

NEHRP Agency Responses to 2017 ACEHR Report Recommendations

OVERARCHING RECOMMENDATIONS ON STATE OF NEHRP

Recommendation 1

ACEHR urges Congressional reauthorization of the Earthquake Hazards Reduction Act and the National Earthquake Hazards Reduction Program (NEHRP).

Lead Agency (NIST) Response: The reauthorization of NEHRP was passed by Congress and signed by the President on December 11, 2018. Public Law 115-307 is now in place with the four Program agencies actively working to further the goals of the Program under this new public law.

Recommendation 2

Commensurate with the NEHRP reauthorization, ACEHR calls for the immediate conduct of an assessment of the nation's earthquake risk reduction progress to date in order to guide future NEHRP direction and funding levels.

Lead Agency (NIST) Response: The Government Accountability Office (GAO) is required under PL 115-307 to conduct an independent assessment of the Program, its progress in mitigating earthquake risk over the past 40 years of NEHRP, and the questions that remain to be addressed.

The four NEHRP agencies will be working to update the Strategic Plan over the next several years to reflect our own assessment of Program progress, needs and directions for the future. The results of the GAO assessment will be used by the agencies once it is available to complete the Plan update.

RECOMMENDATIONS FOR INTERAGENCY COORDINATING COMMITTEE (ICC)

ICC Recommendation 1

ACEHR calls upon the Director NIST Director, as Chair of the ICC, to revitalize the ICC as a mechanism for advancing NEHRP within the respective agencies.

Lead Agency (NIST) Response: The ACEHR recommendation concerning the ICC is acknowledged. The NEHRP agencies will meet their responsibilities under PL 115-307 and actively work to advance the Program. The role of the ICC in advancing the Program will be considered as a topic for discussion for a future ICC meeting.

ICC Recommendation 2

ACEHR calls upon the NIST Director, as Chair of the ICC, to work with the ICC to ensure appropriate and coordinated Program budgets.

Lead Agency (NIST) Response: This ACEHR recommendation is acknowledged and will be considered as a topic for discussion for a future ICC meeting. Budgets have been discussed amongst agencies in previous ICC meetings with mixed success; agency budgets and NEHRP allocations are a complex issue

in today's fiscal environment. We anticipate that agency budgets will be a discussion item in future ICC meetings.

RECOMMENDATIONS FOR NEHRP SECRETARIAT

NEHRP Secretariat Recommendation 1

ACEHR recommends that the NEHRP Secretariat lead the NEHRP agencies in the development of an updated Strategic Plan and implementation strategy necessary for NEHRP to fulfill its mission.

Lead Agency (NIST) Response: The process for updating of the Strategic Plan is under discussion at the NEHRP Program Coordination Working Group level.

Review of the Plan reveals that scope of work in the existing plan is far from complete with important questions that remain to be answered. There are to be sure important topics that are not in the existing plan that will need to be identified in the update.

The ACEHR is asked to provide their perspective on priority topics to include, and topics or areas to eliminate in the existing plan going forward to assist the NEHRP agencies in developing a revised, updated Strategic Plan.

NEHRP Secretariat Recommendation 2

ACEHR recommends the NEHRP Secretariat, with the four NEHRP agencies, facilitate a workshop to advance the use of risk-based rating systems for the seismic performance of buildings in the U.S.

Lead Agency (NIST) Response: The NEHRP Office is exploring the possibilities for a workshop that would bring together code development organizations, proponents of the various rating systems currently available, researchers, building owners, code officials, practicing engineers and other interested parties to discuss the rating concept, its present state and what rating systems can and cannot provide for building owners, occupants, insurers, responders, and communities.

The role of rating systems in a future environment where functional recovery/immediate occupancy considerations are involved may also be a part of this discussion.

Finally, the utility of rating systems must be assessed in a national context with recognition of the varying seismic hazards and mitigation environments that exist across the country, along with an assessment of how seismic ratings would interact with ratings for other building risks (wind, flood, etc.).

NEHRP Secretariat Recommendation 3

ACEHR recommends that the NEHRP Secretariat, with the four NEHRP agencies, develop a uniform policy regarding the dissemination of information on NEHRP research and implementation efforts.

Lead Agency (NIST) Response: We appreciate the comment and reiterate the strong commitment of the NEHRP agencies to effectively disseminate results. Policies concerning dissemination of research results are based on Federal government and individual agency policies regarding publication and dissemination of results. The NEHRP agencies will consider where improvements can be made to dissemination policies to improve the effectiveness of our outreach to the Earthquake Community.

RECOMMENDATIONS FOR FEMA

FEMA Recommendation 1

ACEHR urges the Administration, and the leaders of FEMA and the Department of Homeland Security, to take action to provide FEMA's earthquake program with the resources needed to fully meet the agency's responsibilities as required by law. The persistent underfunding of FEMA jeopardizes the effectiveness of the entire Program.

FEMA Response: FEMA's NEHRP-related activities are housed primarily in the Risk Management Directorate (RMD) of the Federal Insurance and Mitigation Administration (FIMA). Current funding levels of NEHRP-related activities is approximately \$8.5M, which matches levels specified in previous Senate FEMA appropriations reports, and this figure was the basis for the FEMA authorized level specified in the recent NEHRP reauthorization (P.L. 115-307). In addition, FEMA funds and conducts many other earthquake-related activities beyond those identified as being under NEHRP. These include: funding of State earthquake risk reduction grants under the various Hazard Mitigation Assistance Programs (HMA) (roughly 1/3 of all funded projects have been earthquake-related); funding of recent earthquake-related National Level Exercises (NLE) and other related training exercises; and post-earthquake mitigation projects following recent federally-declared earthquake disasters (e.g. South Napa and Anchorage earthquakes).

However, FEMA continually considers how to best meet mission needs, and the resource requirements needed to achieve those missions. In support of the Administration, we do provide information where appropriate to help inform how we can best align resource in meeting the Administration's priorities.

