RISK AND RESILIENCE

$43,150,000
+$2,000,000/ 4.9%

Overview

The economic competiveness and societal well-being of the United States depend on the affordability, availability, quality, and reliability of the infrastructure services provided. These infrastructure services include transportation (road, rail, sea, and air), energy (electricity, gas, oil, and renewable), water, communications and networks (wireless and wired, including the internet), banking and finance, critical manufacturing, food and agriculture, healthcare, and many other components. The increased penetration and use of modern technologies has improved our Nation's productivity and quality of life. These technologies have become deeply embedded into the functioning and the expectations of society, and reliance upon technological infrastructure is truly unprecedented.

Our increasing dependence on infrastructure services has increased the impact of risks that may cause these systems to fail. Risk severity can be understood as the product of the probability of an event and the magnitude of the event's consequences. These risks arise from at least two distinct sources: (a) extreme natural events such as tornadoes, space weather, hurricanes, storms, and earthquakes, and (b) human-induced events such as malicious attacks and mechanical and technological failures. Some predict that extreme weather events and civil unrest will increase in frequency and severity.

It is essential that we work toward improving predictability and risk assessment and increasing resilience in order to reduce the impact of extreme events on our life, society, and economy. NSF is uniquely positioned to support such improvements that require multidisciplinary expertise in science, engineering, and education. NSF is focused on fundamental science and engineering issues such as understanding the dynamic processes that produce extreme events, how people respond to extreme events, and how to engineer resilient infrastructure. The enhanced scientific and engineering knowledge base in these areas will lead to better prediction, improved warning systems, and reduced disruption that will support the missions of other agencies such as the National Oceanic and Atmospheric Administration (NOAA), the Department of Homeland Security (DHS), and the U.S. Geological Survey (USGS). Accordingly, this initiative is seen as complementary, rather than duplicative, to the interests of other agencies. Partnerships with mission agencies are critical to NSF's ability to meet its goal of enabling research results that can be translated into applications that provide societal benefits.

Total Funding for Risk and Resilience

(Dollars in Millions)

FY 2015 Actual	FY 2016 Estimate	FY 2017 Request
$19.34	**$41.15**	**$43.15**

Goals

NSF's goals through this investment are to:

(1) Advance knowledge of risk assessment and predictability through support for improvements in our ability to understand, model, and predict extreme events and natural hazards; and.

(2) Support the creation of tools and technologies for increased resilience, including novel engineered systems solutions for resilient infrastructures, particularly those that leverage the growing infusion of cyber-physical-social components into the infrastructures.

Approach

NSF plans to use the following leadership and governance structure for the Risk and Resilience investment:

- A senior leadership committee composed of assistant directors/office heads to provide long-term strategy and overall guidance;
- Working groups comprised of program officers and division directors, each overseen by assistant directors/office heads who are most relevant to the specific activity, to coordinate programs or activities; and
- Interagency working groups to coordinate interagency activities, as well as arrangements for engagement and collaboration with international partners if needed.

NSF supports basic research in the scientific and engineering disciplines necessary to understand disasters and extreme natural events. A coordinated, interdisciplinary investment in this arena would result in a comprehensive and integrated risk and resilience knowledge base useful for informed decision-making and risk mitigation. An interdisciplinary research effort on risk and resilience systems presents a unique opportunity for NSF to work, within both a national and an international context, toward building a platform for more accurate models and improved predictive capabilities that incorporate relevant social, political, economic, and cultural factors. International partners have considerable expertise and information to offer U.S. researchers in mutually synergistic ways. For example, the NSF Directorate for Computer and Information Science and Engineering (CISE) joint program with the Japan Science and Technology Agency (JST) on Big Data for Disaster Research creates synergies between U.S. and Japanese researchers focused on improving the resilience and responsiveness of emerging computer systems and networks. NSF's Directorate for Engineering (ENG) has longstanding international partnerships in earthquake research programs, providing U.S. researchers access to unique earthquake engineering experimental facilities and opportunities for research collaborations. Advances will be accelerated by similar partnerships with other countries.

NSF is taking a two-pronged approach to meet the goals of the Risk and Resilience investment area as described below.

Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP): Our increasing dependence on infrastructure services has increased the impact of risks that may cause these systems to fail. Furthermore, the impact of deterioration of critical infrastructures becomes amplified since these infrastructures depend on each other for their function. For example, the electrical power system depends on the delivery of fuels for generating stations through transportation services, the production of those fuels depends on the use of electrical power, those fuels are needed by the transportation services, and all of these systems are intertwined with human decision-making. The disruption of electrical power impacts water, emergency services, finance, and government services, among others. All of these services in turn depend on communication and control services provided by cyber-physical infrastructure – including computing, networking, data, and control services provided by complex, multi-scale interdependent systems and software – and cannot function without electricity. This complex set of interdependencies between the components of an interconnected set of critical infrastructures presents significant challenges to conceptualize, understand, model, design, and manage interdependent critical infrastructure systems (ICIs).

The CRISP program is designed to: (1) foster an interdisciplinary research community of engineers, computer and computational scientists, and social and behavioral scientists that will create new approaches and engineering solutions for the design and operation of infrastructure processes and services; (2) enhance the understanding and design of ICIs and processes that provide essential goods and services despite disruptions and failures from any cause--natural, technological, or malicious; (3) create the knowledge for innovation in ICIs so that they safely, securely, and effectively expand the range of goods and services they enable; and (4) improve the effectiveness and efficiency with which ICIs deliver existing goods and services.

Prediction of and Resilience against Extreme EVENTS (PREEVENTS): Natural disasters cause thousands of deaths annually, and, in 2013 alone, they caused over $130 billion in damage worldwide.[1] It is estimated that recovery from Hurricane Sandy will cost over $65 billion, and that the drought of 2012 cost the U.S. economy over $30 billion. A focused research effort, PREEVENTS will help us to better understand and mitigate the risks posed to the U.S. by natural hazards. PREEVENTS will deepen fundamental scientific understanding of natural processes underlying geohazards and extreme events, and will enable improved quantitative models and qualitative research that can enhance societal preparedness and resilience against such events. PREEVENTS will focus on natural hazards and extreme events, and will include the potential for disciplinary and multidisciplinary projects at all scales, especially areas ready for significant near- or medium-term advances.

PREEVENTS is the logical successor to the Hazards SEES program, but with a more GEO-focused perspective. PREEVENTS is designed to (1) enhance understanding of the fundamental processes underlying geohazards and extreme events on various spatial and temporal scales, as well as the variability inherent in such hazards and events; (2) improve models of geohazards, extreme events, and their impacts on natural, social, and economic systems; and (3) develop new tools to enhance societal preparedness and resilience against such impacts. PREEVENTS will focus on natural hazards and extreme events, not purely technological or deliberately or accidentally caused events/processes.

Investment Framework

Risk and Resilience Funding by Directorate
(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request
CISE	$5.50	$6.00	$6.00
ENG	12.00	12.00	14.00
GEO	-	17.75	17.75
MPS	-	0.50	0.50
SBE	1.84	4.90	4.90
Total	**$19.34**	**$41.15**	**$43.15**

Totals may not add due to rounding.

FY 2014 – FY 2016

CRISP: In FY 2014, NSF conducted various planning activities including meetings, presentations, and workgroup formation to identify research areas in Risk and Resilience that NSF is uniquely positioned to support. A pilot competition, titled Resilient Interdependent Infrastructure Processes and Systems (RIPS),[2] jointly supported by the ENG, CISE, and Social, Behavioral, and Economic Sciences (SBE) directorates resulted in submission of 81 projects (156 proposals) that covered a wide range of infrastructures and cyber systems, and ten projects were supported.

In FY 2015, building on RIPS, NSF announced a solicitation for the CRISP program[3] jointly supported by ENG, CISE, and SBE. A total of 90 projects (150 proposals) were submitted. New awards totaling approximately $20.0 million were made in FY 2015 to support research in theory and modeling, as well as

[1] Munich Re (2014). Topics Geo. www.munichre.com/site/corporate/get/documents_E1043212252/mr/assetpool.shared/Documents/5_Touch/_Publications/302-08121_en.pdf

[2] www.nsf.gov/pubs/2014/nsf14524/nsf14524.htm

[3] www.nsf.gov/pubs/2015/nsf15531/nsf15531.htm

major new interdependent infrastructure research using empirical data to conceptualize and study ICIs as processes, services and systems.

