

SEISMOLOGICAL FACILITY FOR THE ADVANCEMENT OF GEOSCIENCE (SAGE) **\$23,160,000**
-\$2,290,000 / -9.0%

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

FY 2018 Actual	FY 2019 (TBD)	FY 2020 Request	Change over FY 2018 Actual	
			Amount	Percent
\$25.45	-	\$23.16	-\$2.29	-9.0%

The Seismological Facility for the Advancement of GEoscience comprises 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 2020 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 2018	FY 2019	FY 2020	ESTIMATES ¹				
	Actual	(TBD)	Request	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Operations & Maintenance	\$25.45	-	\$23.16	\$17.89	\$17.89	\$17.89	\$17.89	\$17.89

¹ Outyear estimates are for planning purposes only.

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 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. After operating 1,700 stations in the lower 48 states between 2004 and 2015, the full 280-station TA network

Major Multi-User Research Facilities

is now deployed in Alaska and western Canada. The TA 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. NSF is currently working with other Federal agencies on a plan for adoption of stations for long-term operations and maintenance, and any stations that are not adopted will be decommissioned in FY 2020 and FY 2021.

- The Magnetotelluric 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 500 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 2018, more than 20,000 unique users downloaded over 134 terabytes 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 program enables audiences beyond seismologists to access and use seismological data and research, including student internships, and programs for under-resourced educational institutions.

Special Emphasis Areas

The capabilities that SAGE provides have extensive societal impacts and supplement existing hazard monitoring efforts by US state and federal agencies. SAGE would provide key seismic-related infrastructure support to the United States Geological Survey (USGS) and National Oceanic and Atmospheric Administration (NOAA). The SAGE Global Seismographic Network is co-funded with support from the USGS and enables earthquake and tsunami hazard warning and monitoring by USGS and NOAA while also supporting the International Monitoring System that informs the Comprehensive Nuclear Test Ban Treaty Organization. SAGE instrumentation also aids in USGS volcano hazard studies. The magnetotelluric studies enabled by SAGE, which measure electromagnetic fields in the Earth, are being used to mitigate damage to the US power grid associated with potential space weather events.

The SAGE facility is used by researchers supported by programs in the Division of Earth Sciences and other divisions in the Directorate of Geosciences; including Geophysics, Tectonics, Frontier Research in Earth Sciences, GeoPRISMS, Marine Geology and Geophysics Programs, and the Earth Sciences Program and the Glaciology Program in the Antarctic Sciences Section of OPP. For NSF sponsored research, SAGE supports deployment of portable seismic instruments and use of data managed by DS to solve major Earth science problems.

Management and Oversight

- NSF Structure: EAR in GEO, through its Instrumentation & Facilities program, 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. In addition, an integrated project team consisting of representatives from EAR, BFA Division of Acquisition and Cooperative Support, and BFA Large Facilities Office work with cognizant program officer in addressing challenges and identifying potential barriers for success. 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: NSF recently completed a review of the SAGE facility which found that SAGE was a critical facility for U.S. and international Earth sciences. In FY 2019 EAR will conduct a joint review of the data services activities of SAGE and its geodetic facility counterpart Geodetic Facility for the Advancement of GEoscience (GAGE).

Renewal/Recompetition/Termination

A successful NSF merit review of the proposal for the SAGE facility took place in 2017 and 2018, and funding for the current SAGE cooperative agreement began in FY 2019 and will end in FY 2023. In preparation for the next recompetition that would begin in FY 2022, NSF will be engaging in two activities. First, NSF has requested the National Academy of Science, Engineering, and Medicine, through the decadal study “*Catalyzing Opportunities for Research in Earth Sciences*”¹, to explore different models to manage geophysical capabilities needed by the Earth Sciences community. Second, NSF will convene an interagency working group to identify the needs other agencies have for the capabilities currently provided by SAGE and GAGE. The information from these two activities will be used to draft the solicitation requesting proposals to support geophysical capabilities for EAR funded research and education.

¹ www8.nationalacademies.org/pa/projectview.aspx?key=51287