FEMA Recommendation 2

ACEHR recommends that FEMA continue to make seismic building code development, adoption and enforcement a priority.

FEMA Response: FEMA continues to place its highest priority on the development, adoption and enforcement of building codes, including seismic building codes. FEMA recently allocated an additional \$2.5M to RMD to support additional multi-hazard building code outreach and awareness.

For FY 2018 and 2019, the FEMA Earthquake Program provided \$400K annually in funding for our Seismic Code Support Committee (SCSC), which reviews recent developments in seismic building design and construction, develops and submits proposed code changes to the various International Codes and monitors and provides testimony on other code change proposals as part of the International code development process. We are currently in the development cycle for the 2021 International Codes and the SCSC has submitted a dozen code change proposals to improve the seismic provisions of the various International Codes as part of this process. Further, the SCSC will be providing testimony in support or opposition for roughly 100 other code change proposals as part of the Code Action Hearings taking place this spring and the Public Comment Hearings taking place this fall.

FEMA Recommendation 3

ACEHR continues to recommend that FEMA return to a directly-funded, state-based program for earthquake hazard mitigation, planning, education and preparedness efforts and to reconsider the current state grant matching formula.

FEMA Response: With the revised matching requirements specified in the recent NEHRP reauthorization (P.L. 115-307), FEMA has already revised its FY 2019 Earthquake Direct State Assistance (EDSA) grant program to consist of only direct funding to the eligible States that agree to meet the required 25% cost share. This allowed us to eliminate the State Support component of the program, where States did not have to meet any type of matching requirement. This recommendation has been met as it is clear that the intention of the recent legislation was to simply the FEMA NEHRP State Assistance grant program by mandating the same participation requirements as all other FEMA Non-Disaster grant programs. Eliminating the State Support component of the program not only advances that legislative intent, it furthers our national goals of reducing earthquake risk and the complexity of the program.

FEMA Recommendation 4

If the decade-long trend of underfunding of FEMA earthquake-related activities persists, ACEHR recommends that FEMA review its areas of responsibility, prioritize those efforts that have maximum impact on seismic resilience, and identify efforts that must be discontinued in order to make meaningful and timely progress on the most crucial efforts.

FEMA Response: The process FEMA uses to fund its projects includes an annual review of its current and proposed projects as a first step in the contracting process. In order to make the best use of the limited funding we have under NEHRP, we have terminated previous initiatives where we felt the public was not getting the best return on its investment. This includes the recent decision to only support the Earthquake Direct State Assistance grant program, eliminate the State Support component of our program, and redirect the funding associated with it to the EDSA grant program

A more recent example would be the decision to revise our recent initiative to develop design guidance on the issue of soil-structure interaction from a three year, \$1M project, to a one year, \$300K project in order to free up FY 2020 funding to resume FEMA's work on developing guidance on the seismic protection of the nation's critical lifelines infrastructure.

RECOMMENDATIONS FOR NIST RESEARCH

NIST Recommendation 1

ACEHR recommends that NIST initiate development of nationally-applicable seismic performance objectives, assessment procedures, and design criteria for lifeline systems.

NIST Response: NIST agrees that lifelines are a critical element in modern communities and need comprehensive attention to develop next generation performance objectives, assessment tools and overarching design and performance criteria. Planning to address this issue will require the input of stakeholders including communities, lifeline system operators, codes and standards developers and engineering professionals. The lifeline program requested by ACEHR would require a significant investment of Program funding as well as time to bring this recommendation to realization.

The reallocation of resources to meet the goals of this work, while important and worthwhile, must be carefully considered, planned and weighed against other activities to make a large effort of this kind succeed. In the current budget realities, reallocation of resources to address lifelines will likely require some planned research topics to be delayed or abandoned. Input regarding lifeline systems and the ACEHR perspective on specific aspects of this problem that should be prioritized is requested.

NIST Recommendation 2

ACEHR recommends that NIST assess the seismic performance of buildings in the eastern and central United States that have been designed primarily for code-compliant wind loads.

NIST Response: The performance of Central and Eastern US buildings in a mixed environment of high design wind and moderate to significant seismic risk is of great interest to NIST. A current project is underway to develop the first set of study buildings to address this topic. Work is being conducted by the NIST Earthquake Engineering Group in conjunction with the NIST Community Resilience Center of Excellence. Design is being done by an outside contractor. Evaluation of the performance of these buildings will commence once the initial set of buildings is received from the design team in FY 2020.

NIST Recommendation 3

ACEHR recommends that NIST develop a proof-of-concept initiative to use a building seismic rating system to evaluate the expected performance of a portfolio of building types.

NIST Response: This recommendation will be reevaluated once a workshop on the current state of building rating systems is completed. Further, this topic is dependent on potential strategic plan changes and we look forward to articulation of priorities from ACEHR as input into the decision process.

RECOMMENDATIONS FOR NSF

NSF Recommendation 1

ACEHR recommends that NSF prepare a synthesis report that identifies how current NEHRP-related investments contribute to NEHRP strategic goals and plans.

NSF Response: NSF supports earthquake-related research as an important priority for national welfare and prosperity consistent with the NSF statutory mission, excerpted from “Building the Future: Investing in Discovery and Innovation - NSF Strategic Plan for Fiscal Years (FY) 2018-2022,” NSF 18-045, https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf18045: “The National Science Foundation was established by the NSF Act of 1950 (Public Law 81-507). NSF adopted the purpose of that Act as its mission: *‘to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes.’* This mission has guided NSF’s activities ever since.” “NSF *promotes the progress of science* by investing in research to expand knowledge in science, engineering, and education, and by investing in actions that increase the capacity of the Nation to conduct and exploit science, technology, education, and mathematics research.”

