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Cyberinfrastructure for Sustained Scientific Innovation (CSSI) - Data and Software: Elements and Frameworks

PROGRAM SOLICITATION

NSF 18-531

REPLACES DOCUMENT(S):

NSF 17-500, NSF 17-526



National Science Foundation

Directorate for Computer & Information Science & Engineering
Office of Advanced Cyberinfrastructure

Directorate for Biological Sciences

Directorate for Education & Human Resources

Directorate for Engineering

Directorate for Geosciences

Directorate for Mathematical & Physical Sciences

Directorate for Social, Behavioral & Economic Sciences

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

April 18, 2018

IMPORTANT INFORMATION AND REVISION NOTES

This solicitation focuses upon the integration of the data and software elements of advanced cyberinfrastructure. By integrating two major and long-running NSF program solicitations [[NSF 17-500](#): Data Infrastructure Building Blocks (DIBBs) and [NSF 17-526](#): Software Infrastructure for Sustained Innovation (SI2)] under a single umbrella called Cyberinfrastructure for Sustained Scientific Innovation (CSSI), NSF seeks to enable funding opportunities that are flexible and responsive to the evolving and emerging needs in integrated data and software cyberinfrastructure.

Revisions are noted below:

- Proposal submission and review information previously appearing in separate DIBBs and SI2 solicitations has now been consolidated within the Program Description section of this integrated solicitation.
- The classes of data and software proposals have been revised for ease of integration:
 - DIBBs Pilot Demonstrations and SI2 Scientific Software Elements categories are now designated as Elements (either *Data Elements* or *Software Elements*).
 - DIBBs Early Implementations and SI2 Scientific Software Integration categories are now designated as Framework Implementations (either *Data Frameworks* or *Software Frameworks*).
 - In a separate call for proposals, a class of proposals supporting planning grants for community cyberinfrastructure has been added (either *Community Data Cyberinfrastructure Planning Grants* or *Community Software Cyberinfrastructure Planning Grants*). The opportunity for planning community data cyberinfrastructure capabilities is new. Planning for *Community Software Cyberinfrastructure* incorporates the S2I2 Conceptualization guidance from prior solicitations.
 - Future solicitations may consider *Community Software Cyberinfrastructure Implementation* and *Community Data Cyberinfrastructure Implementation* proposals.
- The same due date will apply to all Elements and Frameworks classes of proposals.
- Cognizant Program Officer contacts and proposal submission and review instructions are now integrated across all proposal categories within the solicitation.
- The section summarizing priorities for the collaborating NSF directorates and divisions has been updated for 2018. PIs have also been encouraged to 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 gain insight into the priorities for the relevant areas of science and engineering to which their proposals may be responsive.

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award*

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Cyberinfrastructure for Sustained Scientific Innovation (CSSI) - Data and Software:
Elements and Frameworks

Synopsis of Program:

The Cyberinfrastructure for Sustained Scientific Innovation (CSSI) umbrella program encompasses the long-running Data Infrastructure Building Blocks (DIBBs) and Software Infrastructure for Sustained Innovation (SI2) programs, as NSF seeks to enable funding opportunities that are flexible and responsive to the evolving and emerging needs in data and software cyberinfrastructure.

The CSSI umbrella program anticipates four classes of awards:

1. **Elements** (either *Data Elements* or *Software Elements*): These awards target small groups that will create and deploy robust capabilities for which there is a demonstrated need that will advance one or more significant areas of science and engineering.
2. **Framework Implementations** (either *Data Frameworks* or *Software Frameworks*): These awards target larger, interdisciplinary teams organized around the development and application of common infrastructure aimed at solving common research problems faced by NSF researchers in one or more areas of science and engineering, resulting in a sustainable community framework serving a diverse community or communities.
3. **Planning Grants for Community Cyberinfrastructure** (either *Community Data Cyberinfrastructure Planning Grants* or *Community Software Cyberinfrastructure Planning Grants*): Planning awards focus on the establishment of long-term capabilities in cyberinfrastructure, which would serve a research community of substantial size and disciplinary breadth.
4. **Community Cyberinfrastructure Implementations** (either *Community Data Cyberinfrastructure Implementations* or *Community Software Cyberinfrastructure Implementations*): These Community Software Cyberinfrastructure Implementations focus on the establishment of long-term hubs of excellence in cyberinfrastructure and technologies, which will serve a research community of substantial size and disciplinary breadth.

This particular CSSI solicitation requests only Elements and Framework Implementations classes of awards.

NSF anticipates future solicitations that address items 3 and 4 above, namely, Planning Grants for Community Cyberinfrastructure and Community Cyberinfrastructure Implementations.

