

National Science Foundation (NSF)

NSF Earthquake Program Update

**National Earthquake Hazards Reduction Program (NEHRP)
Advisory Committee on Earthquake Hazards Reduction (ACEHR)
August 18, 2014
Golden, CO**

*Joy M. Pauschke, Ph.D., P.E.
Program Director
NEES Operations & Research
Division of Civil, Mechanical and Manufacturing Innovation
National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230
Voice: 703-292-7024
Email: jpauschk@nsf.gov*

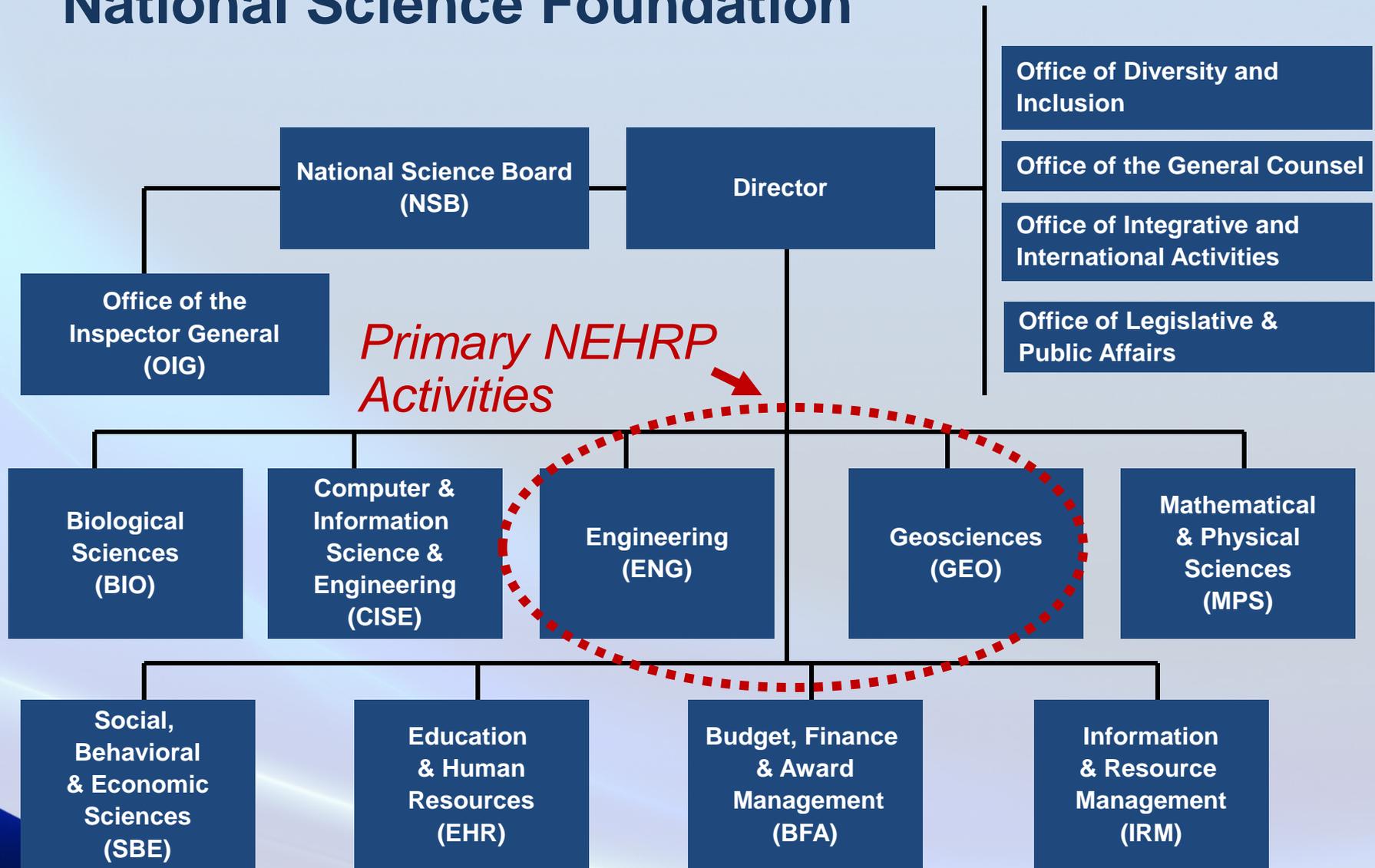


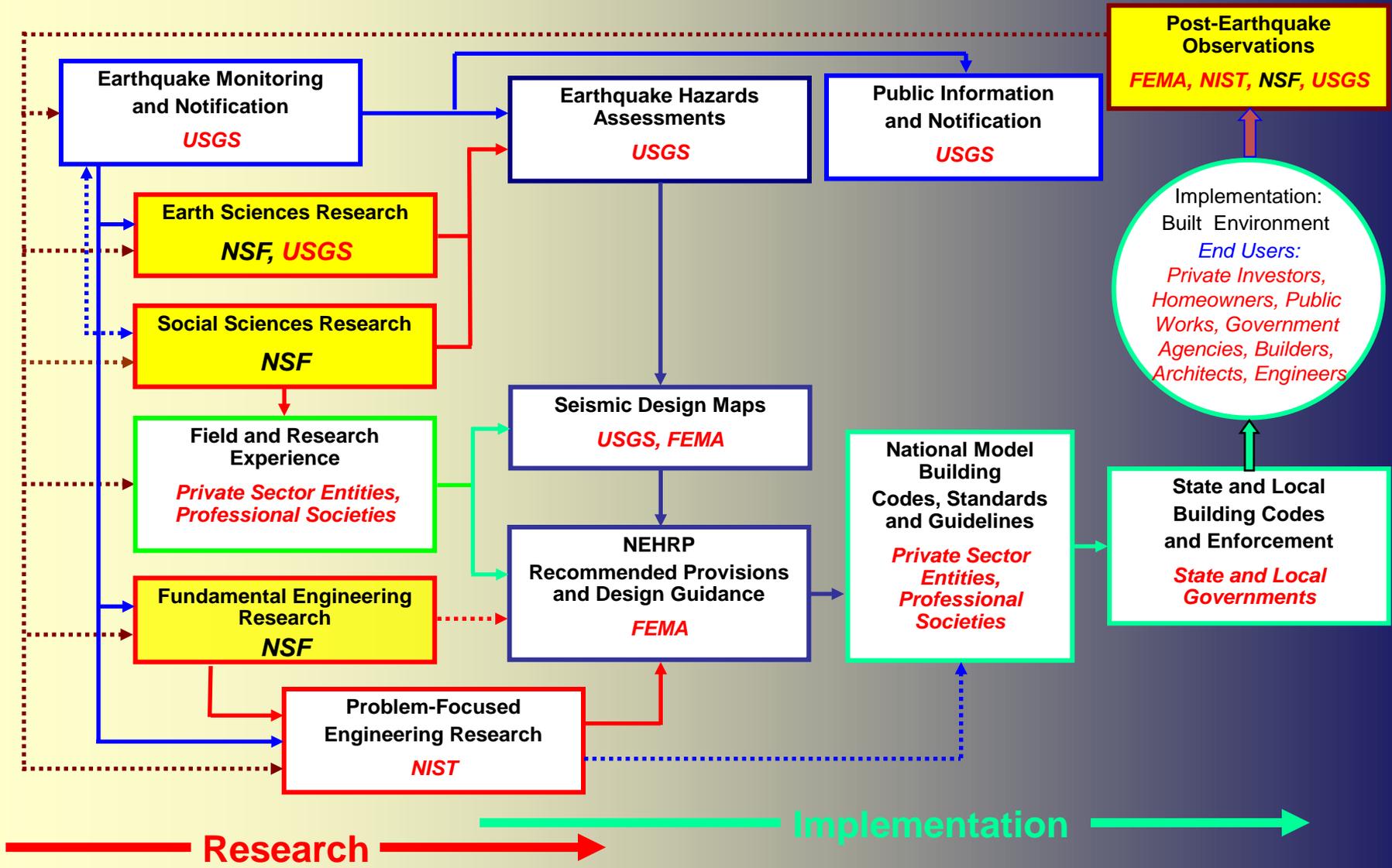
Agenda

- About NSF
- NSF Directorate for Engineering in NEHRP
 - Response to 2013 ACEHR Recommendation
- NSF Directorate for Geosciences in NEHRP
 - Response to 2013 ACEHR Recommendation
- Examples of NSF Interdisciplinary Programs