NSF offers a variety of funding opportunities for earthquake-related research that support the NEHRP Strategic Plan, Goal A, Improve Understanding of Earthquake Processes and Impacts; NEHRP Strategic Plan, Goal B, Develop Cost-Effective Measures to Reduce Earthquake Impacts on Individuals, the Built Environment, and Society-at-Large; and NEHRP Strategic Plan, Goal C, Improve the Earthquake Resilience of Communities Nationwide, through: (1) targeted programs for hazard-related and earthquake-related research, and (2) cross-directorate and NSF-wide science and engineering research and education programs that can support earthquake-related research and education. Primary NSF support for NEHRP Strategic Plan, Goal A, Improve Understanding of Earthquake Processes and Impacts, is provided through awards made by research programs in the NSF Directorates for Geosciences (GEO) and Engineering (ENG), and these awards constitute the major contribution of NSF to the NEHRP Strategic Plan. Awards made in these programs also support undergraduate and graduate students and postdoctoral researchers in the conduct of the research, thus also contributing to NEHRP Strategic Plan, Goal C, Objective 14, Develop the Nation’s Human Resource Base in Earthquake Safety Fields.

NEHRP Strategic Plan, Goal A, Objective 1, Advance Understanding of Earthquake Phenomena and Generation Processes

Programs in the NSF GEO Directorate support NEHRP Strategic Plan, Goal A, Objective 1, Advance Understanding of Earthquake Phenomena and Generation Processes. GEO programs include Geophysics, Tectonics, Geodynamic processes at Rifting and Subducting Margins (GeoPRISMS), Frontier Research in Earth Sciences (FRES), and Prediction of and Resilience against Extreme Events (PREEVENTS). These programs support fundamental research to understand the physics of earthquakes, seismic wave propagation phenomena and paleoseismology that help improve earthquake risk assessment, while increasing resilience and reducing the impact of earthquakes on individuals, society, and the economy. The GEO Directorate also supports, along with USGS, the Southern California Earthquake Center (SCEC), which uses seismic, geodetic, and geologic information about Southern California fault systems as a natural laboratory to understand the physics of earthquakes and its effects. SCEC’s mission emphasizes the connections between information gathering, knowledge formulation through physics-based modeling, and public communication of hazard and risk as well as increasing diversity of its scientific workforce.

Programs in the GEO Directorate that support NEHRP Strategic Plan, Goal A, Objective 1, are the following:

- **Geophysics** https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13682: The Geophysics program supports basic research in the physics of the solid earth to explore its composition, structure, and processes from the Earth's surface to its' deepest interior. Laboratory, field, theoretical, and computational studies are supported. Topics include (but are not limited to) seismicity, seismic wave propagation, and the nature and occurrence of geophysical hazards; the Earth's magnetic, gravity, and electrical fields; the Earth's thermal structure; and geodynamics. Supported research also includes geophysical studies of active deformation, including geodesy, and theoretical and experimental studies of the properties and behavior of Earth materials.
- **Tectonics** https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13673: The Tectonics program supports a broad range of field, laboratory, computational, and theoretical investigations aimed at understanding the deformation of the terrestrial continental lithosphere (i.e. above the lithosphere-asthenosphere boundary). The Program focuses on deformation processes and their tectonic drivers that operate at any depth within the continental lithosphere, on time-scales of decades/centuries (e.g., active tectonics) and longer, and at micro- to plate boundary/orogenic belt length-scales.
- **GEOPRISMS** https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13516: The GeoPRISMS program investigates the coupled geodynamics, earth surface processes, and climate interactions that build and modify continental margins over a wide range of timescales. These interactions cross the shoreline and have applications to margin evolution and dynamics, construction of stratigraphic architecture, accumulation of economic resources, and associated geologic hazards and environmental management.
- **Frontier Research in Earth Sciences (FRES)**
https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504833: The FRES program will support research in Earth systems from its core through the critical zone. The project may focus on all or part of the surface, continental lithospheric, and deeper Earth systems over the entire range of temporal and spatial scales. FRES projects will typically have a larger scientific scope and budget than those considered for funding by core programs in the Division of Earth Sciences (EAR). FRES projects may be interdisciplinary studies that do not fit well within the core programs or cannot be routinely managed by sharing between core programs. Innovative proposals within a single area with results that will have broad relevance to Earth Science research are also encouraged. Investigations may employ any combination of field, laboratory, and computational studies with observational, theoretical, or experimental approaches. Projects should be focused on topics that meet the guidelines for research funded by the Division of Earth Sciences.
- **Prediction of and Resilience against Extreme Events (PREEVENTS)**
<https://www.nsf.gov/pubs/2016/nsf16562/nsf16562.htm>: PREEVENTS seeks projects that will (1) enhance understanding of the fundamental processes underlying natural hazards and extreme events on various spatial and temporal scales, as well as the variability inherent in such hazards and events, and (2) improve our capability to model and forecast such hazards and events. **All projects requesting PREEVENTS support must be primarily focused on these two targets.** In addition, PREEVENTS projects will improve our understanding of the effects of natural hazards and extreme events and will enable development, with support by other programs and organizations, of new tools to enhance societal preparedness and resilience against such impacts.

The GEO Directorate also provides support for Earth science research infrastructure, in support of NEHRP Strategic Plan, Goal A, Objective 1:

- **SAGE (Seismological Facility for the Advancement of Geoscience and EarthScope):** SAGE is a distributed, multi-user, national facility for the development, deployment, and operational support of modern digital seismic instrumentation. SAGE promotes advances in our understanding of Earth structure and dynamics, earthquakes and volcanic eruptions, and interactions between the solid Earth, hydrosphere, and atmosphere through management and operation of: 1) Global and regional continuously operating seismic networks, including the Global Seismographic Network (GSN); 2) Portable geophysical instrumentation for use in principal investigator driven and community experiments; 3) Data management systems for the collection, quality assurance, curation, management, and distribution of open access data and data products; and 4) education, workforce development, and public outreach programs designed to be inclusive and enhance participation of traditionally underrepresented groups in the geosciences.
- **GAGE (Geodesy Advancing Geosciences and EarthScope):** GAGE will continue operations of: 1) the Network of the Americas (NOTA), an integrated set of geodetic networks that includes 1600 continuous GPS sites (with ~350 high-rate, low-latency data streams and ~125 surface meteorological sensors), 78 borehole strainmeters and seismometers, and 6 long-baseline laser strainmeters, and tiltmeters on several volcanoes; 2) global engineering and data services primarily to NSF-funded investigators who use terrestrial and satellite geodetic technologies in their research and provision of network operations support to community GPS networks and NASA's Global GNSS Network (GGN); and 3) Education and community outreach activities.

