



Update

National Science Foundation

**National Earthquake Hazards Reduction Program (NEHRP)
Advisory Committee on Earthquake Hazards Reduction (ACEHR)
March 3, 2016
NIST Headquarters, Gaithersburg, MD**

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Engineering for Natural Hazards Program (PD 16-014Y)

Natural Hazards Engineering Research Infrastructure

Division of Civil, Mechanical and Manufacturing Innovation

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Topics

- NSF Role in NEHRP
- Response to ACEHR 2015 Recommendations
- NSF Directorate for Engineering (ENG) in NEHRP
- NSF Directorate for Geosciences (GEO) in NEHRP



NSF Role in NEHRP

- Supports basic earthquake research - earth sciences, earthquake engineering, and social, behavioral and economic sciences - through programs that support solicited and unsolicited proposals
- Includes support for
 - Basic research in earth sciences, earthquake engineering, and earthquake mitigation, preparedness, response and recovery
 - Research and information centers
 - Research infrastructure/facilities
 - Integration of research with education (e.g., REU students)
 - Rapid response research (RAPID) (perishable data collection)
- Involves disciplinary and multidisciplinary research, from areas such as
 - Computer and information science and engineering
 - Earth sciences
 - Architecture/architectural engineering
 - Engineering (e.g., civil: structural, geotechnical, coastal; mechanical)
 - Social, behavioral, and economic sciences
 - Urban planning and geography



NSF RAPID Awards for 2015 Nepal Earthquake

Award Number	Title	NSF Organization	PI	Organization	Award Amount
1550276	RAPID: The Himalaya Connection Video, Outreach & Education	EHR/DRL	Doug Prose	Earth Images Foundation	\$199,612
1546738	RAPID: Assessment of Cascading Failures and Collective Recovery of Interdependent Critical Infrastructure in Catastrophic Disasters: A Study of 2015 Earthquake in Nepal	ENG/CMMI	Ali Mostafavi	Florida International University	\$49,962
1547554	RAPID: Contribution of Linking Networks in Nepalese Earthquake Response: A Case Study	ENG/CMMI	Bimal Paul	Kansas State University	\$48,945
1550349	RAPID: Field Investigation on the Socio-Technical Features of Post-Disaster Response Logistics in the Aftermath of the Nepal Earthquake	ENG/CMMI	Jose Holguin-Veras	Rensselaer Polytechnic Institute	\$49,495
1548217	RAPID: Investigating the Efficacy of Coordination of Damage Assessment Initiatives following the April 2015 Nepal Earthquake	ENG/CMMI	John Bevington	ImageCat, Inc.	\$49,572
1559687	RAPID: Scalability and Sustainability in Uncertain Environments: Recovery from the Nepal Earthquakes of April 25 and May 12, 2015	ENG/CMMI	Louise Comfort	University of Pittsburgh	\$46,327
1559544	RAPID: The Response-Recovery Transition Phase and its Implications for Long-term Recovery: Case Study, Katmandu.	ENG/CMMI	Himanshu Grover	University of Washington	\$48,901
1545632	RAPID/Collaborative Research: Post-Disaster, Reinforced Concrete Building Performance Data Collection following the April 25, 2015 Nepal Earthquake	ENG/CMMI	Andre Barbosa	Oregon State University	\$57,286
1545595	RAPID/Collaborative Research: Post-Disaster, Reinforced Concrete Building Performance Data Collection following the April 25, 2015 Nepal Earthquake	ENG/CMMI	Andreas Stavridis	SUNY at Buffalo	\$24,040
1266418	Collaborative Research: Geotechnical Extreme Events Reconnaissance (GEER) Association: Turning Disaster Into Knowledge	ENG/CMMI	Jonathan Bray	University of California, Berkely	\$334,188
1300744	Collaborative Research: Geotechnical Extreme Events Reconnaissance (GEER) Association: Turning Disaster Into Knowledge	ENG/CMMI	Ellen Rathje	University of Texas Austin University of California, Berkely	\$37,488
1265761	Collaborative Research: Geotechnical Extreme Events Reconnaissance (GEER) Association: Turning Disaster Into Knowledge	ENG/CMMI	J. David Frost	Georgia Institute of Technology	\$53,629
1546611	Collaborative Research: Rapid Response to the Mw 7.9 Earthquake of April 25, 2015 in Nepal	GEO/EAR	John Nabelek	Oregon State University	\$138,940
1546622	Collaborative Research: Rapid Response to the Mw 7.9 Earthquake of April 25, 2015 in Nepal	GEO/EAR	Abhijit Ghosh	University of California-Riverside	\$15,894
1546636	Collaborative Research: The Nepal Earthquake and Limits on Moment, Fault Geometry and Time Dependent Stress Changes	GEO/EAR	Roger Bilham	University of Colorado at Boulder	\$27,720
1546633	Collaborative Research: The Nepal Earthquake and Limits on Moment, Fault Geometry and Time Dependent Stress Changes	GEO/EAR	Rebecca Bendick	University of Montana	\$31,915
1546630	RAPID Collaborative Research: Landslides caused by the April 2015 Nepal earthquakes, from immediate hazard to tectonic driver	GEO/EAR	A Joshua West	University of Southern California	\$52,737
1546631	RAPID Collaborative Research: Landslides caused by the April 2015 Nepal earthquakes, from immediate hazard to tectonic driver	GEO/EAR	Marin Clark	University of Michigan Ann Arbor	\$52,655
1545923	RAPID: Collaborative Research: Nepal Array Measuring Aftershock Seismicity Trailing Earthquake	GEO/EAR	Simon Klemperer	Stanford University	\$29,336
1545933	RAPID: Collaborative Research: Nepal Array Measuring Aftershock Seismicity Trailing Earthquake	GEO/EAR	Marianne Karplus	University of Texas at El Paso	\$131,790
1547038	RAPID: The Himalaya Connection Video, Expanded	GEO/EAR	Doug Prose	Earth Images Foundation	\$73,000
1560661	RAPID: Disaster as a Catalyst for Social-Ecological Transformation	SBE/BCS	Jeremy Spoon	Portland State University	\$29,998
1547377	RAPID: Narrating Disaster: Calibrating Causality and Responses to the 2015 Earthquakes in Nepal	SBE/BCS	Kristine Hildebrandt	Southern Illinois University at Edwardsville	\$70,287
1547759	RAPID: Psychological and Social Resilience in Post-Earthquake Nepal	SBE/BCS	Steven Folmar	Wake Forest University	\$24,998



