the funds, totaling approximately \$15.0 million annually, for NSF-sponsored research making use of SAGE. Funds permit deployment of portable seismic instruments and use of data managed by DS to solve major Earth science problems.

Management and Oversight

- NSF Structure: The Division of Earth Sciences (EAR) in the Directorate for Geosciences, through its Instrumentation & Facilities program (IF), provides general oversight of SAGE to help assure effective performance and administration. The program also facilitates coordination of SAGE programs and

projects with other NSF-supported facilities, and with other federal agencies, and evaluates and reviews the performance of IRIS in managing and operating SAGE. The EAR Division Director and Integrated Activities Section Head provide other internal oversight.

- **External Structure:** SAGE is managed and operated by 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, and these member representatives elect the nine members of the IRIS Board of Directors. The 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.
- **Reviews:** All major ongoing geoscience facilities routinely undergo reviews of their management, in addition to peer review of proposals for new or continued support. The formal NSF merit review of the five-year proposal for the SAGE facility took place in 2012 and 2013. Although the *ad hoc* reviewers and two independent review panels had a number of specific recommendations at the working level for SAGE, overall the review found that SAGE was a critical facility for U.S. and international Earth sciences. Furthermore, the reviewers found that IRIS is a well-managed and effective organization that has, through its commitment to the collection and open dissemination of the highest quality seismological data, transformed the discipline of seismology. In 2015, an external review of the GSN component of SAGE found that management of GSN by IRIS has been exemplary.

Renewal/Recompetition/Termination

Funding for the SAGE cooperative agreement began in FY 2014 and ends in FY 2018. In FY 2016, in keeping with the phased integration and recompetition plan presented to the National Science Board in December 2009, NSF solicited proposals to manage and operate one or more components of a new facility to support the Earth sciences research and education community. These components are currently supported by SAGE and the related Geodesy Advancing Geosciences and EarthScope facility. The new distributed, multi-user, national facility would support the development, deployment, management, and operational support of modern geodetic, seismic, and related geophysical instrumentation and provide services to serve national goals in basic research and education in the Earth sciences. As part of a robust re-competition and cost review process, various NSF oversight activities have been completed and others are currently underway, such as an independent cost assessments to inform NSF's cost analysis for a potential award.