NEHRP Strategic Plan, Goal A, Objective 2, Advance Understanding of Earthquake Effects on the Built Environment, and NEHRP Strategic Plan, Goal A, Objective 3, Advance Understanding of the Social, Behavioral, and Economic Factors Linked to Implementing Risk Reduction and Mitigation Strategies in the Public and Private Sectors

Awards made through funding opportunities in the NSF ENG Directorate support NEHRP Strategic Plan, Goal A, Objective 2, Advance Understanding of Earthquake Effects on the Built Environment, and NEHRP Strategic Plan, Goal A, Objective 3, Advance Understanding of the Social, Behavioral, and Economic Factors Linked to Implementing Risk Reduction and Mitigation Strategies in the Public and Private Sectors. ENG's programs support fundamental research on the understanding and mitigation of the impacts of earthquakes (and other hazards) on the natural environment (e.g., liquefaction and landslides), built environment, humans, and society.

ENG programs supporting NEHRP Strategic Plan, Goal A, Objective 2, are the following:

- **Engineering for Civil Infrastructure (ECI),**
https://nsf.gov/funding/pgm_summ.jsp?pims_id=505488:
The ECI program supports research on the physical infrastructure, such as the soil-foundation-structure-envelope-nonstructural building system, geostructures, and underground facilities, subjected to and interacting with the natural environment under "normal" operating conditions; intermediate stress conditions (such as deterioration, and severe locational and climate conditions); and extreme single or multi natural hazard events (including earthquakes, windstorms, tsunamis, storm surges, sinkholes, subsidence, and landslides). This program, and its predecessors (e.g., Engineering for Natural Hazards and Geotechnical Engineering and Materials) supports (have supported) research on the effects of earthquakes and tsunamis on different structures (e.g., buildings, tunnels) and the natural environment. The ECI program also supports rapid response research (RAPID) grants for

perishable data collection following an earthquake/tsunami, including support for the Geotechnical Extreme Events Reconnaissance (GEER) and Structural Extreme Events Reconnaissance (StEER).

- **Leading Engineering for America's Prosperity, Health, and Infrastructure (LEAP HI)** https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505475: The LEAP HI program challenges the engineering research community to take a leadership role in addressing demanding, urgent, and consequential challenges for advancing America's prosperity, health and infrastructure. LEAP HI proposals confront engineering problems that are too complex to yield to the efforts of a single investigator - problems that require sustained and coordinated effort from interdisciplinary research teams, with goals that are not achievable through a series of smaller, short-term projects. LEAP HI projects perform fundamental research that may lead to disruptive technologies and methods, lay the foundation for new and strengthened industries, enable notable improvements in quality of life, or reimagine and revitalize the built environment.
- **Natural Hazards Engineering Research Infrastructure (NHERI)** <https://www.designsafe-ci.org/>: NHERI is the next generation of NSF support for a multi-user, natural hazards engineering research facility that replaced NEES (George E. Brown, Jr. Network for Earthquake Engineering Simulation) in 2015. NHERI is a distributed, national facility supported by 11 NSF awards that provides the natural hazards engineering community with access to research infrastructure (earthquake and wind engineering experimental facilities, cyberinfrastructure, computational modeling and simulation tools, and research data), coupled with education and community outreach activities. NHERI enables the community to make research and educational advances collaboratively that can contribute knowledge and innovation to prevent natural hazards, including earthquakes, from becoming societal disasters. Along with direct operations and maintenance support for NHERI awardees, NSF provides separate support for research to be conducted at the NHERI experimental facilities through ongoing research and education programs. The support for such activities is provided primarily through the existing ECI research program. NHERI also supports the CONVERGE award, to coordinate post-disaster reconnaissance groups such as GEER, StEER, and SSEER.
- **Gen-4 Engineering Research Centers (ERC)** https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505599: The ERC program supports convergent research that will lead to strong societal impact. Each ERC has interacting foundational components that go beyond the research project, including engineering workforce development at all participant stages, a culture of diversity and inclusion where all participants gain mutual benefit, and value creation within an innovation ecosystem that will outlast the lifetime of the ERC.
- **Industry/University Cooperative Research Centers (IUCRC)** <https://www.nsf.gov/eng/iip/iucrc/home.jsp>: An IUCRC enables industrially-relevant, pre-competitive research via a multi-member, sustained partnership among industry, academe, and government. NSF supports the development and evolution of IUCRCs, providing a financial and procedural framework for membership and operations in addition to best practices learned over decades of fostering public/private partnerships that provide significant value to the nation, industry and university faculty and students.
- **Innovation Corps - National Innovation Network Teams Program (I-Corps)** https://nsf.gov/funding/pgm_summ.jsp?pims_id=504672&org=ENG&from=home: The purpose of the I-Corps Teams program is to identify NSF-funded researchers who will receive additional support in the form of entrepreneurial education, mentoring and funding to accelerate the translation of knowledge derived from fundamental research into emerging products and services that can attract subsequent third-party funding. The outcomes of I-Corps Teams projects will be threefold:

1) a clear go/no go decision based on an assessment of the viability of the overall business model, 2) substantial first-hand evidence for or against product-market fit, with a pithy definition of the customer segments and corresponding value propositions, and 3) a narrative of a compelling technology demonstration for potential partners.