Examples of Industrial Innovation Partnership Awards Earthquake-Related

- **Award 1519719: SBIR Phase I: Rapid Calculation of Earthquake Damage and Repair Costs for High-Performance Building Design, Curt Haselton, PI**
http://www.nsf.gov/awardsearch/showAward?AWD_ID=1519719&HistoricalAwards=false
- **Award 1444883: I-Corps: Creation of State-of-the-Art Software for Seismic Building Damage and Monetary Loss Analysis, Curt Haselton, PI**
http://www.nsf.gov/awardsearch/showAward?AWD_ID=1444883&HistoricalAwards=false
- **Award 1448204: SBIR Phase I: Implementing a low-cost seismic network using mobile phones and MEMS accelerometers, Yildirim Battalgazi, PI**
http://www.nsf.gov/awardsearch/showAward?AWD_ID=1448204&HistoricalAwards=false
- **Award 1500293: PFI:AIR - TT: A Hybrid Metal/Glass Composite System for Multihazard Resilient Bridge Columns, Arash Esmaili Zaghi, PI**
http://www.nsf.gov/awardsearch/showAward?AWD_ID=1500293&HistoricalAwards=false



2015 ACEHR Report: NSF Recommendation 1

ACEHR calls upon NSF to clarify current and future programmatic funding commitments in support of NEHRP. This information should be integral to NEHRP coordination efforts by the ICC and the NEHRP Secretariat.

NSF Response: NSF has annually provided budget information to NEHRP, as evidenced in the annual reporting in the table below and included in NEHRP Annual Reports.²

FY	Enacted NSF NEHRP Budget (M) ¹		FY	Enacted NSF NEHRP Budget (M) ¹
2005	53.1		2011	55.3
2006	53.8		2012	53.2
2007	54.2		2013	52.2
2008	53.6		2014	42.0
2009	56.0		2015	52.2
2010	55.0		2016	54.2

Notes:

1. NSF NEHRP budget supports program activities, excluding Agency Operations and Award Management (AOAM) costs. NSF FY 2005-2014 NEHRP budget included support for George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) and Global Seismographic Network (GSN), but excluding *EarthScope* activities. NSF FY 2015-2016 budgets include support for the GSN and the earthquake engineering portion of the Natural Hazards Engineering Research Infrastructure (NHERI), but excludes *EarthScope* activities.
2. FY 2017 Administration requested NSF NEHRP Budget of \$54.2 M - NSF planned NEHRP budget supports program activities, excluding Agency Operations and Award Management (AOAM) costs. Budget includes support for the Global Seismographic Network (GSN) and the earthquake engineering portion of the Natural Hazards Research Infrastructure (NHERI), but excludes *EarthScope* activities.