National Science Foundation





NEHRP Impact on the Built Environment



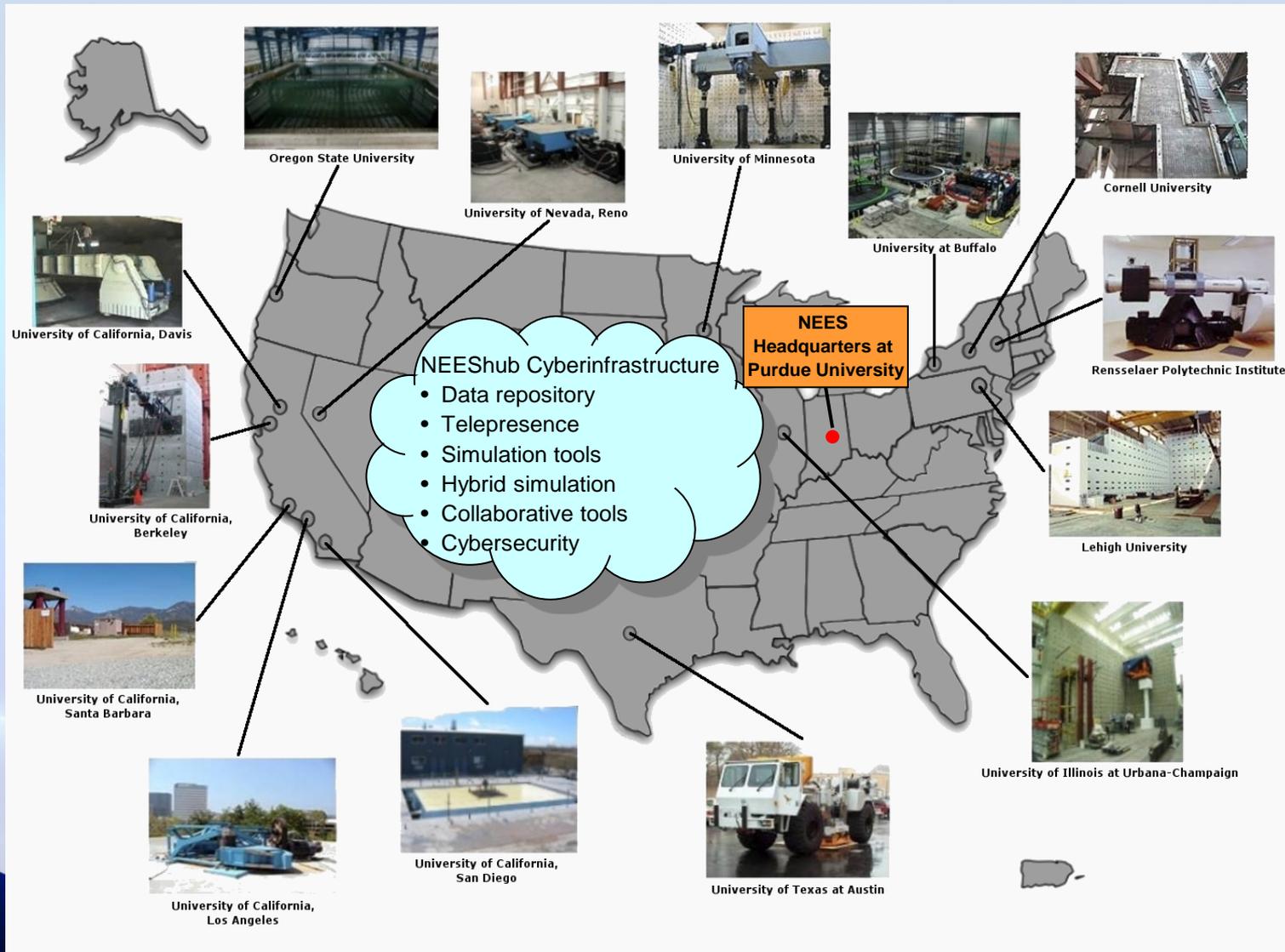
NEHRP - NSF Directorate for Engineering

Division of Civil, Mechanical and Manufacturing Innovation

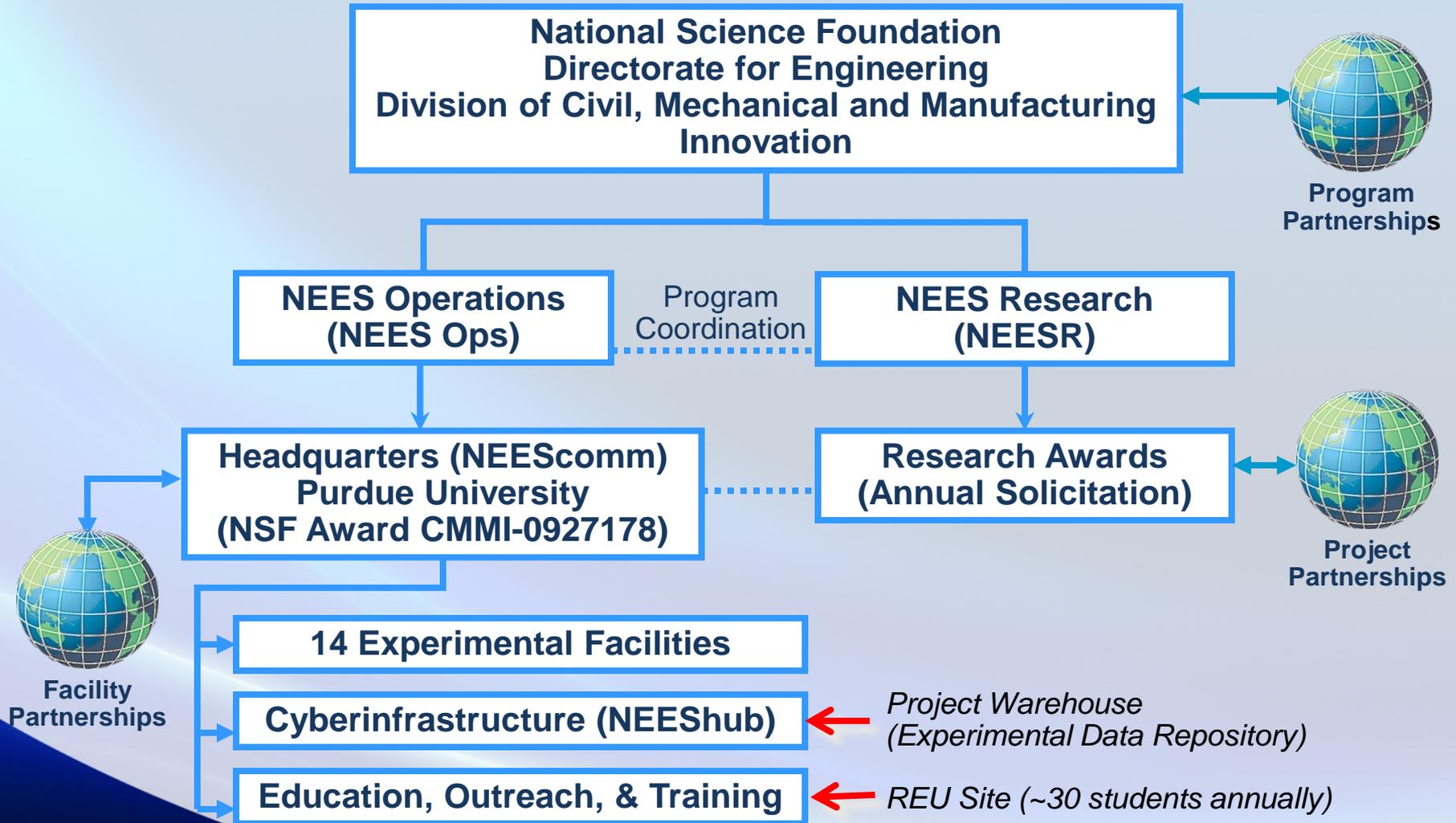
- **George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES)**
 - **Operations (Purdue University)**
 - **Fundamental Research**
- **Fundamental Research Programs (Unsolicited Proposals)**
 - **Hazard Mitigation and Structural Engineering (HMSE)**
 - **Geotechnical Engineering (GTE)**
 - **Infrastructure Management and Extreme Events (IMEE)**
 - **Natural Hazards Center (University of Colorado, Boulder)**



George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES)



