

Software Infrastructure for Sustained Innovation (SSE, SSI, S2I2)

Software Elements, Frameworks and Institute Conceptualizations

PROGRAM SOLICITATION

NSF 17-526

REPLACES DOCUMENT(S):

NSF 15-553, NSF 16-532



National Science Foundation

Directorate for Computer & Information Science & Engineering
Office of Advanced Cyberinfrastructure
Division of Computing and Communication Foundations
Division of Information & Intelligent Systems
Division of Computer and Network Systems

Directorate for Biological Sciences

Directorate for Education & Human Resources

Directorate for Engineering
Division of Chemical, Bioengineering, Environmental and Transport Systems
Division of Civil, Mechanical and Manufacturing Innovation
Division of Electrical, Communications and Cyber Systems

Directorate for Geosciences

Directorate for Mathematical & Physical Sciences
Division of Astronomical Sciences
Division of Chemistry
Division of Materials Research
Division of Mathematical Sciences
Division of Physics

Directorate for Social, Behavioral & Economic Sciences

Full Proposal Deadline(s) (due by 5 p.m. submitter's local time):

March 07, 2017

SSE Proposals

April 11, 2017

S2I2 Conceptualization Proposals

September 19, 2017

SSI Proposals

IMPORTANT INFORMATION AND REVISION NOTES

Revisions are as follows:

- The Introduction section has been revised to state an interest in proposals that advance the National Strategic Computing Initiative (NSCI).
- The paragraph on additional NSF unit-specific participation information within the section titled Synopsis of the Program has been revised to reflect the current priorities of these units, including, but not limited to, advancing the goals of the NSCI.
- The section on solicitation-specific review criteria has been refined in the interest of greater clarity.
- This solicitation now includes the option to submit S²I² Conceptualization proposals.

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) ([NSF 17-1](#)), which is effective for proposals submitted, or due, on or after January 30, 2017. Please be advised that proposers who opt to submit prior to January 30, 2017, must also follow the guidelines contained in [NSF 17-1](#).

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Software Infrastructure for Sustained Innovation (SSE, SSI, S2I2)

Synopsis of Program:

Software Infrastructure for Sustained Innovation (SI²) is a bold and long-term investment that maintains a sustained focus on realizing the Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21, https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf10015), which envisions a highly reusable and interoperable cyberinfrastructure architecture that integrates large-scale computing, high-speed networks, massive data archives, instruments and major facilities, observatories, experiments, and embedded sensors and actuators, across the nation and the world, to help make great strides towards revolutionizing virtually every science and engineering discipline.

Software is a primary modality through which CIF21 innovation and discovery has been realized. Software permeates all aspects and layers of cyberinfrastructure (from application codes and frameworks, programming systems, libraries and system software, to middleware, operating systems, networking and the low-level drivers), and catalyzes new thinking, paradigms and practices in science and engineering. Software, in fact, is a cyberinfrastructure in itself.

This software cyberinfrastructure requires a robust, agile architecture and a highly usable and reusable service model, one that allows evolution in order to address increasing scale and complexity, accommodate disruptive hardware trends, allow ever-increasing data volumes, complex application structures and workflows, and emerging considerations such as security, reproducibility, fault tolerance and energy efficiency. Additionally, software must support new scientific and engineering frontiers and their computational methodologies. Education is an important element needed to sustain this vision. SI² contributes to an able workforce capable of exploiting the full capability of the cyberinfrastructure and the promise for innovation in science and engineering.

The SI² program focuses on supporting robust, reliable and sustainable software that will support and advance sustained scientific innovation and discovery. Thus, proposals are strongly encouraged to describe their approach to quality software development through a defined software engineering process that includes software testing, the appropriate use of analysis tools and capabilities such as those made available through the Software Assurance Marketplace (SWAMP, <https://continuousassurance.org/>), and collaborations with resources such as Software Carpentry (<http://software-carpentry.org/>) and the Center for Trustworthy Scientific Cyberinfrastructure (CTSC, <http://trustedci.org/>), in order to gain access to expertise where needed, such as in software design and engineering, as well as in cybersecurity.

The Division of Advanced Cyberinfrastructure (CISE/ACI) partners with Directorates and Offices across the Foundation to support SI², a long-term comprehensive program focused on realizing a sustained software infrastructure that is an integral part of CIF21. The goal of this program is to catalyze and nurture the interdisciplinary processes required to support the entire software lifecycle, and result in the development of sustainable community software elements and reusable components at all levels of the software stack. The program addresses all aspects of cyberinfrastructure, from embedded sensor systems and instruments, to desktops and high-end data and computing systems, to major instruments and facilities.

The SI² program aspires to support vibrant partnerships among academia, government, and industry researchers, including international entities, for the development and stewardship of a sustainable software infrastructure that can enhance productivity and accelerate innovation in science and engineering.

For 2017, and in addition to regular SI² proposals, the SI² solicitation welcomes proposals that advance the objectives of the National Strategic Computing Initiative (NSCI), an effort aimed at sustaining and enhancing the U.S. scientific, technological, and economic leadership position in high-performance computing (HPC) research, development, and deployment. Information about the NSCI together with the strategic plans, results of community workshops, background studies and other relevant resources, which suggest priority areas in both the domain sciences and the HPC and software infrastructure, are available at <https://www.nsf.gov/nscli/>. Proposers are encouraged to review these materials for priority areas identified by the research community.

As in previous rounds of this program, SI² includes three classes of awards:

1. **Scientific Software Elements (SSE):** SSE awards target small groups that will create and deploy robust software elements for which there is a demonstrated need that will advance one or more significant areas of science and engineering.
2. **Scientific Software Integration (SSI):** SSI awards target larger, interdisciplinary teams organized around the development and application of common software infrastructure aimed at solving common research problems faced by NSF researchers in one or more areas of science and engineering. SSI awards will result in a sustainable community software framework serving a diverse community or communities.
3. **Scientific Software Innovation Institutes (S²I²):** S²I² awards are intended to establish long-term hubs of

excellence in software infrastructure and technologies, which will serve a research community of substantial size and disciplinary breadth. S²I² includes two subclasses of awards: *Conceptualization Awards*, which are planning awards aimed at organizing an interdisciplinary community and understanding their software requirements and challenges; and *Implementation Awards*, which will be made to implement community activities that support software infrastructure, for example, such as those developed by the conceptualization awards. **Only Conceptualization proposals will be accepted for this solicitation cycle.** However, successful Conceptualization proposals must reflect the quality, commitment, and planning that will be needed to lead to full Implementation awards. Conceptualization proposals submitted to NSF in response to this solicitation must exhibit clear relevance to the overall S²I² program and should be responsive to this solicitation and its review criteria. Proposals that are not relevant or not responsive to the solicitation will not be considered for funding and will be returned without review. Conceptualization proposals must also be in areas not covered by current Conceptualization and Implementation awards. For a list of awards, see Implementation of NSF Software Vision (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504817).

The S²I² program recently launched its first two Software Institutes (https://www.nsf.gov/news/news_summ.jsp?preview=y&cntn_id=189347). The Science Gateways Software Institute (<http://www.sciencegateways.org>) and the Molecular Science Software Institute (<http://molssi.org>) will serve as long-term hubs of excellence and community engagement in the areas of building effective science gateways and in advancing discoveries in molecular science and materials through the use of advanced software tools. Proposals of all types should seek to leverage these Institutes, where appropriate.

Please refer to (i) A Vision and Strategy for Software for Science, Engineering, and Education (NSF 12-113) and (ii) Implementation of NSF Software Vision (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504817) for further information about NSF's vision for software as part of cyberinfrastructure and the programs that support this vision.