For 2018, this solicitation welcomes proposals that support the goals of the:

- **National Strategic Computing Initiative (NSCI)**. NSCI is aimed at sustaining and enhancing U.S. scientific, technological, and economic leadership in high-performance computing (HPC) research, development, and deployment, enhancing the productivity of the Nation's fundamental research ecosystem. Information about the NSCI together with associated strategic plans, results of community workshops, background studies and other relevant resources, which suggest priority areas in both the domain sciences and HPC and software infrastructure, are available at <https://www.nsf.gov/nscli/>.
- **Harnessing the Data Revolution (HDR)**. HDR is one of NSF's 10 Big Ideas for Future Investment (https://www.nsf.gov/about/congress/reports/nsf_big_ideas.pdf). HDR is aimed at fundamental data science research, research data cyberinfrastructure, and the development of a 21st-century data-capable workforce. HDR will enable new modes of data-driven discovery – allowing researchers to ask and answer new questions in frontier science and engineering, generate new knowledge and understanding, and accelerate discovery and innovation.

Proposers are encouraged to review the above-linked materials about NSCI and HDR for priority areas identified by the research community. A sub-section summarizing priorities for the collaborating NSF directorates and divisions has been included with this 2018 solicitation – see the 'Programmatic Areas of Interest' included at the end of the Program Description section.

Prospective Principal Investigators (PIs) should be aware that this is a multi-directorate activity and that they are encouraged to submit proposals with broad, interdisciplinary interests. Further, not all divisions are participating at the same level and division-specific priorities differ. Thus, PIs interested in proposing to this solicitation are encouraged to refer to core program descriptions, Dear Colleague Letters, and recently posted descriptions on directorate and divisional home pages to gain insight as to the priorities for the relevant areas of science and engineering to which their proposal may be responsive.

Finally, 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 gain insight into the priorities for the relevant areas of science and engineering to which their proposals should be responsive.

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.

- Vipin Chaudhary, Program Director, CISE/OAC, telephone: (703) 292-2254, email: CSSIQueries@nsf.gov
- Amy Walton, Program Director, CISE/OAC, telephone: (703) 292-4538, email: CSSIQueries@nsf.gov
- Rajiv Ramnath, Program Director, CISE/OAC, telephone: (703) 292-4776, email: CSSIQueries@nsf.gov
- Peter H. McCartney, Program Director, BIO/DBI, telephone: (703) 292-8470, email: CSSIQueries@nsf.gov
- Almadena Y. Chtchelkanova, Program Director, CISE/CCF, telephone: (703) 292-8910, email: CSSIQueries@nsf.gov
- Sol Greenspan, Program Director, CISE/CCF, telephone: (703) 292-8910, email: CSSIQueries@nsf.gov
- Sylvia Spengler, Program Director, CISE/IIS, telephone: (703) 292-8930, email: CSSIQueries@nsf.gov
- John C. Cherniavsky, Senior Advisor, EHR/DRL, telephone: (703) 292-5136, email: CSSIQueries@nsf.gov
- Ronald Joslin, Program Director, ENG/CBET, telephone: (703) 292-7030, email: CSSIQueries@nsf.gov
- Christina Payne, Associate Program Director, ENG/CBET, telephone: (703) 292-2895, email: CSSIQueries@nsf.gov
- Joanne D. Culbertson, Program Director, ENG/CMMI, telephone: (703) 292-4602, email: CSSIQueries@nsf.gov
- Jenshan Lin, Program Director, ENG/ECCS, telephone: (703) 292-7950, email: CSSIQueries@nsf.gov
- Subhashree (Shree) Mishra, Program Director, GEO/AGS, telephone: (703) 292-8521, email: CSSIQueries@nsf.gov
- Marc Stieglitz, Program Director, GEO/OPP, telephone: (703) 292-2461, email: CSSIQueries@nsf.gov
- Nigel A. Sharp, Program Director, MPS/AST, telephone: (703) 292-4905, email: CSSIQueries@nsf.gov
- Evelyn Goldfield, Program Director, MPS/CHE, telephone: (703) 292-2173, email: CSSIQueries@nsf.gov
- Lin He, Program Director, MPS/CHE, telephone: (703) 292-4956, email: CSSIQueries@nsf.gov
- Daryl W. Hess, Program Director, MPS/DMR, telephone: (703) 292-4942, email: CSSIQueries@nsf.gov
- Christopher W. Stark, Program Director, MPS/DMS, telephone: (703) 292-4869, email: CSSIQueries@nsf.gov
- Yong Zeng, Program Director, MPS/DMS, telephone: (703) 292-2301, email: CSSIQueries@nsf.gov
- Vyacheslav (Slava) Lukin, Program Director, MPS/PHY, telephone: (703) 292-7382, email: CSSIQueries@nsf.gov
- Bogdan Mihaila, Program Director, MPS/PHY, telephone: (703) 292-8235, email: CSSIQueries@nsf.gov
- Cheryl L. Eavey, Program Director, SBE/SES, telephone: (703) 292-7269, email: CSSIQueries@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

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 28

The number of awards of each type 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 15 Element awards, and 13 Framework Implementations awards are anticipated, subject to the availability of funds.