2015 ACEHR Report: NSF Recommendation 2

ACEHR recommends NSF develop a mechanism for documenting, reporting, and publicizing current NEHRP-related research and the findings from it.

NSF response:

- Information (award abstracts) on expired and active NSF awards is available through the NSF award search <http://www.nsf.gov/awardsearch/>
- Publications resulting from NSF-supported awards will be available in a searchable database at NSF's Public Access Repository <http://par.nsf.gov>
 - Required for all awards made for proposals submitted on/after January 25, 2016
 - For funded researchers: An extension to NSF Awards and Reporting on <http://www.research.gov>



2015 ACEHR Report: NSF Recommendation 4 (slide 1 of 2)

ACEHR recommends NSF review lessons of multi-disciplinary hazard - related initiatives to assess the quality of cross-disciplinary, and especially social science, participation. At the same time, NSF should continue and enhance investment in social science research related to earthquake hazards and disasters.

NSF response:

NSF continues to review the accomplishments and continuing challenges of cross-disciplinary and multi-disciplinary research. In recent years - and with explicit attention to these concerns - NSF-supported researchers in engineering, social sciences, computer science, and other fields have undertaken strongly cross- and multi-disciplinary research, through both multi-investigator and single-investigator projects. NSF's RAPID funding mechanism, which supports the collection of perishable research data, particularly regarding new or emergent phenomena, has been instrumental in this regard, as have larger, multi-year programs such as:

- Interdisciplinary Research in Hazards and Disasters (Hazards SEES) - NSF 12-610 and NSF 14-581.
- Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP) - NSF 15-531 and its predecessor, Resilient Interdependent Infrastructure Processes and Systems (RIPS) - NSF 14-524,
- Infrastructure Management and Extreme Events program in the Directorate for Engineering, Division of Civil, Mechanical and Manufacturing Innovation, continues to provide a stable base for the growth and development of a broadly multi-disciplinary research community devoted to the investigation of sociotechnical phenomena associated with hazard preparation, mitigation, response and recovery.



2015 ACEHR Report: NSF Recommendation 4 (slide 2 of 2)

ACEHR recommends NSF review lessons of multi-disciplinary hazard- related initiatives to assess the quality of cross-disciplinary, and especially social science, participation. At the same time, NSF should continue and enhance investment in social science research related to earthquake hazards and disasters.

NSF response: Recent awards through these programs:

- Directorate for Engineering, Division of Civil, Mechanical, and Manufacturing Innovation, core research program: *Infrastructure Management and Extreme Events (IMEE)*. Recent awards: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13353 (see link at bottom of page)
- Cross-Directorate (Computer and Information Science and Engineering; Engineering; and Social, Behavioral, and Economic Sciences): *Resilient Interdependent Infrastructure Processes and Systems (RIPS)* NSF 14-524. Recent awards: http://www.nsf.gov/news/news_summ.jsp?cntn_id=132852
- Cross-Directorate (Computer and Information Science and Engineering; Engineering; and Social, Behavioral, and Economic Sciences): *Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP)* NSF 15-531. Recent awards: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505180 (see link at bottom of page)
- Cross-Directorate (competitions involved Computer and Information Science and Engineering; Engineering; Geosciences; Mathematical and Physical Sciences; Social, Behavioral, and Economic Sciences; and Office of Integrative and International Activities): *Interdisciplinary Research in Hazards and Disasters (Hazards SEES)* NSF 12-610 and NSF 14-581. Recent awards: http://nsf.gov/funding/pgm_summ.jsp?pims_id=504804 (see link at bottom of page)



Directorate for Engineering (ENG)



FY 2016 ENG Programs Supporting NEHRP in the Division of Civil, Mechanical and Manufacturing Innovation (CMMI)