Prospective Principal Investigators (PIs) should be aware that S²I² is a multi-directorate activity and that they are encouraged to submit proposals for software with broad, interdisciplinary interest. PIs are encouraged to refer to core program descriptions, Dear Colleague Letters, and recently posted initiatives on directorate and divisional home pages to gain insight about the priorities for the relevant areas of science and engineering to which their proposal may be responsive.

As not all divisions are participating at the same level and division priorities differ, it is strongly recommended that prospective PIs contact program officer(s) from the list of Cognizant Program Officers in the division(s) that typically support the scientists and engineers who would make use of the proposed work, to ascertain that the scientific focus and budget of the proposed work are appropriate for this solicitation. Please note that some NSF directorates have additional specific information about their participation in this program, as follows:

- Within the Directorate for Computer & Information Science & Engineering (CISE)
 - The Division of Advanced Cyberinfrastructure (ACI) manages the S²I² program, and is especially interested in proposals that:
 - Seek to develop, deploy and sustain foundational infrastructure components, and multidisciplinary and omni-disciplinary computational tools and components.
 - Advance the objectives of the NSCI, particularly objectives 2 and 4, by situating the above-referenced tools and components within an ecosystem architecture that is positioned for future advancements in science and engineering;
 - Meaningfully leverage or complement other community cyberinfrastructure (CI) projects - such as the eXtreme Digital (XD) project (<http://xsede.org>) - and projects funded under NSF programs such as Campus Cyberinfrastructure - Data, Networking, and Innovation (CC²DNI), and Cyber-security Innovation for Cyberinfrastructure (CICI) and prior programs such as Data Infrastructure Building Blocks (DIBBs) – and build on existing community CI services and software, to enable new science and engineering not previously possible; and
 - Contain innovation and empirical research as an integral component of the project. Such research might encompass reproducibility, provenance, effectiveness, usability, and adoption of the software, its adaptability to new technologies and to changing requirements, and the software development lifecycle processes used in the project;
 - The Divisions of Computing and Communication Foundations (CCF), Computer and Network Systems (CNS), and Information and Intelligent Systems (IIS) are interested in supporting SSE and SSI proposals that advance software infrastructure to sustain and advance progress in CISE research areas; integrate CISE research areas (e.g., programming languages and high-performance computing) into new cyberinfrastructure; or advance and adapt software engineering research to impact the software sustainability needs of scientific disciplines.
- The Directorate for Biological Sciences (BIO) is primarily interested in the S²I² program as a means to collaborate with other NSF directorates to support proposals that impact a multi-disciplinary community that includes BIO-supported researchers. PIs wishing to submit software development projects that focus primarily on biological sciences should submit to Advances in Biological Informatics (ABI; NSF 15-582).
- The Directorate for Education and Human Resources (EHR) is interested in proposals that focus on innovative software infrastructure that supports the directorate's research areas, namely STEM learning and learning environments, STEM workforce development, and broadening participation in STEM. For example, EHR is interested in research studies on how software tools foster STEM learning.
- The Directorate for Engineering (ENG) is primarily interested in proposals that focus on innovative computational tools that enable advances and scientific discovery in the research areas supported by its divisions of Chemical, Bioengineering, Environmental, and Transport Systems (CBET), Civil, Mechanical and Manufacturing Innovation (CMMI), and Electrical, Communications and Cyber Systems (ECCS). SSE proposals that are planned to become part of larger SSI-type integrated software systems, leading to increased community involvement, will be given priority in SSE funding decisions.

The Directorate for Geosciences (GEO) is interested in software development projects that serve the academic geosciences (atmospheric, geospatial, ocean, earth and polar sciences). Projects must demonstrate strong connections with geosciences end-users and their research needs. Understanding of and integration with GEO and/or NSF investments in cyberinfrastructure, participation in EarthCube and interaction between geo- and cyber/computer scientists will be considered in prioritizing funding of SSI and SSE projects. PIs should contact and consult with both the SI² GEO Program Officer as well as Program Officers in the relevant geosciences domains.

- Within the Directorate for Mathematics and Physical Sciences (MPS):
 - The Division of Astronomical Sciences (AST) is interested in proposals to support the development and dissemination of sustainable software that enables progress on key questions in astronomy and astrophysics.
 - The Division of Chemistry (CHE) encourages proposals that focus on innovative software tools that enable advances in the division's research areas and at the interface of chemistry and other research domains, including software to enable scientific advances in NSF priority areas. This division encourages the development of software tools that support multiscale modeling of multiple and diverse interactions in complex chemical networks. It also encourages software that enables data-driven discovery in molecular science.
 - The Division of Materials Research (DMR) encourages proposals that focus on innovative software tools that enable advances in the division's research areas and at the interfaces of materials research with other research domains. The division is particularly interested in projects that develop software tools to enable and support research under the Materials Genome Initiative, such as Designing Materials to Revolutionize and Engineer our Future (DMREF; NSF 16-613), and under Sustainable Chemistry, Engineering, and Materials (SusChEM; NSF 16-093).
 - The Division of Mathematical Sciences (DMS) welcomes proposals building computational tools that have broad application in mathematical sciences and related areas.
 - The Division of Physics (PHY) will consider proposals that focus on innovative computational tools that enable advances in the division's research areas.
 - MPS also supports education and community development in cyberinfrastructure, for example, through proposals that include visitor support (particularly for graduate students and postdoctoral researchers), postdoctoral opportunities, or short training courses that increase interactions of domain scientists and software and/or cyberinfrastructure specialists.
- The Directorate for Social, Behavioral & Economic Sciences (SBE) is interested in proposals that focus on innovative software infrastructure that supports the directorate's research priorities, such as those outlined in SBE 2020 (https://www.nsf.gov/sbe/sbe_2020/). In particular, SBE is interested in proposals that will further the goals of SBE and at least one of the other directorates participating in this solicitation.

Cognizant Program Officer(s):

Please note that the following information is current at the time of publishing. See program website for any updates to the points of contact.

- Rajiv Ramnath, Program Director, CISE/ACI, telephone: (703) 292-4776, email: SI2Queries@nsf.gov
- Vipin Chaudhary, Program Director, CISE/ACI, telephone: (703) 292-2254, email: SI2Queries@nsf.gov
- Peter H. McCartney, Program Director, BIO/DBI, telephone: (703) 292-8470, email: SI2Queries@nsf.gov
- Almadena Y. Chtchelkanova, Program Director, CISE/CCF, telephone: (703) 292-8910, email: SI2Queries@nsf.gov
- Sol Greenspan, Program Director, CISE/CCF, telephone: (703) 292-8910, email: SI2Queries@nsf.gov
- John C. Cherniavsky, Senior Advisor, EHR, telephone: (703) 292-5136, email: SI2Queries@nsf.gov
- Eva Zanterkia, Program Director, GEO/EAR, telephone: (703) 292-4734, email: SI2Queries@nsf.gov
- Nigel A. Sharp, Program Director, MPS/AST, telephone: (703) 292-4905, email: SI2Queries@nsf.gov
- Evelyn Goldfield, MPS/CHE, telephone: (703) 292-2173, email: SI2Queries@nsf.gov
- Daryl W. Hess, Program Director, MPS/DMR, telephone: (703) 292-4942, email: SI2Queries@nsf.gov
- Christopher W. Stark, Program Director, MPS/DMS, telephone: (703) 292-4869, email: SI2Queries@nsf.gov
- Yong Zeng, Program Director, MPS/DMS, telephone: (703) 292-2301, email: SI2Queries@nsf.gov
- Bogdan Mihaila, Program Director, MPS/PHY, telephone: (703) 292-8235, email: SI2Queries@nsf.gov
- Ronald Joslin, Program Director, ENG/CBET, telephone: (703) 292-7030, email: SI2Queries@nsf.gov
- Joanne D. Culbertson, Program Director, ENG/CMMI, telephone: (703) 292-4602, email: SI2Queries@nsf.gov
- Hao Ling, Program Director, ENG/ECCS, telephone: (703) 292-2210, email: SI2Queries@nsf.gov
- Cheryl L. Eavey, SBE/SES, telephone: (703) 292-7269, email: SI2Queries@nsf.gov

Applicable Catalog of Federal Domestic Assistance (CFDA) Number(s):

- 47.041 --- Engineering
- 47.049 --- Mathematical and Physical Sciences
- 47.050 --- Geosciences

- 47.070 --- Computer and Information Science and Engineering
- 47.074 --- Biological Sciences
- 47.075 --- Social Behavioral and Economic Sciences
- 47.076 --- Education and Human Resources
- 47.079 --- Office of International Science and Engineering
- 47.083 --- Office of Integrative Activities (OIA)

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 23

The number of SSE and SSI awards will be determined by separate review processes and will be based on quality of proposals, availability of funds, and responsiveness to priorities of the participating directorates/divisions. Up to 10 SSE awards, 12 SSI awards and 3 S²I² Conceptualization are estimated, subject to the availability of funds.