- **Partnerships for Innovation (PFI)**

https://nsf.gov/funding/pgm_summ.jsp?pims_id=504790&org=ENG&from=home: The PFI Program within the Division of Industrial Innovation and Partnerships (IIP) offers researchers from all disciplines of science and engineering funded by NSF the opportunity to perform translational research and technology development, catalyze partnerships and accelerate the transition of discoveries from the laboratory to the marketplace for societal benefit. PFI has five broad goals, as set forth by the American Innovation and Competitiveness Act of 2017 (“the Act”, [S.3084 — 114th Congress; Sec. 602. Translational Research Grants](#)): (1) identifying and supporting NSF-sponsored research and technologies that have the potential for accelerated commercialization; (2) supporting prior or current NSF-sponsored investigators, institutions of higher education, and non-profit organizations that partner with an institution of higher education in undertaking proof-of-concept work, including the development of technology prototypes that are derived from NSF-sponsored research and have potential market value; (3) promoting sustainable partnerships between NSF-funded institutions, industry, and other organizations within academia and the private sector with the purpose of accelerating the transfer of technology; (4) developing multi-disciplinary innovation ecosystems which involve and are responsive to the specific needs of academia and industry; and (5) providing professional development, mentoring, and advice in entrepreneurship, project management, and technology and business development to innovators.

- **Small Business Innovation Research (SBIR) Program**

https://nsf.gov/funding/pgm_summ.jsp?pims_id=505233&org=ENG&from=home: The SBIR program focuses on transforming scientific discovery into products and services with commercial potential and/or societal benefit. Unlike fundamental research, the NSF SBIR program supports startups and small businesses in the creation of innovative, disruptive technologies, getting discoveries out of the lab and into the market. The NSF SBIR Program funds research and development. The program is designed to provide equity-free funding and entrepreneurial support at the earliest stages of company and technology development.

- **Small Business Technology Transfer (STTR) Program**

https://nsf.gov/funding/pgm_summ.jsp?pims_id=505362&org=ENG&from=home: The STTR program focuses on transforming scientific discovery into products and services with commercial potential and/or societal benefit. Unlike fundamental research, the NSF STTR program supports startups and small businesses in the creation of innovative, disruptive technologies, getting discoveries out of the lab and into the market. The STTR Program funds research and development. The program is designed to provide equity-free funding and entrepreneurial support at the earliest stages of company and technology development.

The ENG program supporting NEHRP Strategic Plan, Goal A, Objective 3, is the following:

- **Humans, Disasters, and the Built Environment (HDBE) program**

https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13353: The HDBE program supports fundamental, multidisciplinary research on the interactions between humans and the built environment within and among communities exposed to natural, technological and other types of hazards and disasters, including earthquakes. The program's context is provided by ongoing and

emerging changes in three interwoven elements of a community: its population, its built environment (critical infrastructures, physical and virtual spaces, and buildings and related structures) and the hazards and disasters to which it is exposed. The HDBE program seeks research that integrates these elements and that can contribute to theories that hold over a broad range of scales and conditions. Research funded through this program is expected to inform how communities can cultivate and engage a broad range of physical, social and other resources to ensure improved quality of life for their inhabitants. This program provides support for the Natural Hazards Research Center at the University of Colorado at Boulder. The HDBE program also supports rapid response research (RAPID) grants for perishable data collection following an earthquake/tsunami, including support for the Social Sciences Extreme Events Reconnaissance (SSEER).

NEHRP Strategic Plan, Goal A, Improve Understanding of Earthquake Processes and Impacts; NEHRP Strategic Plan, Goal B, Develop Cost-Effective Measures to Reduce Earthquake Impacts on Individuals, the Built Environment, and Society-at-Large; and/or NEHRP Strategic Plan, Goal C, Improve the Earthquake Resilience of Communities Nationwide

Examples of NSF cross-directorate and NSF-wide funding opportunities that have supported and/or can support earthquake-related research, education, and human resource development in support of the NEHRP Strategic Plan are the following programs listed below (see <https://www.nsf.gov/funding/azindex.jsp> for a full list of NSF funding opportunities A-Z). Depending on the focus of the particular award supported under one of these programs, the award can contribute to NEHRP Strategic Plan, Goal A, Improve Understanding of Earthquake Processes and Impacts; NEHRP Strategic Plan, Goal B, Develop Cost-Effective Measures to Reduce Earthquake Impacts on Individuals, the Built Environment, and Society-at-Large; and/or NEHRP Strategic Plan, Goal C, Improve the Earthquake Resilience of Communities Nationwide:

- **Accelerating Research through International Network-to-Network Collaborations (AccelNet)**
https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505584:
The goals of the AccelNet program are to accelerate the process of scientific discovery and prepare the next generation of U.S. researchers for multiteam international collaborations. The AccelNet program supports strategic linkages among U.S. research networks and complementary networks abroad that will leverage research and educational resources to tackle grand scientific challenges that require significant coordinated international efforts. The program seeks to foster high-impact science and engineering by providing opportunities to create new collaborations and new combinations of resources and ideas among linked global networks.
- **Computational and Data-Enabled Science and Engineering (CDS&E)**
https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504813: Advanced computational infrastructure and the ability to perform large-scale simulations and accumulate massive amounts of data have revolutionized scientific and engineering disciplines. The goal of the CDS&E program is to identify and capitalize on opportunities for major scientific and engineering breakthroughs through new computational and data analysis approaches. The intellectual drivers may be in an individual discipline or they may cut across more than one discipline in various Directorates. The key identifying factor is that the outcome relies on the development, adaptation, and utilization of one or more of the capabilities offered by advancement of both research and infrastructure in computation and data, either through cross-cutting or disciplinary programs.
- **Faculty Early Career Development (CAREER) Program**
https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503214: The CAREER Program is a

Foundation-wide activity that offers the National Science Foundation's most prestigious awards in support of early-career faculty who have the potential to serve as academic role models in research and education and to lead advances in the mission of their department or organization. Activities pursued by early-career faculty should build a firm foundation for a lifetime of leadership in integrating education and research.