- Engineering for Natural Hazards (ENH)
 - Research awards, including RAPID awards
- Infrastructure Management and Extreme Events (IMEE)
 - Research awards, including RAPID awards
 - Support for Natural Hazards Center at University of Colorado, Boulder
- Natural Hazards Engineering Research Infrastructure (NHERI)
(NSF 14-605 and NSF 15-598)
 - Earthquake and wind engineering research, education, and community outreach resources
 - Four components competed
 - Network Coordination Office
 - Cyberinfrastructure
 - Computational Modeling and Simulation Center
 - Experimental Facilities, including a RAPID facility



2015 ACEHR Report: NSF Recommendation 3 (slide 1 of 4)

ACEHR recommends NSF report the status of earthquake-related research and funding commitments under the Natural Hazards Engineering Research Infrastructure (NHERI) initiative.

NSF Response: Status at http://nsf.gov/news/news_summ.jsp?cntn_id=136380&org=NSF

NHERI supports research infrastructure. Under program solicitation NSF 14-605, *Natural Hazards Engineering Research Infrastructure (NHERI)*, in FY 2015, NSF made eight awards to establish NHERI: one for cyberinfrastructure and seven for experimental facilities:

- [Cyberinfrastructure](http://www.DesignSafe-ci.org) at University of Texas at Austin (www.DesignSafe-ci.org)
- [Twelve-Fan Wall of Wind](#) at Florida International University,
- [Large-Scale, Multi-Directional, Hybrid Simulation Testing Capabilities](#) at Lehigh University,
- [Large Wave Flume and Directional Wave Basin](#) at Oregon State University,
- [Geotechnical Centrifuges](#) at the University of California, Davis,
- [Large, High-Performance Outdoor Shake Table](#) at the University of California, San Diego,
- [Boundary Layer Wind Tunnel, Wind Load and Dynamic Flow Simulators, and Pressure Loading Actuators](#) at the University of Florida; and,
- [Large, Mobile Dynamic Shakers for Field Testing](#) at the University of Texas at Austin.



2015 ACEHR Report: NSF Recommendation 3 (slide 2 of 4)

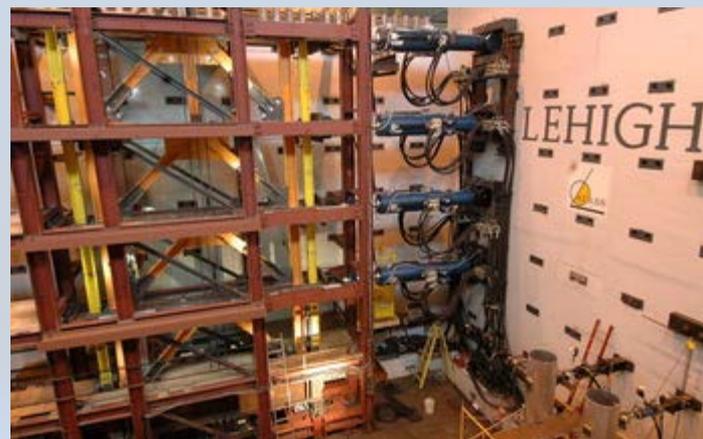
ACEHR recommends NSF report the status of earthquake-related research and funding commitments under the Natural Hazards Engineering Research Infrastructure (NHERI) initiative.

NSF Response: Status at http://nsf.gov/news/news_summ.jsp?cntn_id=136380&org=NSF



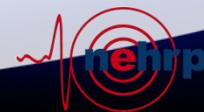
The 12-fan Wall of Wind at Florida International University, one of the experimental facilities in NSF's Natural Hazards Engineering Research Infrastructure, will enable better engineering against tornadoes, hurricanes and other windstorms.

Credit: Courtesy of FIU



At Lehigh University, the NSF Natural Hazards Engineering Research Infrastructure facility enables earthquake engineers to perform hybrid simulation, which combines computer modeling and physical testing. Here, an experimental substructure for a hybrid simulation of a self-centering, concentrically-braced steel frame is subjected to the maximum considered earthquake, which is likely to occur approximately once in 2,500 years.

Credit: Lehigh University



2015 ACEHR Report: NSF Recommendation 3 (slide 3 of 4)

ACEHR recommends NSF report the status of earthquake-related research and funding commitments under the Natural Hazards Engineering Research Infrastructure (NHERI) initiative.