Anticipated Funding Amount: \$17,500,000

Estimated program budget, number of awards and average award size/duration are subject to the availability of funds. Up to \$5,000,000 is expected to be available for SSE awards, up to \$11,000,000 is expected to be available for awards to SSI proposals, and up to \$1,500,000 is expected to be available for S²I² Conceptualization awards, subject to availability of funds.

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Universities and Colleges - Universities and two- and four-year colleges (including community colleges) accredited in, and having a campus located in, the US acting on behalf of their faculty members. Such organizations also are referred to as academic institutions.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.
- Federally funded research and development centers (FFRDCs) may not receive funds directly from NSF under this solicitation.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits for SSE and SSI proposals.

Each organization may only submit one S²I² Conceptualization proposal within the calendar year.

Limit on Number of Proposals per PI or Co-PI:

An individual may participate as PI, co-PI or other Senior Personnel in at most one full proposal in the pair of SSE and SSI competitions that occurs in a given calendar year. Thus, an individual may not participate on more than one SSE or SSI proposal, or on an SSI proposal that follows an SSE proposal on which the individual is participating. Any individual whose biographical sketch is provided as part of the proposal will be considered as Senior Personnel in the proposed activity, with or without financial support from the project. In the event that an individual exceeds this limit, any proposal submitted to this solicitation with this individual listed as PI, co-PI, or Senior Personnel after the first proposal is received at NSF will be returned without review. No exceptions will be made. For this purpose, a multi-institution collaborative project is treated as one proposal that is considered submitted when the last component proposal is submitted.

There is no limit on the number of S²I² Conceptualization proposals per PI, though there is a limit of one S²I² Conceptualization proposal per institution per calendar year.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Not required
- **Preliminary Proposal Submission:** Not required
- **Full Proposals:**
 - Full Proposals submitted via FastLane: *NSF Proposal and Award Policies and Procedures Guide (PAPPG)* guidelines

apply. The complete text of the PAPPG is available electronically on the NSF website at:

https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.

- o Full Proposals submitted via Grants.gov: *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov* guidelines apply (Note: The *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide).

B. Budgetary Information

- **Cost Sharing Requirements:**

Inclusion of voluntary committed cost sharing is prohibited.

- **Indirect Cost (F&A) Limitations:**

Not Applicable

- **Other Budgetary Limitations:**

Not Applicable

C. Due Dates

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

March 07, 2017

SSE Proposals

April 11, 2017

S2I2 Conceptualization Proposals

September 19, 2017

SSI Proposals

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria. Additional merit review considerations apply. Please see the full text of this solicitation for further information.

Award Administration Information

Award Conditions:

Additional award conditions apply. Please see the full text of this solicitation for further information.

Reporting Requirements:

Standard NSF reporting requirements apply.

TABLE OF CONTENTS

Summary of Program Requirements

I. Introduction

II. Program Description

III. Award Information

IV. Eligibility Information

V. Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

B. Budgetary Information

C. Due Dates

D. FastLane/Grants.gov Requirements

- VI. **NSF Proposal Processing and Review Procedures**
 - A. Merit Review Principles and Criteria
 - B. Review and Selection Process
- VII. **Award Administration Information**
 - A. Notification of the Award
 - B. Award Conditions
 - C. Reporting Requirements
- VIII. **Agency Contacts**
- IX. **Other Information**

I. INTRODUCTION

Software Infrastructure for Sustained Innovation (SI²) is a bold and long-term investment that maintains a sustained focus on realizing the Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21, https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf10015), which envisions a highly reusable and interoperable cyberinfrastructure architecture that integrates large-scale computing, high-speed networks, massive data archives, instruments and major facilities, observatories, experiments, and embedded sensors and actuators, across the nation and the world, to help make great strides towards revolutionizing virtually every science and engineering discipline.

Software is a primary modality through which CIF21 innovation and discovery has been realized. Software permeates all aspects and layers of cyberinfrastructure (from application codes and frameworks, programming systems, libraries and system software, to middleware, operating systems, networking and the low-level drivers), and catalyzes new thinking, paradigms and practices in science and engineering. Software, in fact, is a cyberinfrastructure in itself.

This software cyberinfrastructure requires a robust, agile architecture and a highly usable and reusable service model, one that allows evolution in order to address increasing scale and complexity, accommodate disruptive hardware trends, allow ever-increasing data volumes, complex application structures and workflows, and emerging considerations such as security, reproducibility, fault tolerance and energy efficiency. Additionally, software must support new scientific and engineering frontiers and their computational methodologies. Education is an important element needed to sustain this vision. SI² contributes to an able workforce capable of exploiting the full capability of the cyberinfrastructure and the promise for innovation in science and engineering.

The SI² program focuses on supporting robust, reliable and sustainable software that will support and advance sustained scientific innovation and discovery. Thus, proposals are strongly encouraged to describe their approach to quality software development through a defined software engineering process that includes software testing, consider the use of analysis tools and capabilities such as those made available through the Software Assurance Marketplace (SWAMP, <https://continuousassurance.org/>), and include collaborations with resources such as Software Carpentry (<http://software-carpentry.org/>) and the Center for Trustworthy Scientific Cyberinfrastructure (CTSC, <http://trustedci.org/>), in order to gain access to expertise where needed, such as in software design and engineering, as well as in cybersecurity.

The Division of Advanced Cyberinfrastructure (CISE/ACI) partners with Directorates and Offices across the Foundation to support SI², a long-term comprehensive program focused on realizing a sustained software infrastructure that is an integral part of CIF21. The goal of this program is to catalyze and nurture the interdisciplinary processes required to support the entire software lifecycle, and result in the development of sustainable community software elements and reusable components at all levels of the software stack. The program addresses all aspects of cyberinfrastructure, from embedded sensor systems and instruments, to desktops and high-end data and computing systems, to major instruments and facilities.

The SI² program aspires to support vibrant partnerships among academia, government, and industry researchers, including international entities, for the development and stewardship of a sustainable software infrastructure that can enhance productivity and accelerate innovation in science and engineering.

For 2017, and in addition to regular SI² proposals, the SI² solicitation welcomes proposals that advance the objectives of the National Strategic Computing Initiative (NSCI), an effort aimed at sustaining and enhancing the U.S. scientific, technological, and economic leadership position in HPC research, development, and deployment. Information about the NSCI together with the strategic plans, results of community workshops, background studies and other relevant resources, which suggest priority areas in both the domain sciences and the High Performance Computing (HPC) and software infrastructure, are available at <https://www.nsf.gov/nscli>. Proposers are encouraged to review these materials for priority areas identified by the research community.