- **Growing Convergence Research (GCR) (NSF Big Idea)**

https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505637: The GCR program is identified as one of 10 Big Ideas. Convergence research is a means for solving vexing research problems, in particular, complex problems focusing on societal needs. It entails integrating knowledge, methods, and expertise from different disciplines and forming novel frameworks to catalyze scientific discovery and innovation. GCR identifies [Convergence Research](#) as having two primary characteristics:

- *Research driven by a specific and compelling problem.* Convergence Research is generally inspired by the need to address a specific challenge or opportunity, whether it arises from deep scientific questions or pressing societal needs.
- *Deep integration across disciplines.* As experts from different disciplines pursue common research challenges, their knowledge, theories, methods, data, research communities and languages become increasingly intermingled or integrated. New frameworks, paradigms or even disciplines can form sustained interactions across multiple communities.

- **Harnessing the Data Revolution (HDR) (NSF Big Idea)** <https://www.nsf.gov/cise/harnessingdata/>: The HDR program is a national-scale activity to enable new modes of data-driven discovery that will allow new fundamental questions to be asked and answered at the frontiers of science and engineering. Through this NSF-wide activity, HDR will generate new knowledge and understanding, and accelerate discovery and innovation.

- **Mid-scale Research Infrastructure-1 (Mid-scale RI-1) (NSF Big Idea)**

https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505602: Within Mid-scale RI-1, proposers may submit two types of projects, "Implementation" and "Design". Design and Implementation projects may comprise any combination of equipment, infrastructure, computational hardware and software, and necessary commissioning. Design includes planning (preliminary and final design) of research infrastructure with an anticipated total project cost that is appropriate for future Mid-scale RI-1, Mid-scale RI-2 or MREFC-class investments. Mid-scale RI-1 uses an inclusive definition of implementation, which can include traditional stand-alone construction or acquisition and can include a degree of advanced development leading immediately to final system acquisition and/or construction. Mid-scale RI-1 "Implementation" projects may have a total project cost ranging from \$6 million up to below \$20 million. Projects must directly enable advances in fundamental science, engineering or science, technology, engineering and mathematics (STEM) education research in one or more of the research domains supported by NSF. Implementation projects may support new or upgraded research infrastructure.

- **Mid-scale Research Infrastructure-2 (Mid-scale RI-2) (NSF Big Idea)**

https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505550: Mid-scale RI-2 supports implementation of projects that comprise any combination of equipment, instrumentation, computational hardware and software, and the necessary commissioning and human capital in support of implementation of the same. The total cost for Mid-scale RI-2 projects ranges from \$20 million to below the minimum award funded by the Major Research Equipment and

Facilities Construction (MREFC) Program, currently \$70 million. Mid-scale RI-2 projects will directly enable advances in any of the research domains supported by NSF, including STEM education. Projects may also include upgrades to existing research infrastructure.

- **Research Experiences for Undergraduates (REU)**

https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5517:

The REU program supports active research participation by undergraduate students in any of the areas of research funded by NSF. REU projects involve students in meaningful ways in ongoing research programs or in research projects specifically designed for the REU program. This solicitation features two mechanisms for support of student research: (1) *REU Sites* are based on independent proposals to initiate and conduct projects that engage a number of students in research. REU Sites may be based in a single discipline or academic department or may offer interdisciplinary or multi-department research opportunities with a coherent intellectual theme. Proposals with an international dimension are welcome. (2) *REU Supplements* may be included as a component of proposals for new or renewal NSF grants or cooperative agreements or may be requested for ongoing NSF-funded research projects.

- **Science and Technology Centers (STC): Integrative Partnerships**

https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5541:

The STC program supports exceptionally innovative, complex research and education projects that require large-scale, long-term awards. STCs focus on creating new scientific paradigms, establishing entirely new scientific disciplines and developing transformative technologies which have the potential for broad scientific or societal impact. STCs conduct world-class research through partnerships among institutions of higher education, national laboratories, industrial organizations, other public or private entities, and via international collaborations, as appropriate. They provide a means to undertake potentially groundbreaking investigations at the interfaces of disciplines and/or highly innovative approaches within disciplines. STCs may involve any area of science and engineering that NSF supports. STC investments support the NSF vision of creating and exploiting new concepts in science and engineering and providing global leadership in research and education.

NSF Recommendation 2

ACEHR recommends that NSF work with the NEHRP Secretariat to devise a reporting and information-sharing approach that provides a better basis for coordinating NSF NEHRP-related activities with other NEHRP agency activities.

NSF Response: NSF's information sharing mechanism is its website <https://www.nsf.gov> and its public, searchable databases about its awards and its awardee-submitted project outcomes:

- NSF Award Abstracts <https://www.nsf.gov/awardsearch/>
- NSF Public Access Repository (NSF-PAR) <https://par.nsf.gov/>
- NSF Research Spending and Results, including Project Outcomes Reports: https://www.research.gov/research-portal/appmanager/base/desktop?_nfpb=true&_eventName=viewQuickSearchFormEvent_so_rsr

To coordinate with the other NEHRP agencies, NSF staff regularly share information on funding opportunities and awards through participation in the NEHRP Program Coordination Working Group meetings convened by NIST, as well as during post-earthquake teleconferences organized by USGS. NSF also contributes to the NEHRP Annual Report and other Congressionally-mandated NEHRP activities.

NSF Recommendation 3

ACEHR recommends that NSF fund a workshop or other forum on past and future opportunities for multidisciplinary research initiatives to contribute to the success of NEHRP.

NSF Response: Through federal funding, the several extensive, multidisciplinary research agenda/roadmap documents are already available that can contribute to the success of NEHRP. NSF-supported researchers, as well as members of the NEHRP Advisory Committee for Earthquake Hazards Reduction (ACEHR), have been contributors to and/or committee members for these reports:

- National Research Council. 2011. *National Earthquake Resilience: Research, Implementation, and Outreach*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/13092>.
- National Research Council. 2012. *Disaster Resilience: A National Imperative*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/13457>.