NSF Response: Status at http://nsf.gov/news/news_summ.jsp?cntn_id=136380&org=NSF



The 9-meter geotechnical centrifuge at the University of California, Davis--part of the NSF Natural Hazards Engineering Research Infrastructure--can simulate the high pressures found deep in the ground within small-scale models while hydraulic actuators simulate earthquakes. Hundreds of sensors measure the response of the soil and model structures.

Credit: Center for Geotechnical Modeling, UC Davis



The biggest shake table in the U.S., at the University of California, San Diego, is part of the NSF Natural Hazards Engineering Research Infrastructure. By reproducing earthquake seismic waves, the shake table enables researchers to test new designs for large structures made of concrete, wood, masonry and other materials. Here, a wooden structure shows damage after testing on the UCSD shake table.

Credit: UC San Diego/Jacobs School of Engineering

2015 ACEHR Report: NSF Recommendation 3 (slide 4 of 4)

ACEHR recommends NSF report the status of earthquake-related research and funding commitments under the Natural Hazards Engineering Research Infrastructure (NHERI) initiative.

NSF Response:

In FY 2016, three NHERI components are being competed under NSF 15-598, NHERI: Network Coordination Office, Computational Modeling and Simulation Center, and Post-Disaster, Rapid Response Research Facility.

The five-year NHERI funding profile, as stated in NSF 14-605 (and NSF 15-598) and subject to the annual budgets of NSF, the annual performance of the NHERI awards, and the extent of utilization of NHERI resources by NSF-supported research and education awards:

- FY 2015 \$12,000,000 (actual \$18,235,978)
- FY 2016 \$13,000,000
- FY 2017 \$12,500,000
- FY 2018 \$12,500,000
- FY 2019 \$12,000,000

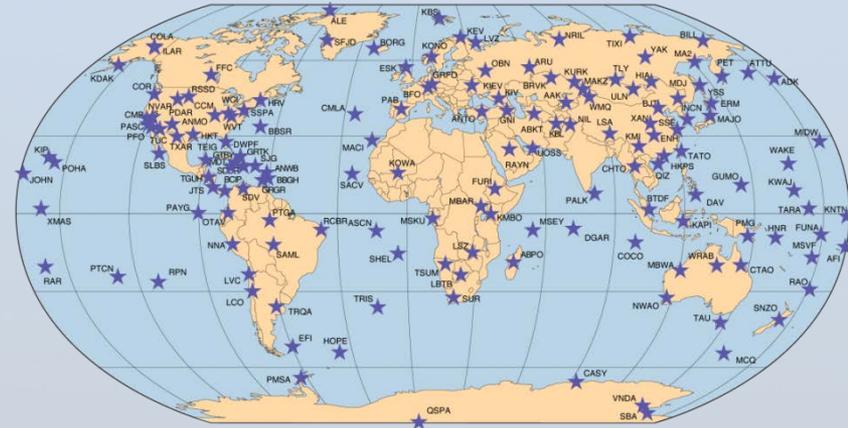


Directorate for Geosciences (GEO)