II. PROGRAM DESCRIPTION

The goal of the SI² program is to create a software ecosystem that scales from individual or small groups of software innovators to large hubs of software excellence. The program includes three classes of awards:

1. Scientific Software Elements (SSE)

2. Scientific Software Integration (SSI)
3. Scientific Software Innovation Institutes (S²I²)

This solicitation includes SSE and SSI classes of awards and S²I² Conceptualization awards only.

The S²I² program envisions an integrated software infrastructure composed of interlocking projects of the above three classes. Specifically, SSE awardees are expected to develop meaningful affiliations with one or more SSI groups and with S²I² institutes as they come online in future years. Similarly, it is expected that each SSE or SSI group will affiliate with one or more S²I² institutes as they come online. S²I² institutes are expected to link with each other as well as with other major elements of the national cyberinfrastructure.

A competitive S²I² proposal will:

- Describe application areas in science or engineering where the identified software is needed and describe how the use of the identified software will have a significant impact on science and engineering research;
- Describe the targeted user communities of the proposed software and how they will be engaged; and
- Provide a compelling discussion of the software's potential use by a wider audience and its contribution to a national cyberinfrastructure.

Scientific Software Elements (SSE): SSE awards target small groups that will create and deploy robust software elements for which there is a demonstrated need that will advance one or more significant areas of science and engineering. It is expected that the created software elements will be designed so as to demonstrate potential for addressing issues of sustainability, manageability, usability and interoperability, and will be disseminated into the community as reusable software resources. The development approach may support the hardening of early prototypes and/or expanding functionality to increase end-user relevance.

Scientific Software Integration (SSI): SSI awards target larger, interdisciplinary teams organized around the development and application of common software infrastructure aimed at solving common research problems faced by NSF researchers in one or more areas of science and engineering. SSI awards will result in a sustainable community software framework serving a diverse community or communities. These awards will focus on software architectures, processes that explicitly address issues of sustainability, manageability, usability, composability, and interoperability, as well as environments (e.g., code repository, build and test framework, reporting mechanisms, etc.) that are meaningful for the targeted science community. Well-reasoned dissemination and outreach mechanisms, pathways for integration of community software elements (such as those developed by SSE teams) into the developed framework, as well as support structures, will be an integral part of these awards. When appropriate, collaborations with industry and government entities, as well as partnering with international efforts are encouraged. Some SSI awards are anticipated to be continuing grants, and funds will be released annually subject to agreed-upon milestones, and based on approval by NSF and the availability of funds.

Scientific Software Innovation Institutes (S²I²) will focus on the establishment of long-term hubs of excellence in software infrastructure and technologies, which will serve a research community of substantial size and disciplinary breadth. It is expected that outcomes of S²I² go beyond the software itself and also include the infrastructure and process by which software is developed and sustained in response to, and to successfully enable, transformative new science. These institutes will provide expertise, processes and architectures, resources, and implementation mechanism to transform computational science and engineering innovations and community software into robust and sustained software infrastructure for enabling science and engineering, which in turn will transform research practices and productivity. S²I² proposals are expected to bring together interdisciplinary teams of scientists, engineers, and educators along with software engineers and technologists. An S²I² proposal must describe the vision and rationale for the proposed institute as a multi-faceted enterprise with credible connections to the community it serves. The proposal must make a compelling case for the institute's need and scope, and state its anticipated impact on the target communities. Furthermore, in addition to innovating in the domain (or domains) as well as the computational and computer science aspects of the software, the proposals must also focus on the required processes and services necessary to support the community. The institutes will provide necessary structures and mechanisms for support, outreach, and workforce development, with a proactive approach to diversity, and will stimulate interaction between all stakeholders through various means including the definition of joint research directions, community standards and models, and collaborative development activities. The institutes will also provide pathways for community involvement, enabling software elements developed within the community to be transitioned to conform to community software frameworks, standards and processes, and to be made accessible, usable and extendible by the community. Institutes are encouraged to leverage existing infrastructure investments. Where appropriate, engagement with industry and government entities as well as partnering with international efforts are encouraged. Proposals should identify a clear set of near-, mid-, and long-term goals, and should describe how the project will organize itself to accomplish those goals. Finally, and very importantly, proposals should include a model for longer-term sustainability of the institute after NSF-funding has ended.

S²I² awards are subdivided into Conceptualization and Implementation awards which are described below.

(a) Conceptualization Awards: S²I² Conceptualization Awards are planning awards aimed at organizing an interdisciplinary community and understanding its software requirements and challenges. Example activities that may be undertaken as part of a Conceptualization Award include focused workshops, special sessions at professional meetings, sandpits, focus groups, etc. These awards will typically be 1 year in duration. The product of a Conceptualization Award will be a strategic plan for enabling science and education through a sustained software infrastructure that will be freely available to the community, and will address the following elements:

- the science community and the specific grand challenge research questions that the S²I² will support;
- specific software elements and frameworks that are relevant to the community, the sustainability challenges that need to be addressed, and why addressing these challenges will be transformative;
- appropriate software architectures and lifecycle processes, development, testing and deployment methodologies, validation and verification processes, end usability and interface considerations, and required infrastructure and technologies;
- the required organizational, personnel and management structures and operational processes;
- the requirements and necessary mechanisms for human resource development, including integration of education and

- training, mentoring of students, postdoctoral fellows as well as software professionals, and proactively addressing diversity and broadening participation;
- potential approaches for long-term sustainability of the software institute as well as the software; and
 - potential risks including risks associated with establishment and execution, necessary infrastructure and associated technologies, community engagement, and long-term sustainability.

The strategic plan resulting from the conceptualization phase is expected to serve as the conceptual design upon which a subsequent S²I² Implementation proposal could be based.

Note that Conceptualization proposals will only be encouraged when NSF funding is available. Thus PIs are encouraged to contact relevant NSF program officers before submitting such proposals.

(b) S²I² Implementation Awards: While this solicitation cycle does not include S²I² Implementation proposals, these awards are described here for completeness. S²I² Implementation Awards aim to implement community strategic plans, such as those outlined in conceptualization phase described above. Proposals for Implementation Awards will only be considered in response to specific areas that are explicitly identified by NSF. The size of these awards as well as the structure of the institute will be based, in part, on the targeted community and its needs. Awards are expected to be cooperative agreements between NSF and the awardee(s), and funds will be released annually subject to agreed-to milestones, annual project reviews (starting 18 months after a given project begins), and based on approval by NSF and the availability of funds.

The SI² program recently launched its first two software institutes (https://www.nsf.gov/news/news_summ.jsp?preview=y&cntn_id=189347). The Science Gateways Software Institute (<https://www.sciencegateways.org>) and the Molecular Science Software Institute (<https://molssi.org>) will serve as long-term hubs of excellence and community engagement in the areas of building effective science gateways and in advancing discoveries in molecular science and materials through the use of advanced software tools. Proposals of all types should seek to leverage these Institutes, where appropriate.

Industry and International Participation in SI²: NSF encourages participation by industry and international collaborators in all classes of SI² awards where it clearly strengthens the proposed activity (e.g., involvement of specific and unique expertise or resources or addressing sustainability).

International participants are encouraged to seek support from their funding organizations. NSF funds may not be used to support the expenses of international researchers at their home institution. However, NSF funds may be used for travel expenses for US scientists and students in exchange integral to the project, or for international collaborators to participate in activities in the US. For those who plan to submit a proposal with international counterparts, please contact the Office of International Science and Engineering (OISE) program officer who covers that country (see <https://www.nsf.gov/od/oise/country-list.jsp>).

The SI² program recognizes that software is a fundamental infrastructure that spans academic, government, civic, and commercial organizations. The program encourages proposals to explore novel partnerships beyond academe wherever beneficial and permissible within the guidelines of the NSF Proposal and Award Policies and Procedures Guide (PAPPG; [NSF 17-1](#)).