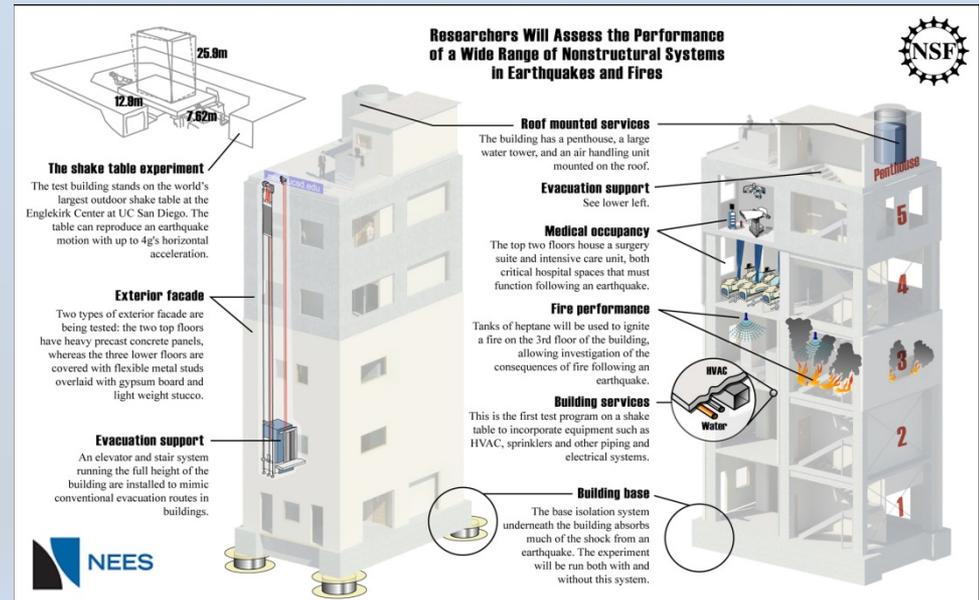
NSF NEES Program FY 2010-FY 2014



Full-scale Test on Building Nonstructural Components and Systems (NSF award CMMI-0936505)



Photo credit: UCSD and Tara Hutchinson



Credit: Detail illustrations and layout Zina Deretsky, National Science Foundation; Building illustrations UC San Diego Department of Structural Engineering.

Illustration depicting several of the components contained in a massive shake-table experiment being conducted by researchers at University of California, San Diego (UCSD), Worcester Polytechnic Institute (WPI), Howard University, & San Diego State University.

- Tests completed in 2012
- Performance of nonstructural components and systems at full-scale using the NSF-supported NEES UCSD large outdoor shake table
- 40 industry partners



Base Isolation Tests at Japan's E-Defense Shake Table Facility in 2011



Credit: Joy Pauschke

Five-story test on base isolation and nonstructural systems at Japan's E-Defense shake table facility during August 2011

(NSF Awards CMMI-1113275, Keri Ryan, PI and CMMI-0721399, Emmanuel Maragakis, PI)



NSF Support for Post-earthquake, Rapid Response Research (RAPIDs)

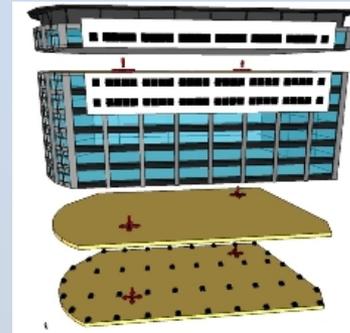
- NSF supports post-earthquake, rapid response research (RAPIDs) through
 - Unsolicited proposals to core programs, primarily through the RAPID proposal mechanism
 - Supplements to existing NSF research awards
 - Core program research awards, e.g., Geo-Engineering Extreme Events Reconnaissance (GEER) (CMMI-1266418, CMMI-1265761, CMMI-1300744)
 - Event-based Dear Colleague Letter, as warranted (e.g., 2010 Haiti earthquake and 2010/2011 New Zealand earthquakes and 2011 Japan earthquake/tsunami)
- NSF supports dissemination of rapid response research findings via grantee workshops, e.g.,
 - 2010 Haiti earthquake workshop and report
http://www.eqclearinghouse.org/20100112-haiti/wp-content/uploads/2010/10/Haiti-Workshop-Report_FINAL1.pdf
 - 2010 Chile earthquake workshop and report
http://www.eqclearinghouse.org/20100227-chile/wp-content/uploads/2010/11/Chile-Workshop-Report_FINAL.pdf
 - 2010/2011 New Zealand earthquakes and 2011 Japan earthquake/tsunami workshop and report
https://www.eeri.org/wp-content/uploads/JAPAN_NZ_RAPID_Workshop_Final.pdf



NSF Awards following New Zealand Earthquakes



Photo from nees.utexas.edu



Credit: Robin Farrell



Credit: Henri Gavin

Liquefaction Mitigation

- RAPID: Field Investigation of Shallow Ground Improvement Methods for Inhibiting Liquefaction Triggering, Christchurch, New Zealand
Award CMMI-1343524, Professors Kenneth Stokoe and Brady Cox, University of Texas at Austin
- RAPID: Deep Shear Wave Velocity Profiling for Seismic Characterization of Christchurch, NZ - Reliably Merging Large Active-Source and Passive-Wavefield Surface Wave Methods
Award CMMI-1303595, Professor Brady Cox, University of Texas at Austin
- RAPID: Pile Downdrag Behavior Based on Blast Liquefaction Testing
Award CMMI-1408892, Professor Kyle Rollins, Brigham Young University