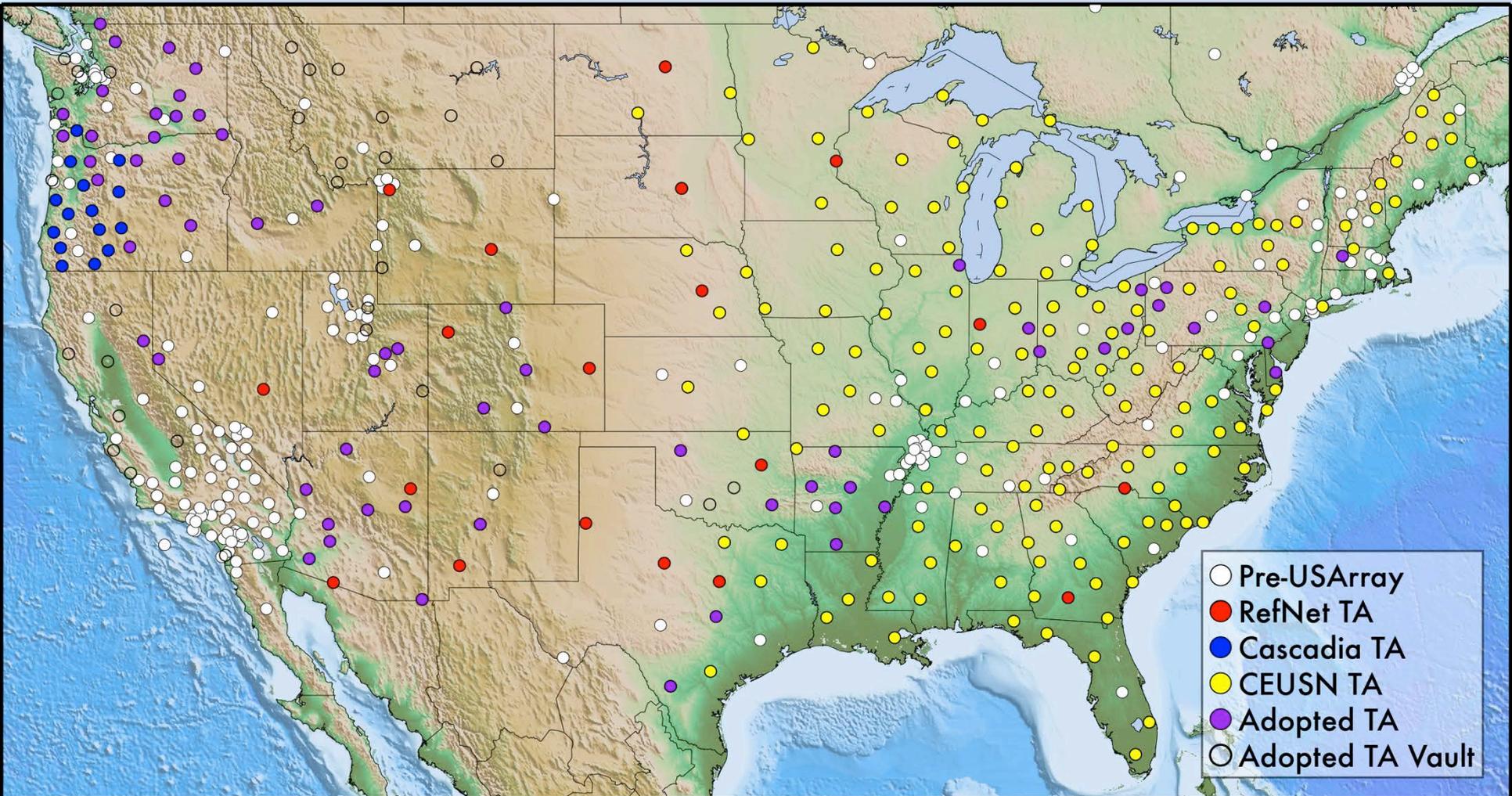


SAGE Seismic Facility

- SAGE: Seismological Facilities for the Advancement of Geoscience and EarthScope
- Operations planned FY14-18
 - Annual budget ~\$25M
- NEHRP links
 - Primary: Global Seismographic Network (GSN)
 - External review in 2015 concluded that “continued federal funding of the GSN [is] essential”
 - Contributing: Transportable Array
 - Data key in understanding induced seismicity
 - Conversion of selected stations to long-term operations
 - Data used for EEW systems
 - Contributing: Data management
 - ACEHR notes this is key resource for community



Long-term legacy from Transportable Array



~221 long-term broadband stations prior to TA

260 TA stations added to the long-term network

Courtesy IRIS

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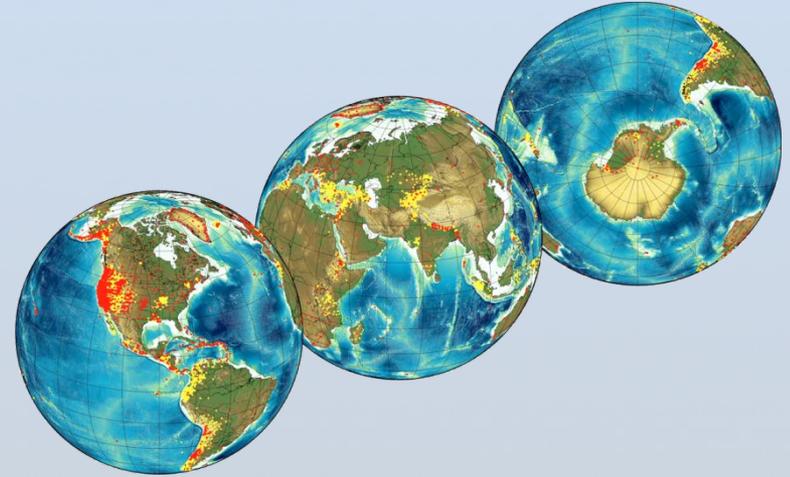
CEUSN: Central & Eastern US Seismic Network