III. AWARD INFORMATION

Estimated program budget, number of awards and average award size/duration are subject to the availability of funds.

An SSE award shall not exceed a total of \$500,000 and a duration of 3 years. SSI awards shall range from \$200,000 to \$1,000,000 per year, and shall be 3 to 5 years in duration. Projects in the upper portion of this range must be exceptional in terms of scientific impact, and as with all proposals, should be discussed with program officers from the divisions that fund the researchers that would be impacted. Proposed funding amounts should be commensurate with the work being proposed, the size of the community that will be affected, and the level of impact anticipated. Note that SSE and SSI are not categories of funding, but rather, are types of projects, as described elsewhere in this solicitation.

The number of SSE and SSI awards will be determined by separate review processes and will be based on the proposals submitted and the availability of funds.

The actual number of S²I² Conceptualization awards may vary based on the quality of proposals, responsiveness to the solicitation, and availability of funds. Note that funded conceptualization awards may lead to full implementation awards in the future, but that the number of full implementation awards will be smaller than the number of conceptualization awards. Up to 3 S²I² Conceptualization awards (each up to \$500,000) may be funded in FY 2017, totaling \$1,500,000.

It is expected that a significant number of the awards made through this solicitation will be to projects that are strongly aligned with the National Strategic Computing Initiative.

It is strongly recommended that prospective PIs contact a program officer from the list of Cognizant Program Officers in the division(s) closest to the major disciplinary impact of the proposed work to ascertain that the scientific and engineering focus and budget of the proposed work are appropriate for this solicitation.

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Universities and Colleges - Universities and two- and four-year colleges (including community colleges) accredited in, and having a campus located in, the US acting on behalf of their faculty members. Such organizations also are referred to as academic institutions.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.
- Federally funded research and development centers (FFRDCs) may not receive funds directly from NSF under this solicitation.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits for SSE and SSI proposals.

Each organization may only submit one S²I² Conceptualization proposal within the calendar year.

Limit on Number of Proposals per PI or Co-PI:

An individual may participate as PI, co-PI or other Senior Personnel in at most one full proposal in the pair of SSE and SSI competitions that occurs in a given calendar year. Thus, an individual may not participate on more than one SSE or SSI proposal, or on an SSI proposal that follows an SSE proposal on which the individual is participating. Any individual whose biographical sketch is provided as part of the proposal will be considered as Senior Personnel in the proposed activity, with or without financial support from the project. In the event that an individual exceeds this limit, any proposal submitted to this solicitation with this individual listed as PI, co-PI, or Senior Personnel after the first proposal is received at NSF will be returned without review. No exceptions will be made. For this purpose, a multi-institution collaborative project is treated as one proposal that is considered submitted when the last component proposal is submitted.

There is no limit on the number of S²I² Conceptualization proposals per PI, though there is a limit of one S²I² Conceptualization proposal per institution per calendar year.

Additional Eligibility Info:

None.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Full Proposal Preparation Instructions: Proposers may opt to submit proposals in response to this Program Solicitation via Grants.gov or via the NSF FastLane system.

- Full proposals submitted via FastLane: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg. Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.
- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov*. The complete text of the *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the Download Package button. Paper copies of the Grants.gov Application Guide also may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

In determining which method to utilize in the electronic preparation and submission of the proposal, please note the following:

Collaborative Proposals. All collaborative proposals submitted as separate submissions from multiple organizations must be submitted via the NSF FastLane system. PAPPG Chapter II.D.3 provides additional information on collaborative proposals.

See PAPPG Chapter II.C.2 for guidance on the required sections of a full research proposal submitted to NSF. Please note that the proposal preparation instructions provided in this program solicitation may deviate from the PAPPG instructions.

The following provides additional guidance beyond that contained in the PAPPG or NSF Grants.gov Application Guide.

Cover Sheet: Provide a short informative title for the proposed SI² project. To assist NSF staff in sorting proposals for review, proposal titles should begin with "SI2-SSE:", "SI2-SSI:" or "SI2-S²I² Conceptualization:". The system allows one PI and at most four co-PIs to be designated for each proposal. Proposals for all three classes (SSE, SSI and S²I²Conceptualization) that are to be considered as responsive to the NSCI should prefix their title with "NSCI" (followed by "SI2-SSE", "SI2-SSI" or "SI2-S²I² Conceptualization", as appropriate).

If your project involves international partners, check the international activities box and list the countries involved. If needed, additional lead personnel should be designated as non-co-PI Senior Personnel on the Budget form.

Project Summary (1-page limit):

The Project Summary consists of an overview, a statement on the intellectual merit of the proposed activity, and a statement on the broader impacts of the proposed activity.

The overview includes a summary description of the SI² project, the innovative software infrastructure being proposed, its research and education goals, and the community (communities) that will be impacted. The statement on intellectual merit should describe the potential of the proposed software to advance knowledge. The statement on broader impacts should describe the potential of the proposed activity to benefit society and contribute to the achievement of specific, desired societal outcomes. The Project Summary should be written in the third person, informative to other persons working in the same or related fields, and, insofar as possible, understandable to a scientifically or technically-literate lay reader. It should not be an abstract of the proposal.

Project Description (15-page limit):

Please note that per guidance in the PAPPG, the Project Description must contain, as a separate section within the narrative, a discussion of the broader impacts of the proposed activities. Proposers may decide where to include this section within the Project Description.

The Project Description should explicitly address the following additional items:

For SI² (SSE and SSI) proposals (including NSCI-designated proposals), the project description should define a research and development agenda that will lead to robust and sustainable software. The Project Description should explicitly address and discuss the following items:

- How the proposed software will fill a recognized need and advance research capability within a significant area or areas of science and engineering. Provide a compelling discussion of the software's potential use by its intended and broader communities, preferably via use cases developed in concert with relevant domain scientists.
- How the project integrates innovation and discovery into the project activities.
- How the proposed software compares to alternative or existing elements (including other commercial and research solutions) and what are the limitations of these existing elements.
- PIs who have been previously funded under an SSE or SSI award should show quantifiable evidence of the use, impact and sustainability of the previously funded software, and should also include a citation to the published software in their biographical sketches as one of their relevant products.
- The architecture of the software and the software engineering process to be used for the design, development, documentation, testing, validation and release of the software, its deployment and associated outreach to the end user community, and an acceptance and evaluation plan that involves end users.
- How security, trustworthiness, provenance, reproducibility, and usability will be addressed by the project and integrated into the proposed software system and the software engineering process.
- How adaptability to new technologies and changing requirements will be addressed by the project and built into the proposed software system.
- Which software license will be used for the released software, and why this license has been chosen.
- The project plan, including user interactions and a community-driven approach, and a timeline including a proof-of-concept demonstration of the key software components. The proposal must include a list of tangible metrics, with end user involvement, to be used to measure the success of the software element developed, especially the quantitative and qualitative definition of a "working prototype" against which that milestone will be judged, and the steps necessary to take the software element from prototype to dissemination into the community as reusable software resources.
- The outreach and education plan for additional end user groups to take advantage of the proposed work, with the potential to have impact beyond the institution, including the possible adoption of approaches, curricula, and instructional material broadly within the relevant disciplines.
- Sustainability of the developed software beyond the lifetime of the award.
- How the proposed software will leverage and be interoperable with widely used tools by the community, and with NSF and national cyberinfrastructure investments, as appropriate.
- If the proposal seeks to be considered as responsive to the NSCI, how it advances this initiative.

For S²I² Conceptualization Proposals (including NSCI-designated proposals), the Project Description should describe:

- The rationale for the envisioned institute, its mission and goals, and its responsiveness to community needs and to programmatic areas of interest to the SI² program and associated Dear Colleague Letters.
- The scientific and engineering communities and software elements/frameworks targeted, and the specific software sustainability challenges that will be addressed.