In FY 2016, building on strong foundations of core science and engineering programs in CISE, ENG, and SBE, NSF issued a new solicitation for the CRISP program[4] that will continue to catalyze collaborations among researchers across the domains of engineering; computer information and computational science; and the social, behavioral, and economic sciences to create theoretical frameworks and multi-disciplinary models of ICIs.

PREEVENTS: In FY 2015, NSF issued a final solicitation under the Interdisciplinary Research in Hazards and Disasters (Hazards Science, Engineering, and Education for Sustainability (SEES)) program[5] and issued a Dear Colleague Letter (DCL)[6] to announce the upcoming PREEVENTS program, describing general program goals. Research supported by the Hazards SEES program laid the groundwork for PREEVENTS.

The DCL issued in FY 2015 solicited proposals for workshops and Research Coordination Networks (RCN) and relevant funding opportunities with existing GEO programs to be supported in FY 2016. PREEVENTS workshops will foster community development in some disciplinary areas; foster cross-disciplinary communities for problems that need such an approach but are not yet well established; and gather information for use in future PREEVENTS solicitations. RCNs will advance program goals by supporting groups of investigators to share information and ideas; coordinate ongoing or planned research activities; foster synthesis and new collaborations; develop community standards; and in other ways advance science and education through communication and sharing of ideas across disciplinary, organizational, geographic, and international boundaries. These activities will inform a solicitation to be issued in FY 2016.

FY 2017 Request

In FY 2017, NSF will continue the CRISP and PREEVENTS research programs, which will advance our scientific and engineering knowledge base and educate the next generation of scientists and engineers for increasing the resilience of our infrastructures in the face of changing and increasing risks.

CRISP: In FY 2017, NSF will continue support for the CRISP program that will deepen fundamental knowledge and stimulate innovations to improve resilience, interoperations, performance, and readiness in ICIs; to understand organizational, social, psychological, spatial, legal, political, and economic obstacles to improving ICIs, and to identify strategies for overcoming these obstacles; and to understand the role of these advances in the context of increasingly smart and connected communities that are dependent upon the successful operation of ICIs.

PREEVENTS: In FY 2017, NSF will continue to support proposals on the fundamental science behind natural hazards and extreme events, including those that are multidisciplinary or require a collaborative team to address the research or technological challenge.

FY 2018 – FY 2020

In FY 2018 – FY 2020, NSF will continue to support the CRISP program and related research activities to advance knowledge and discoveries in critical interdependent infrastructure systems and processes. NSF will also continue to support PREEVENTS-related research to enhance our understanding of risk and resilience knowledge base useful for informed decision-making and risk mitigation.

[4] www.nsf.gov/pubs/2016/nsf16519/nsf16519.htm
[5] www.nsf.gov/publications/pub_summ.jsp?WT.z_pims_id=504804&ods_key=nsf14581
[6] www.nsf.gov/pubs/2015/nsf15117/nsf15117.jsp

Evaluation Framework

Investments and activities under the Risk and Resilience umbrella will be subject to periodic reviews and assessments. All specific investments will be subject to rigorous peer review using NSF's merit review processes, and under the review of cross-NSF teams, from staff level to program and division director-level to an agency senior management steering committee. As the investment area evolves, decisions will be made regarding changes in emphasis areas, the need to assimilate Risk and Resilience efforts into core programs, and timing for sunsetting of specific investments.

NSF will use lessons learned from large, cross-NSF investment areas (e.g., SEES and NSF Innovation Corps (I-Corps™)) to inform evaluation planning and design for Risk and Resilience. It is anticipated that NSF will have centralized capacity to develop a statement of work for enlisting contractor support.

Evaluation activities include:

- Consulting internally and externally regarding evaluation strategy and methodology;
- Characterizing the initial portfolio, using new NSF portfolio management tools;
- Developing evaluation research questions;
- Analyzing NSF project reports for indications of advancement/growth of research; and
- Collecting and analyzing workforce development metrics.