NSF has, and will continue to, support disciplinary and multidisciplinary workshops to establish earthquake-related research agendas, including community needs for research facilities. NSF-supported workshops, including research coordination network (RCN) awards, typically address specific research themes to develop focused research agendas. Examples of recent NSF-supported disciplinary and multidisciplinary research agenda-setting workshops and awards are the following:

- 1) National Research Council. 2011. *Grand Challenges in Earthquake Engineering Research: A Community Workshop Report*. Washington, DC: The National Academies Press (NSF Award 1047519) <https://doi.org/10.17226/13167>
- 2) NHERI Five-Year Science Plan Workshop, March 18-19, 2019 (NSF Award 1612144) <https://www.designsafe-ci.org/facilities/nco/science-plan/>
- 3) NHERI RAPID Facility User Workshop, January 26-27, 2017 (NSF Award 1611820) <https://rapid.designsafe-ci.org/workshops/>
- 4) Natural Hazards Center Workshop, July, annually (NSF Award 1635593) <https://hazards.colorado.edu/workshop/2019>
<https://hazards.colorado.edu/workshop/2018/session-summaries>
- 5) Workshop: Coastal Engineering Research Framework, November 12-13, 2018 (NSF Award 1835563)
- 6) Interdisciplinary Methods and Approaches for Hazards and Disaster Research, February 8-9, 2018 (NSF Awards 1744225 and 1649879)
- 7) Workshop on Methods of Disaster Research: Interdisciplinary Approaches, (NSF Awards 1649879 and 1650202)
- 8) United States-New Zealand-Japan International Workshop on Liquefaction-Induced Ground Movements Effects, November 2-4, 2016 (NSF Award 1640922) https://peer.berkeley.edu/sites/default/files/jonathan-d-bray-ross-w-boulanger-2017_02.pdf
- 9) Additive Manufacturing for Civil Infrastructure Design and Construction, July 13-14, 2018 (NSF Award 1713983) <https://events.tti.tamu.edu/wp-content/uploads/2017/04/nsf-3dp-workshop-report.pdf>
- 10) RCN: Research Network in Hybrid Simulation for Multi-Hazard Engineering (NSF Award 1661621)
- 11) RCN: A Research Coordination Network for the SZ4D Initiative (NSF Award 1828096)
- 12) RCN: Planning for a Modeling Collaboratory for Subduction Zone Science (NSF Award 1824343)
- 13) Annual SCEC Meetings supported through the SCEC5 (Feb 2017-Jan 2022) (NSF Award 1600087)
- 14) Annual meetings to promote earthquake science through SAGE (NSF Award 1851048)
- 15) Workshop: Hazards and Disaster Researchers Meeting: Improving Post-Disaster Rapid Reconnaissance Research; Broomfield, Colorado; July 11-12, 2018 (NSF Award 1833298)

- 16) Resilience of Interdependent Infrastructure Systems: A CRISP/RIPS Grantees Workshop - September 25-26, 2018 - Fairfax/Arlington, VA (NSF Award 1807998)
- 17) Scoping Workshops for Coastlines and People (NSF Award 1844215)
- 18) Workshop on modeling earthquake source processes: from tectonics to dynamic rupture; October 8-10, 2018, Pasadena, CA (NSF Award 1836288)

Outcomes from the NSF-supported Workshop on Methods of Disaster Research: Interdisciplinary Approaches, (NSF Awards 1649879 and 1650202) are a series of articles published in a Special Issue of the Journal *Risk Analysis*, edited by Seth Guikema, University of Michigan, and Lori Peek, University of Colorado, Boulder:

1. Behrendt, Adam, Kathryn Lukasiewicz, Daniel Seaberg, and Jun Zhuang. 2019. "Trends in Multidisciplinary Hazard and Disaster Research: A 1982–2017 Case Study." *Risk Analysis* <https://doi.org/10.1111/risa.13308>
2. Berke, Philip, Steven M. Quiring, Francisco Olivera, and Jennifer A. Horney. 2018. "Addressing Challenges to Building Resilience Through Interdisciplinary Research and Engagement." *Risk Analysis* <https://doi.org/10.1111/risa.13202>
3. Esnard, Ann-Margaret, and Betty Lai. 2018. "Interdisciplinary Approaches to Examining Postdisaster School Recovery." *Risk Analysis* <https://doi.org/10.1111/risa.13137>
4. Ganapati, N. Emel, and Ali Mostafavi. 2018. "Cultivating Metacognition in Each of Us: Thinking About 'Thinking' in Interdisciplinary Disaster Research." *Risk Analysis* <https://doi.org/10.1111/risa.13226>
5. Ge, Yue "Gurt," Christopher W. Zobel, Pamela Murray-Tuite, Roshanak Nateghi, and Haizhong Wang. 2019. "Building an Interdisciplinary Team for Disaster Response Research: A Data-Driven Approach." *Risk Analysis* <https://doi.org/10.1111/risa.13280>
6. Gharaibeh, Nasir, Isaac Oti, Michelle Meyer, Marcus Hendricks, and Shannon Van Zandt. 2019. "Potential of Citizen Science for Enhancing Infrastructure Monitoring Data and Decision-Support Models for Local Communities." *Risk Analysis* <https://doi.org/10.1111/risa.13256>
7. Hardy, R. Dean. 2018. "A Sharing Meanings Approach for Interdisciplinary Hazards Research." *Risk Analysis* <https://doi.org/10.1111/risa.13216>
8. Johnson, David R. 2019. "Integrated Risk Assessment and Management Methods Are Necessary for Effective Implementation of Natural Hazards Policy." *Risk Analysis* <https://doi.org/10.1111/risa.13268>
9. Mitsova, Diana. 2018. "Integrative Interdisciplinary Approaches to Critical Infrastructure Interdependency Analysis." *Risk Analysis* <https://doi.org/10.1111/risa.13129>
10. Morss, Rebecca E., Heather Lazrus, and Julie L. Demuth. 2018. "The 'Inter' Within Interdisciplinary Research: Strategies for Building Integration Across Fields." *Risk Analysis* <https://doi.org/10.1111/risa.13246>
11. Mostafavi, Ali, and N. Emel Ganapati. 2019. "Toward Convergence Disaster Research: Building Integrative Theories Using Simulation." *Risk Analysis* <https://doi.org/10.1111/risa.13303>
12. Reilly, Allison C., Robin L. Dillon, and Seth D. Guikema. 2018. "Agent-Based Models as an Integrating Boundary Object for Interdisciplinary Research." *Risk Analysis* <https://doi.org/10.1111/risa.13134>
13. Sapat, Alka. 2018. "Lost in Translation? Integrating Interdisciplinary Disaster Research with Policy Praxis." *Risk Analysis* <https://doi.org/10.1111/risa.13198>
14. Sherman-Morris, Kathleen, J. Brian Houston, and Jishnu Subedi. 2018. "Theoretical Matters: On the Need for Hazard and Disaster Theory Developed Through Interdisciplinary Research and Collaboration." *Risk Analysis* <https://doi.org/10.1111/risa.13223>