- Approaches for reaching out to the relevant communities and engaging them in the conceptual design process.
- The anticipated impact to the scientific and engineering communities in terms of research, innovation and productivity.
- The overarching approach as well as specific steps that will be taken towards the conceptual design of the envisioned institute.
- The qualifications of the PIs to lead the conceptualization effort for the envisioned institute.
- A steering committee comprising leading members of the targeted community that could assume key roles in the leadership and/or management of the envisioned institute. Brief biographies of the members of the steering committee and their role in the conceptualization process should be included.
- If the proposal seeks to be considered as responsive to the NSCI, the relevance to this NSCI, in a clearly identifiable section.

Budget: Awardees are expected to participate in annual PI meetings near NSF with travel costs supported by the award. These travel costs should be included in the FastLane budget.

Supplementary Documentation: In addition to the **Data Management Plan** (please follow the CISE Data Management Guidance - https://www.nsf.gov/cise/cise_dmp.jsp) and the **Postdoctoral Research Mentoring Plan** (if required), the following items are the only items permitted as supplementary documentation.

1. **Management and Coordination Plan** (SSI proposals only, 3-page limit, to be submitted as a Supplementary Document): Each SSI proposal must contain a clearly labeled Management and Coordination Plan, which includes: 1) the specific roles of the PI, co-PIs, other senior personnel and paid consultants at all institutions involved; 2) how the project will be managed across institutions and disciplines; 3) identification of the specific coordination mechanisms that will enable cross-institution and/or cross-disciplines scientific integration (e.g., yearly workshops, graduate student exchange, project meetings at conferences, use of videoconferences, use of common software repositories, build process and/or test suites, etc.); and 4) pointers to the budget line items that support these management and coordination mechanisms.
2. **Project Personnel and Partner Institutions** (required for all award categories): Provide current, accurate information for all personnel and institutions involved in the project. NSF staff will use this information in the merit review process to manage conflicts of interest. The list must include all PIs, Co-PIs, Senior Personnel, paid/unpaid Consultants or Collaborators, Subawardees, Postdocs, project-level advisory committee members, and writers of letters of support. This list should be numbered and include (in this order) Full name, Organization(s), and Role in the project, with each item separated by a semi-colon. Each person listed should start a new numbered line. For example:
 - Mary Smith; XYZ University; PI
 - John Jones; University of PQR; Senior Personnel
 - Jane Brown; XYZ University; Postdoc
 - Bob Adams; ABC Inc.; Paid Consultant
 - Mary White; Welldone Institution; Unpaid Collaborator
 - Tim Green; ZZZ University; Subawardee
3. **Letters of Collaboration** (optional, may be submitted as a Supplementary Document): Include documentation of funded or unfunded collaborative arrangements of significance to the proposal through letters of collaboration. (See [PAPPG Chapter II.C.2.d\(iv\)](#)). Letters of collaboration should be limited to stating the intent to collaborate and should not contain endorsements or evaluation of the proposed project. The recommended format for letters of collaboration is as follows:

"If the proposal submitted by Dr. [insert the full name of the Principal Investigator] entitled [insert the proposal title] is selected for funding by NSF, it is my intent to collaborate and/or commit resources as detailed in the Project Description or the Facilities, Equipment or Other Resources section of the proposal."

Scan your signed letters of collaboration, containing only text similar to that above, and upload them into the Supplementary Documents section of FastLane or [Grants.gov](#), but do not send originals.

Do not submit letters of support. For example, letters of endorsement and letters of a laudatory nature for the proposed project are not acceptable.

Single Copy Documents:

Collaborators and Other Affiliations Information:

For this solicitation, the *Collaborators & Other Affiliations* information specified in the PAPPG should be submitted using the spreadsheet template found at <https://www.nsf.gov/cise/collab/>. For each proposal, a completed spreadsheet for each PI, co-PI, or senior personnel must be uploaded directly into Fastlane in .xls or .xlsx format as a "Collaborator and Other Affiliations" Single Copy Document. NSF staff use this information in the merit review process to help manage reviewer selection; the spreadsheet will ensure the Collaborator and Other Affiliations information has a common, searchable format.

Note the distinction to (2) above for Supplementary Documents: the listing of all project participants is collected by the project lead and entered as a Supplementary Document, which is then automatically included with all proposals in a project. The Collaborators and Other Affiliations are entered for each participant within each proposal and, as Single Copy Documents, are available only to NSF staff. Collaborators and Other Affiliations due to participants listed on (2) that are not PIs, co-PIs, or senior personnel can be uploaded under Additional Single Copy Documents using Transfer File.

No other items or appendices are to be included. Full proposals containing items other than those required above or by the *Proposal and Award Policies and Procedures Guide (PAPPG)* will not be reviewed.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Budget Preparation Instructions:

Awardees are expected to participate in annual PI meetings with travel costs supported by the award. These travel costs should be included in the proposed budget.

C. Due Dates

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

March 07, 2017

SSE Proposals

April 11, 2017

S2I2 Conceptualization Proposals

September 19, 2017

SSI Proposals

D. FastLane/Grants.gov Requirements

For Proposals Submitted Via FastLane:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: <https://www.fastlane.nsf.gov/a1/newstan.htm>. For FastLane user support, call the FastLane Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov. The FastLane Help Desk answers general technical questions related to the use of the FastLane system. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

Before using Grants.gov for the first time, each organization must register to create an institutional profile. Once registered, the applicant's organization can then apply for any federal grant on the Grants.gov website. Comprehensive information about using Grants.gov is available on the Grants.gov Applicant Resources webpage: <http://www.grants.gov/web/grants/applicants.html>. In addition, the NSF Grants.gov Application Guide (see link in Section V.A) provides instructions regarding the technical preparation of proposals via Grants.gov. For Grants.gov user support, contact the Grants.gov Contact Center at 1-800-518-4726 or by email: support@grants.gov. The Grants.gov Contact Center answers general technical questions related to the use of Grants.gov. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this solicitation.

Submitting the Proposal: Once all documents have been completed, the Authorized Organizational Representative (AOR) must submit the application to Grants.gov and verify the desired funding opportunity and agency to which the application is submitted. The AOR must then sign and submit the application to Grants.gov. The completed application will be transferred to the NSF FastLane system for further processing.

Proposers that submitted via FastLane are strongly encouraged to use FastLane to verify the status of their submission to NSF. For proposers that submitted via Grants.gov, until an application has been received and validated by NSF, the Authorized Organizational Representative may check the status of an application on Grants.gov. After proposers have received an e-mail notification from NSF, Research.gov should be used to check the status of an application.

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

Proposals received by NSF are assigned to the appropriate NSF program for acknowledgement and, if they meet NSF requirements, for review. All proposals are carefully reviewed by a scientist, engineer, or educator serving as an NSF Program Officer, and usually by three to ten other persons outside NSF either as *ad hoc* reviewers, panelists, or both, who are experts in the particular fields represented by the proposal. These reviewers are selected by Program Officers charged with oversight of the review process. Proposers are invited to suggest names of persons they believe are especially well qualified to review the proposal and/or persons they would prefer not review the proposal. These suggestions may serve as one source in the reviewer selection process at the Program Officer's discretion. Submission of such names, however, is optional. Care is taken to ensure that reviewers have no conflicts of interest with the proposal. In addition, Program Officers may obtain comments from site visits before recommending final action on proposals. Senior NSF staff further review recommendations for awards. A flowchart that depicts the entire NSF proposal and award process (and associated timeline) is included in PAPPG Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: https://www.nsf.gov/bfa/dias/policy/merit_review/.