Seismic Isolation Systems

- RAPID: Performance of the Base-Isolated Christchurch Women's Hospital during the Sequence of Strong Earthquakes and Aftershocks in New Zealand from September 2010 through 2011 and
- EAGER: Instrumentation and Modeling of Seismic Isolation in Aftershocks
Awards CMMI-1138714 and CMMI-1258466, Professor Henri Gavin, Duke University



IMEE Programmatic Action

Enabling the Next Generation of Hazard Researchers

NSF Awards CMMI-9531297, 0218413, 0758484 & 1424075

- First three awards have recruited and mentored 44 young faculty working in areas of hazards, disasters, and risk research
- Researchers from the areas of political science, public policy, urban and regional planning, geography, civil engineering, decision sciences, economics, operations research, and sociology
- Has led to research on topics such as homeland security, enhanced emergency response, emergency medical services, protecting power and other lifelines, community resilience, and frameworks to reduce losses and speed recovery in vulnerable areas



NSF Response to 2013 ACEHR Recommendations

ACEHR RECOMMENDATION: ENDORSE THE CONTINUATION OF NEES

The committee recommends continued support of the NEES infrastructure and collaboratory and of the associated research that uses these facilities, at current or increased levels.

NSF Response: NSF has issued the NSF 14-054 Dear Colleague Letter (DCL) “Support for Natural Hazards Engineering Research Infrastructure and Research during FY 2015-FY 2019” http://www.nsf.gov/pubs/2014/nsf14054/nsf14054.jsp?WT.mc_id=USNSF_25&WT.mc_ev=click , which includes a discussion of planned support for earthquake engineering research infrastructure and research during 2015 - 2019.



NEES History

Date	Activity
Pre-1998	Planning for NEES
1998	National Science Board approves NEES for construction
2000-2004	Major Research Equipment and Facilities Construction (MREFC)
2005-2014	10-year Support for NEES Operations and Research
2011-2012	Planning for Earthquake Engineering Research and Research Infrastructure beyond FY 2014
2013	Recompeted a Reduced NEES2 Infrastructure (NSF 13-537); no award
2014	NSF 14-054 Dear Colleague Letter: Natural Hazards Engineering Research Infrastructure (NHERI) – up to 10 awards
2015	Five-year awards made for NHERI
~2017	Completion of Community Decadal Science Plan for Natural Hazards Engineering Research, Education, and Research Infrastructure for 2020 - 2029
~2018	NSF Decision on Program beyond 2019



Recent Studies

National Research Council, *National Earthquake Resilience: Research, Implementation, and Outreach*. Washington, DC: The National Academies Press, 2011, http://www.nap.edu/catalog.php?record_id=13092.

National Research Council, *Grand Challenges in Earthquake Engineering Research: A Community Workshop Report*. Washington, DC: The National Academies Press, 2011, http://books.nap.edu/catalog.php?record_id=13167.

NIST GCR 14-973-13, *Measurement Science R&D Roadmap for Windstorm and Coastal Inundation Impact Reduction*. (This roadmap developmental effort was supported in part by NSF, through award CMMI-1235689, to obtain community input on related long-term fundamental research challenges in windstorm and coastal inundation impact reduction), http://www.nist.gov/customcf/get_pdf.cfm?pub_id=915541.



NSF 14-054 Dear Colleague Letter

Support for Natural Hazards Engineering Research Infrastructure and Research during FY 2015 - FY 2019

Operations of Research Infrastructure (solicitation pending)

- Network Coordination Office (one award)
- Cyberinfrastructure (one award)
- Computational Modeling and Simulation Center (one award)
- Experimental Facilities for Earthquake and Wind Engineering Research, including a RAPID Facility (up to seven awards)

Research

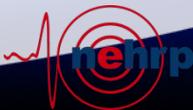
- Focus on Multi-hazard Resilient and Sustainable Civil Infrastructure
- Initiated with NSF 14-557 Decision Frameworks for Multi-hazard Resilient and Sustainable Buildings