15. Subedi, Jishnu, J. Brian Houston, and Kathleen Sherman-Morris. 2018. “Interdisciplinary Research as an Iterative Process to Build Disaster Systems Knowledge.” *Risk Analysis* <https://doi.org/10.1111/risa.13244>
16. Sutley, Elaina J. 2018. “An Approach for Guiding the Development and Assessing the Interdisciplinarity of New Methodologies for Community Disaster Resilience.” *Risk Analysis* <https://doi.org/10.1111/risa.13253>
17. Tate, Eric, Valerie Decker, and Craig Just. 2018. “Evaluating Collaborative Readiness for Interdisciplinary Flood Research.” *Risk Analysis* <https://doi.org/10.1111/risa.13249>
18. Wong-Parodi, Gabrielle, and Mitchell J. Small. 2019. “A Decision-Centered Method to Evaluate Natural Hazards Decision Aids by Interdisciplinary Research Teams.” *Risk Analysis* <https://doi.org/10.1111/risa.13261>

NSF Recommendation 4

ACEHR recommends that NSF more fully engage NEHRP partner agencies and external organizations to anticipate and foster the translation of research accomplishments into demonstrable advances for earthquake resilience.

NSF Response: NSF’s published policy is for NSF-supported awardees to disseminate and share their research results. From NSF 19-1, Proposal and Award Policies and Procedures Guide (PAPPG), Section XI, D.4 (excerpts below):

“4. Dissemination and Sharing of Research Results

- a. Investigators are expected to promptly prepare and submit for publication, with authorship that accurately reflects the contributions of those involved, all significant findings from work conducted under NSF grants...
- b. Investigators are expected to share with other researchers, at no more than incremental cost and within a reasonable time, the primary data, samples, physical collections and other supporting materials created or gathered in the course of work under NSF grants. Grantees are expected to encourage and facilitate such sharing...
- c. Investigators and grantees are encouraged to share software and inventions created under the grant or otherwise make them or their products widely available and usable.
- d. NSF normally allows grantees to retain principal legal rights to intellectual property developed under NSF grants to provide incentives for development and dissemination of inventions, software and publications that can enhance their usefulness, accessibility and upkeep...
- f. Each NSF grant contains, as part of the grant terms and conditions, an article implementing dissemination and sharing of research results.”

NSF’s information sharing mechanism is the website <https://www.nsf.gov> and its public, searchable databases about its awards and awardee-submitted project outcomes:

- NSF Award Abstracts <https://www.nsf.gov/awardsearch/>
- NSF Public Access Repository (NSF-PAR) <https://par.nsf.gov/>
- NSF Research Spending and Results, including Project Outcomes Reports: https://www.research.gov/research-portal/appmanager/base/desktop?_nfpb=true&_eventName=viewQuickSearchFormEvent_so_rsr

NSF does not support demonstration projects. As discussed above, NSF provides funding opportunities to support translational research and technology development through programs such as:

- Industry/University Cooperative Research Centers
- Small Business Innovation Research Program
- Small Business Technology Transfer Program
- Innovation Corps - National Innovation Network Teams Program (I-Corps)
- Partnerships for Innovation
- Growing Convergence Research

RECOMMENDATIONS FOR USGS

USGS Recommendation 1

ACEHR recommends that the USGS continue to use advisory panels and other community-based forums to target immediate and long-term needs and strategies to meet its obligations under NEHRP.

USGS Response: The USGS intends to continue to use advisory panels such as ACEHR, the Scientific Earthquake Studies Advisory Committee (SESAC), and the National Earthquake Prediction Evaluation Council (NEPEC), and other committees and mechanisms, to gather stakeholder input and inform strategic direction.

USGS Recommendation 2

ACEHR recommends that the USGS continue the development and implementation of the Advanced National Seismic System (ANSS) and that it becomes a line-item in the USGS budget.

USGS Response: The USGS intends to continue to prioritize the development and implementation of the ANSS as described in Circular 1429 published in 2017.

USGS Recommendation 3

ACEHR recommends that the USGS continue to support and develop online products that address community needs for information about earthquake hazards.

USGS Response: The USGS intends to support the current suite of online earthquake products. Recently, a USGS ground-failure product that provides estimates of the extent and severity of landslides and liquefaction has been added along with a product that provides forecasts of aftershock size and frequency. This USGS also recently completed the development of the “2PAGER” product, which links USGS ground shaking information to the FEMA HAZUS database, to provide prompt, quantitative estimate of the impacts and response needs for a damaging earthquake in the U.S.

USGS Recommendation 4

ACEHR recommends that the USGS maintain its strong internal and external research programs, commensurate with the extraordinary developments in data acquisition, and which address critical knowledge gaps.

USGS Response: The USGS intends to maintain the size and scope of its internal and external earthquake research, commensurate with the resources provided to those efforts by Congress.