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *Investing in Science, Engineering, and Education for the Nation's Future: NSF Strategic Plan for 2014-2018*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

One of the strategic objectives in support of NSF's mission is to foster integration of research and education through the programs, projects, and activities it supports at academic and research institutions. These institutions must recruit, train, and prepare a diverse STEM workforce to advance the frontiers of science and participate in the U.S. technology-based economy. NSF's contribution to the national innovation ecosystem is to provide cutting-edge research under the guidance of the Nation's most creative scientists and engineers. NSF also supports development of a strong science, technology, engineering, and mathematics (STEM) workforce by investing in building the knowledge that informs improvements in STEM teaching and learning.

NSF's mission calls for the broadening of opportunities and expanding participation of groups, institutions, and geographic regions that are underrepresented in STEM disciplines, which is essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

A. Merit Review Principles and Criteria

The National Science Foundation strives to invest in a robust and diverse portfolio of projects that creates new knowledge and enables breakthroughs in understanding across all areas of science and engineering research and education. To identify which projects to support, NSF relies on a merit review process that incorporates consideration of both the technical aspects of a proposed project and its potential to contribute more broadly to advancing NSF's mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF makes every effort to conduct a fair, competitive, transparent merit review process for the selection of projects.

1. Merit Review Principles

These principles are to be given due diligence by PIs and organizations when preparing proposals and managing projects, by reviewers when reading and evaluating proposals, and by NSF program staff when determining whether or not to recommend proposals for funding and while overseeing awards. Given that NSF is the primary federal agency charged with nurturing and supporting excellence in basic research and education, the following three principles apply:

- All NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.
- NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These "Broader Impacts" may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. The project activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified.
- Meaningful assessment and evaluation of NSF funded projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects. If the size of the activity is limited, evaluation of that activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus, individual projects should include clearly stated goals, specific descriptions of the activities that the PI intends to do, and a plan in place to document the outputs of those activities.

These three merit review principles provide the basis for the merit review criteria, as well as a context within which the users of the criteria can better understand their intent.

2. Merit Review Criteria

All NSF proposals are evaluated through use of the two National Science Board approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. **Both** criteria are to be given **full consideration** during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (PAPPG Chapter II.C.2.d(i), contains additional information for use by proposers in development of the Project Description section of the proposal). Reviewers are strongly encouraged to review the criteria, including PAPPG Chapter II.C.2.d(i), prior to the review of a proposal.

When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- **Intellectual Merit:** The Intellectual Merit criterion encompasses the potential to advance knowledge; and
- **Broader Impacts:** The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to
 - a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
 - b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?

3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

Broader impacts may be accomplished through the research itself, through the activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. NSF values the advancement of scientific knowledge and activities that contribute to achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

Proposers are reminded that reviewers will also be asked to review the Data Management Plan and the Postdoctoral Researcher Mentoring Plan, as appropriate.

Additional Solicitation Specific Review Criteria

All proposals must clearly address the following solicitation-specific review criteria through well-identified proposal elements.

SSE and SSI Proposals:

- To what extent does the proposed software fill a recognized need and advance research capability within a significant area (or areas) of science and engineering?
- To what extent does the project integrate innovation and research into the project activities?
- How well does the proposal describe how the proposed software compares to alternative or existing elements (including commercial solutions)?
- If the PI claims to have previously developed widely-used software, particularly if funded under an SI² award, how significant was the use and impact of the previously funded software, as shown by the quantifiable evidence in the proposal? Is the software properly listed in the PI's biographical sketch? What progress has been made towards sustainability?
- To what extent has the software architecture and software engineering process been described, and how well does it support the goals of the project? To what extent has the proposal described an approach to quality software development through a defined software engineering process that includes software testing, and the use of analysis tools and capabilities such as those made available through the Software Assurance Marketplace (SWAMP, <https://continuousassurance.org/>)? Have proposals included collaborations with resources such as Software Carpentry (<http://software-carpentry.org/>) and the Center for Trustworthy Scientific Cyberinfrastructure (CTSC, <http://trustedci.org/>), in order to gain access to expertise where needed, such as in software design and engineering and cybersecurity?
- How well does the proposal present and discuss the project plan and timeline, including proof-of-concept demonstrations of key software elements and the steps necessary to take the software from prototype to dissemination into the community as reusable software resources? How well does the project plan include user interaction, a community-driven approach, and a timeline of new feature releases?
- How well does the software engineering and development plan include and/or enable the integration of relevant activities to ensure the software is responsive to new computing developments?
- To what extent are issues of security, trustworthiness, provenance, reproducibility, and usability addressed and integrated into the proposed software and software engineering process?
- To what extent is adaptability to new technologies and changing requirements addressed by the project and built into the proposed software system?
- Are tangible metrics described to measure the success of any software that may be developed? How appropriate are these metrics?
- Does the proposal state the software license to be used and is the choice both suitably justified and appropriate, given the goals of the project?
- How appropriate is the plan to extend the work to additional user communities?
- How well does the project address the sustainability of the developed software beyond the lifetime of the award?
- To what extent does the proposed software build upon and leverage, and to what extent is it interoperable with, widely used tools by the community, and NSF and national cyberinfrastructure investments, as appropriate?

For S²I² Conceptualization Proposals:

- How compelling is the rationale for the envisioned institute, its mission and goals, and its responsiveness to community needs and to programmatic areas of interest to the SI² program and associated Dear Colleague Letters?
- To what extent does the proposal describe the scientific and engineering communities and software elements/frameworks to be targeted, and the specific software sustainability challenges that will be addressed?
- To what extent does the proposal describe approaches for reaching out to the relevant communities and engaging them in the conceptual design process?
- To what extent does the proposal describe the anticipated impact to the scientific and engineering communities in terms of research, innovation and productivity?
- To what extent does the proposal describe the overarching approach as well as specific steps that will be taken towards the conceptual design of the envisioned institute?
- What qualifies the PIs to lead the conceptualization effort for the envisioned institute?
- How qualified are the members of the steering committee in their ability to assume key roles in the leadership and/or management of the envisioned institute?

For NSCI-designated proposals of all types:

- How well does the proposal advance the goals of the NSCI?

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by Ad hoc Review and/or Panel Review.

Reviewers will be asked to evaluate proposals using two National Science Board approved merit review criteria and, if applicable, additional program specific criteria. A summary rating and accompanying narrative will generally be completed and submitted by each reviewer and/or panel. The Program Officer assigned to manage the proposal's review will consider the advice of reviewers and will formulate a recommendation.

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF strives to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. Large or particularly complex proposals or proposals from new awardees may require additional review and processing time. The time interval begins on the deadline or target date, or receipt date, whichever is later. The interval ends when the Division Director acts upon the Program Officer's recommendation.

After programmatic approval has been obtained, the proposals recommended for funding will be forwarded to the Division of Grants and Agreements for review of business, financial, and policy implications. After an administrative review has occurred, Grants and Agreements Officers perform the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments, obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

Once an award or declination decision has been made, Principal Investigators are provided feedback about their proposals. In all cases, reviews are treated as confidential documents. Verbatim copies of reviews, excluding the names of the reviewers or any reviewer-identifying information, are sent to the Principal Investigator/Project Director by the Program Officer. In addition, the proposer will receive an explanation of the decision to award or decline funding.

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

Notification of the award is made to *the submitting organization* by a Grants Officer in the Division of Grants and Agreements. Organizations whose proposals are declined will be advised as promptly as possible by the cognizant NSF Program administering the program. Verbatim copies of reviews, not including the identity of the reviewer, will be provided automatically to the Principal Investigator. (See Section VI.B. for additional information on the review process).