Cyberinfrastructure continuity

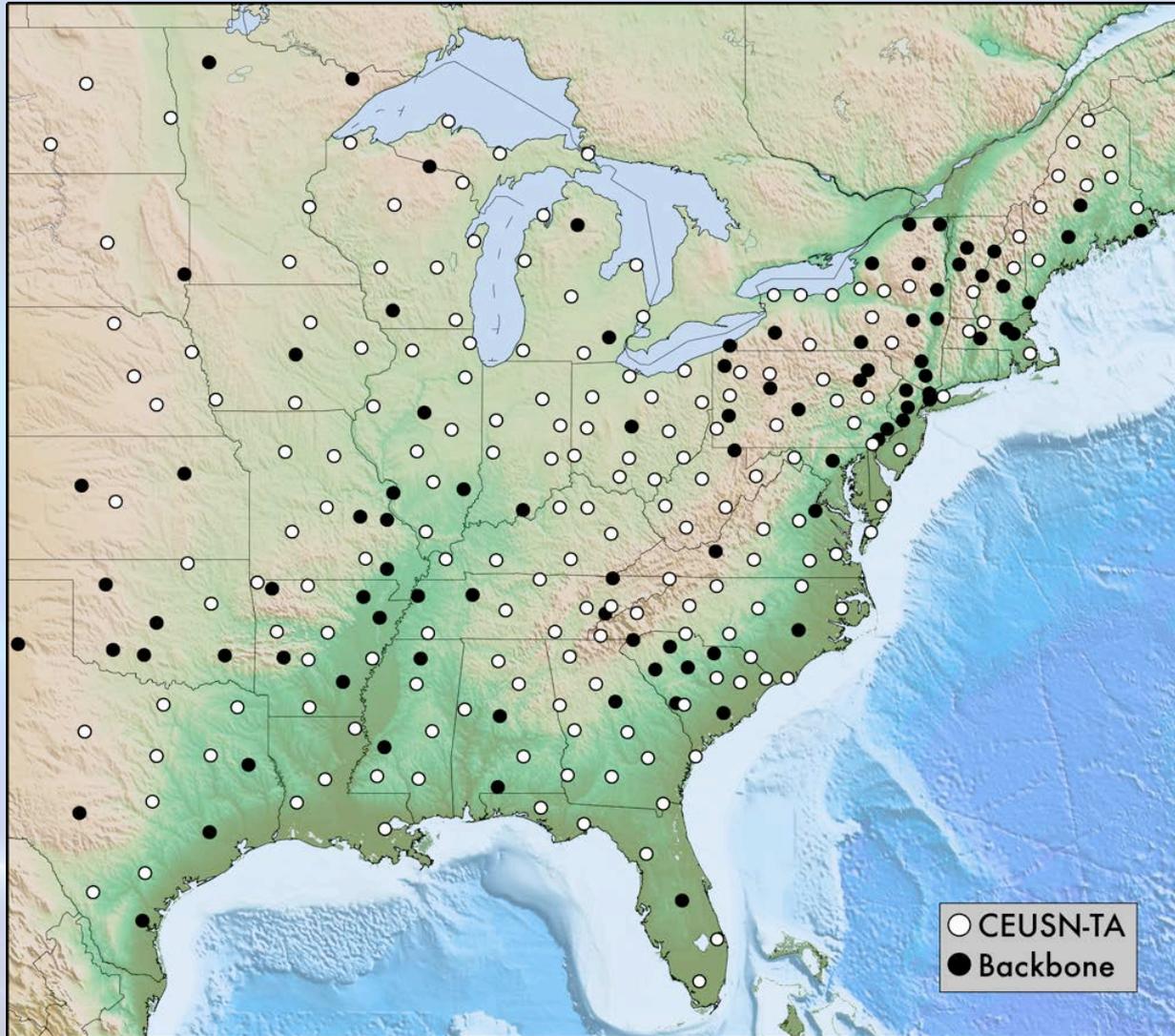
- Purdue University will operate the cyberinfrastructure until transition to new awardee in 2015



Directorate for Geosciences



Central & Eastern US Seismic Network: CEUSN



CEUSN

- **Goal**

- Convert to long-term ops up to ~160 EarthScope Transportable Array seismic stations
- Enhance research and monitoring in central and eastern United States, including monitoring of critical facilities