- Joint effort of NSF, USGS, other partners
- Goal
 - Convert to long-term ~160 TA seismic stations
 - Enhance research and monitoring in central & eastern United States, including monitoring of critical facilities
- Estimated costs
 - 5-yr conversion: \$12M
 - Annual O&M: \$1.6M
- Status
 - All stations collecting data, all data publicly available
 - Funding through FY15: \$10.3M NSF, \$582k USGS
 - Anticipated through FY17: \$10.3M NSF, \$1.7M USGS



GAGE: Geodetic Facilities

- GAGE: Geodesy Advancing Geosciences and EarthScope
- Integration of prior geodetic facilities & EarthScope/PBO
- Operations planned FY14-18
 - Annual budget ~\$12.5M (NSF/NASA)
- Primary NEHRP link:
 - GAGE-provided GPS data now incorporated into USGS National Seismic Hazard Maps
- Real-time, high-rate GPS being assessed for use in Earthquake Early Warning systems



NGEO: National Geophysical Observatory for Geoscience

- Second stage in two-stage integration & recompetition process for EAR-supported facilities that provide geodetic, seismic, and related geophysical instrumentation, data, and educational capabilities
- Successor capabilities to current SAGE and GAGE facilities
- NGEO would “*comprise a distributed, multi-user, national facility for the development, deployment, management, and operational support of modern geodetic, seismic, and related geophysical instrumentation and services to serve national goals in basic research and education in the Earth sciences [and] would support mission goals of [NASA, NOAA, and USGS].*”
- Solicitation released 26 February 2016 ([NSF 16-546](#))
- Letters of intent due 1 Aug 2016, Proposals due 30 Dec 2016
- Awards, if any, would start 1 Oct 2018
- Anticipated total budget: \$387 million over 10 years*

*subject to many caveats described in solicitation



Additional GEO Activities

- Continued joint support (w/USGS) for Southern California Earthquake Center (SCEC)
(~\$2.7-3.0M NSF/year) www.scec.org
- Fundamental research via Geophysics, Tectonics, EarthScope, GeoPRISMS, Geomorphology & Land-Use Dynamics, and other core EAR programs
- New program: PREEVENTS
 - GEO element of NSF-wide Risk & Resilience activity



PREEVENTS

- Program w/multidisciplinary portfolio to improve
 - Fundamental understanding of processes underlying natural hazards and extreme events in geosciences
 - Capability to model such events and processes
- Projects **must address both topics**
- Other goals:
 - Improve understanding of effects of natural hazards & extreme events
 - Enable development, with support from other programs and organizations, of tools to enhance societal preparedness and resilience
- Focused on natural hazards
- GEO-centered, with potential for links
- Budget: \$17.75M (FY16 estimate), \$17.75M (FY17 request)



PREEVENTS: Status

- Dear Colleague Letter and FAQs released in fall 2015
- Internal co-funding model announced
- Solicitation in development
- Ongoing discussions across agencies
- Timeline
 - FY16: internal co-funding of relevant proposals received in GEO programs
 - FY16: Release of solicitation, deadline late summer
 - FY17: First awards under PREEVENTS solicitation
 - FY19: Second solicitation for full program
 - FY20: Program evaluation



National Science Foundation

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<http://www.nsf.gov/funding/>

NSF, Directorate for Engineering, Division of Civil, Mechanical and Manufacturing Innovation, Resilient and Sustainable Infrastructures Cluster Programs

http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13545&org=CMMI&from=home

NSF, Directorate for Geosciences, Division of Earth Sciences

<http://www.nsf.gov/div/index.jsp?div=ear>

Science Nation (video): Engineering Innovative Seismic Retrofits that Don't Break the Bank

http://www.nsf.gov/news/special_reports/science_nation/reinforcedbuildings.jsp