B. Award Conditions

An NSF award consists of: (1) the award notice, which includes any special provisions applicable to the award and any numbered amendments thereto; (2) the budget, which indicates the amounts, by categories of expense, on which NSF has based its support (or otherwise communicates any specific approvals or disapprovals of proposed expenditures); (3) the proposal referenced in the award notice; (4) the applicable award conditions, such as Grant General Conditions (GC-1)*; or Research Terms and Conditions* and (5) any announcement or other NSF issuance that may be incorporated by reference in the award notice. Cooperative agreements also are administered in accordance with NSF Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATC) and the applicable Programmatic Terms and Conditions. NSF awards are electronically signed by an NSF Grants and Agreements Officer and transmitted electronically to the organization via e-mail.

*These documents may be accessed electronically on NSF's Website at https://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF. Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

More comprehensive information on NSF Award Conditions and other important information on the administration of NSF awards is contained in the NSF *Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=papppg.

Special Award Conditions:

- Awardees are expected to participate in annual PI meetings with travel costs supported by the award.
- Some awards, in particular SSI awards, are anticipated to be continuing grants, where funds are released annually subject to agreed-upon milestones, based on approval by NSF and the availability of funds.

C. Reporting Requirements

For all multi-year grants (including both standard and continuing grants), the Principal Investigator must submit an annual project report to the cognizant Program Officer no later than 90 days prior to the end of the current budget period. (Some programs or awards require submission of more frequent project reports). No later than 120 days following expiration of a grant, the PI also is required to submit a final project report, and a project outcomes report for the general public.

Failure to provide the required annual or final project reports, or the project outcomes report, will delay NSF review and processing of any future funding increments as well as any pending proposals for all identified PIs and co-PIs on a given award. PIs should examine the formats of the required reports in advance to assure availability of required data.

PIs are required to use NSF's electronic project-reporting system, available through Research.gov, for preparation and submission of annual and final project reports. Such reports provide information on accomplishments, project participants (individual and organizational), publications, and other specific products and impacts of the project. Submission of the report via Research.gov constitutes certification by the PI that the contents of the report are accurate and complete. The project outcomes report also must be prepared and submitted using Research.gov. This report serves as a brief summary, prepared specifically for the public, of the nature and outcomes of the project. This report will be posted on the NSF website exactly as it is submitted by the PI.

More comprehensive information on NSF Reporting Requirements and other important information on the administration of NSF awards is contained in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.

VIII. AGENCY CONTACTS

Please note that the program contact information is current at the time of publishing. See program website for any updates to the points of contact.

General inquiries regarding this program should be made to:

- Rajiv Ramnath, Program Director, CISE/ACI, telephone: (703) 292-4776, email: SI2Queries@nsf.gov
- Vipin Chaudhary, Program Director, CISE/ACI, telephone: (703) 292-2254, email: SI2Queries@nsf.gov
- Peter H. McCartney, Program Director, BIO/DBI, telephone: (703) 292-8470, email: SI2Queries@nsf.gov
- Almadena Y. Chtchelkanova, Program Director, CISE/CCF, telephone: (703) 292-8910, email: SI2Queries@nsf.gov
- Sol Greenspan, Program Director, CISE/CCF, telephone: (703) 292-8910, email: SI2Queries@nsf.gov
- John C. Cherniavsky, Senior Advisor, EHR, telephone: (703) 292-5136, email: SI2Queries@nsf.gov
- Eva Zanzerkia, Program Director, GEO/EAR, telephone: (703) 292-4734, email: SI2Queries@nsf.gov
- Nigel A. Sharp, Program Director, MPS/AST, telephone: (703) 292-4905, email: SI2Queries@nsf.gov
- Evelyn Goldfield, MPS/CHE, telephone: (703) 292-2173, email: SI2Queries@nsf.gov
- Daryl W. Hess, Program Director, MPS/DMR, telephone: (703) 292-4942, email: SI2Queries@nsf.gov
- Christopher W. Stark, Program Director, MPS/DMS, telephone: (703) 292-4869, email: SI2Queries@nsf.gov
- Yong Zeng, Program Director, MPS/DMS, telephone: (703) 292-2301, email: SI2Queries@nsf.gov
- Bogdan Mihaila, Program Director, MPS/PHY, telephone: (703) 292-8235, email: SI2Queries@nsf.gov
- Ronald Joslin, Program Director, ENG/CBET, telephone: (703) 292-7030, email: SI2Queries@nsf.gov
- Joanne D. Culbertson, Program Director, ENG/CMMI, telephone: (703) 292-4602, email: SI2Queries@nsf.gov
- Hao Ling, Program Director, ENG/ECCS, telephone: (703) 292-2210, email: SI2Queries@nsf.gov
- Cheryl L. Eavey, SBE/SES, telephone: (703) 292-7269, email: SI2Queries@nsf.gov

For questions related to the use of FastLane, contact:

- FastLane Help Desk, telephone: 1-800-673-6188; e-mail: fastlane@nsf.gov.

For questions relating to Grants.gov contact:

- Grants.gov Contact Center: If the Authorized Organizational Representatives (AOR) has not received a confirmation message from Grants.gov within 48 hours of submission of application, please contact via telephone: 1-800-518-4726; e-mail: support@grants.gov.

IX. OTHER INFORMATION

The NSF website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this website by potential proposers is strongly encouraged. In addition, "NSF Update" is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF [Grants Conferences](#). Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. "NSF Update" also is available on [NSF's website](#).

Grants.gov provides an additional electronic capability to search for Federal government-wide grant opportunities. NSF funding opportunities may be accessed via this mechanism. Further information on Grants.gov may be obtained at <http://www.grants.gov>.

See also:

- A Vision and Strategy for Software for Science, Engineering, and Education -- https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf12113
- Implementation of NSF Software Vision -- https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504817

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The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861-75). The Act states the purpose of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering."

NSF funds research and education in most fields of science and engineering. It does this through grants and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the US. The Foundation accounts for about one-fourth of Federal support to academic institutions for basic research.

NSF receives approximately 55,000 proposals each year for research, education and training projects, of which approximately 11,000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships. The agency operates no laboratories itself but does support National Research Centers, user facilities, certain oceanographic vessels and Arctic and Antarctic research stations. The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

Facilitation Awards for Scientists and Engineers with Disabilities (FASSED) provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See the *NSF Proposal & Award Policies & Procedures Guide* Chapter II.E.6 for instructions regarding preparation of these types of proposals.

The National Science Foundation has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment or general information. TDD may be accessed at (703) 292-5090 and (800) 281-8749, FIRS at (800) 877-8339.

The National Science Foundation Information Center may be reached at (703) 292-5111.

The National Science Foundation promotes and advances scientific progress in the United States by competitively awarding grants and cooperative agreements for research and education in the sciences, mathematics, and engineering.

To get the latest information about program deadlines, to download copies of NSF publications, and to access abstracts of awards, visit the NSF Website at <https://www.nsf.gov>

- **Location:** 4201 Wilson Blvd. Arlington, VA 22230
- **For General Information** (NSF Information Center): (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**
 - Send an e-mail to: nsfpubs@nsf.gov
 - or telephone: (703) 292-7827
- **To Locate NSF Employees:** (703) 292-5111

PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, [NSF-50](#), "Principal Investigator/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004), and [NSF-51](#), "Reviewer/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004). Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

An agency may not conduct or sponsor, and a person is not required to respond to, an information collection unless it displays a valid Office of Management and Budget (OMB) control number. The OMB control number for this collection is 3145-0058. Public reporting burden for this collection of information is estimated to average 120 hours per response, including the time for reviewing instructions. Send comments regarding the burden estimate and any other aspect of this collection of information, including suggestions for reducing this burden, to:

Suzanne H. Plimpton
Reports Clearance Officer
Office of the General Counsel
National Science Foundation
Arlington, VA 22230

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