- **Costs**

- 5-yr conversion: \$12M
- Annual O&M: \$1.6M

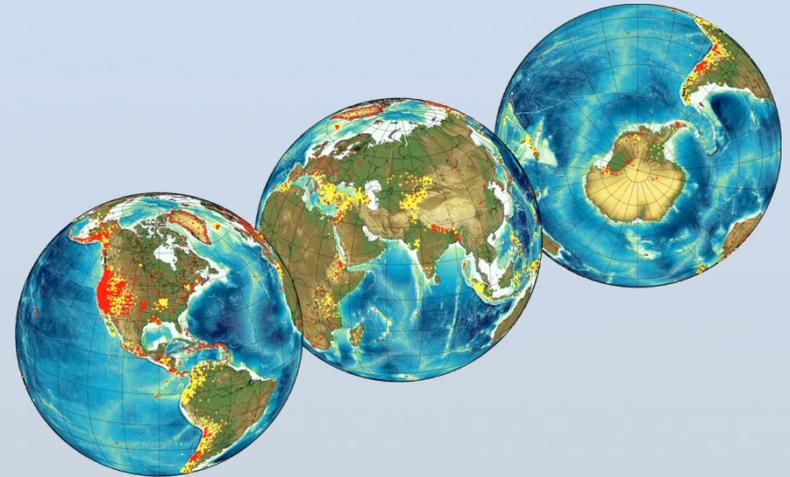
- **Status**

- NSF/USGS Interagency Agreement for joint funding
- To date: \$6.2M from NSF, \$200k from USGS
- All target stations currently collecting data
- All are publicly available



GAGE: Geodetic Facilities

- GAGE: Geodesy Advancing Geosciences and EarthScope
- Integration of prior geodetic facilities & EarthScope/PBO
- Operations:
 - Year 1 nearly complete
 - Annual budget ~\$12.5M (NSF/NASA)
 - Planned through 2018
- 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



NSF Response to 2013 ACEHR Recommendations

ACEHR RECOMMENDATION: PROVIDE INCREASED MONITORING TO ASSESS THE IMPACT OF INDUCED SEISMICITY

NSF should begin sponsoring the conversion of EarthScope Transportable Array stations to permanent seismic stations maintained and operated by the USGS as soon as possible.

NSF Response: NSF has begun sponsoring these conversions and anticipates supporting further conversions and operations of the Central and Eastern US Seismic Network stations through FY 2017, subject to the availability of future funding. In FY 2013, NSF provided \$2.5M, and in FY 2014, NSF anticipates providing approximately \$3.5M to IRIS, our awardee responsible for the Transportable Array. We are in close coordination with USGS Earthquake Hazards Program staff, which have indicated their intention to provide at least \$200,000 for operations in FY 2014, ramping upward to at least \$800,000 in FY 2017 and beyond, again pending availability of future funding. NSF intends to end its support for these stations in FY 2017. Currently, all 158 stations that are planned for conversion are collecting data, which are available both directly to agency partners and to the community via the IRIS Data Management Center.



Additional GEO Activities

- Continued joint support (w/USGS) for Southern California Earthquake Center at ~\$2.7M/year
<http://www.scec.org>
- Support for wide range of fundamental research via Geophysics, Tectonics, EarthScope, GeoPRISMS, Geomorphology & Land-Use Dynamics, and other EAR programs



Examples of NSF Interdisciplinary Research Programs

- NSF ENG/CMMI

Infrastructure Management and Extreme Events

“...focuses on the impact of large-scale hazards on civil infrastructure and society and on related issues of preparedness, response, mitigation, and recovery. The program supports research to integrate multiple issues from engineering, social, behavioral, political, and economic sciences. It supports fundamental research on the interdependence of civil infrastructure and society, development of sustainable infrastructures, and civil infrastructure vulnerability and risk reduction.

- NSF GEO, CISE, ENG, MPS, and SBE Directorates and OIIA

NSF 14-581, Interdisciplinary Research in Hazards and Disasters (Hazards SEES)

Hazards SEES...seeks to: (1) advance understanding of the fundamental processes associated with specific natural hazards and technological hazards linked to natural phenomena, and their interactions; (2) better understand the causes, interdependences, impacts, and cumulative effects of these hazards on individuals, the natural and built environment, and society as a whole; and (3) improve capabilities for forecasting or predicting hazards, mitigating their effects, and enhancing the capacity to respond to and recover from resultant disasters. The overarching goal of Hazards SEES is to catalyze well-integrated interdisciplinary research efforts in hazards-related science and engineering in order to reduce the impact of hazards, enhance the safety of society, and contribute to sustainability.

- NSF CISE, ENG, and SBE Directorates

NSF 14-524, Resilient Interdependent Infrastructure Processes and Systems (RIPS)

“The goals of the...RIPS solicitation are (1) to foster an interdisciplinary research community that discovers new knowledge for the design and operation of infrastructures as processes and services (2) to enhance the understanding and design of interdependent critical infrastructure systems (ICIs) and processes that provide essential goods and services despite disruptions and failures from any cause, natural, technological, or malicious, and (3) to create the knowledge for innovation in ICIs to advance society with new goods and services.”



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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>