Anticipated Funding Amount: \$34,000,000

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

Up to \$9,000,000 is expected to be available for Elements awards, and up to \$25,000,000 is expected to be available for Framework Implementations awards, subject to the availability of funds.

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.
- 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.
- NSF-sponsored federally funded research and development centers (FFRDCs) may apply, provided that they are not including costs for which federal funds have already been awarded or are expected to be awarded.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI: 1

An individual may participate as PI, co-PI, or other Senior Personnel on at most one proposal across the Elements and Framework Implementations for this solicitation. Thus, if an individual participates on an Elements proposal, he or she may not participate on a Framework Implementations proposal, and vice versa. Note that 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 any 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.

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.
 - 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):

April 18, 2018

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.

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I. INTRODUCTION

The Office of Advanced Cyberinfrastructure (OAC) enables science and engineering research and education by developing, creating, and supporting secure, advanced, scalable, and global research cyberinfrastructure (CI). OAC investments emphasize cyberinfrastructure that is:

- **Science-driven:** Promotes science and engineering excellence, enabling fundamentally new scientific and engineering advances; benefits science and engineering communities beyond initial targets;
- **Innovative:** Emphasizes unique NSF contributions; builds the capability, capacity, and cohesiveness of a national CI ecosystem; considers both human and technical aspects of the CI;
- **Collaborative:** Fosters partnerships and community development; actively engages CI experts, specialists, and scientists working in concert with domain scientists who are users of CI;
- **Leveraged:** Builds on existing, recognized capabilities;
- **Strategic:** Encourages measurement of progress and sharing of results; and

Sustained: Provides benefits beyond the participants and the lifetime of the award.

Over the past decade, OAC has supported a series of programs and activities that develop, deploy, and provision cyberinfrastructure. The OAC portfolio has been distributed into five thematic areas: Data, High-Performance Computing, Networking/Cybersecurity, Software, and Learning and Workforce Development.

OAC Data and Software programs have been long-term investments, focused on catalyzing new thinking, paradigms, and practices in developing and using data and software CI to understand natural, human, and engineered systems. Science and engineering challenges and use cases drive CI development, and successful CI systems strike a balance reflective of both the underlying technology and disciplinary research needs.

The core Data program in OAC has been the *Data Infrastructure Building Blocks (DIBBs)* program, which has encouraged development of robust and shared data-centric cyberinfrastructure capabilities to accelerate interdisciplinary and collaborative research in areas of inquiry stimulated by data.

The core Software program in OAC has been the *Software Infrastructure for Sustained Innovation (SI2)* program, which 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.

The goal of the integrated CSSI program is to create a CI ecosystem that spans all levels of the data and software stack and scales from individual or small groups of innovators to large community resources. 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 program will continue to nurture the interdisciplinary processes required to support the entire data and software lifecycle, and will successfully integrate development and support with innovation and research. Furthermore, the program will result in the development of sustainable CI communities that transcend scientific and geographical boundaries. The program envisions vibrant partnerships among academia, government laboratories and industry, including international entities, for the development and stewardship of a sustainable infrastructure that can enhance productivity and accelerate innovation in science and engineering. Furthermore, integrated education activities will play a key role in developing and sustaining the cyberinfrastructure over time and in creating a workforce capable of fully realizing its potential to transform science and engineering.

II. PROGRAM DESCRIPTION

The goal of the CSSI umbrella program is to create a software and data cyberinfrastructure ecosystem that scales from individuals or small groups of researchers/innovators to large communities. The CSSI program anticipates four classes of awards:

1. **Elements** (either *Data Elements* or *Software Elements*): These awards target small groups that will create and deploy robust capabilities for which there is a demonstrated need, and that will advance one or more significant areas of science and engineering. It is expected that the created elements will be disseminated to the community as reusable resources, with the potential for sustainability. The development approach may support the hardening of early prototypes and/or expanding functionality to increase end-user relevance.
2. **Framework Implementations** (either *Data Frameworks* or *Software Frameworks*): These awards target larger, interdisciplinary teams organized around the development and application of common infrastructure aimed at solving common research problems faced by NSF researchers in one or more areas of science and engineering, resulting in a sustainable community framework serving a diverse community or communities. Some awards are anticipated to be continuing grants, where funds will be released annually subject to agreed-upon milestones, based on approval by NSF and the availability of funds.
3. **Planning Grants for Community Cyberinfrastructure** (either *Community Data Cyberinfrastructure Planning Grants* or *Community Software Cyberinfrastructure Planning Grants*): Planning grants focus on the establishment of long-term capabilities in cyberinfrastructure, which would serve a research community of substantial size and disciplinary breadth.
4. **Community Cyberinfrastructure Implementations** (either *Community Data Cyberinfrastructure Implementation* or *Community Software Cyberinfrastructure Implementation*): These Community Cyberinfrastructure Implementations focus on the establishment of long-term hubs of excellence in cyberinfrastructure and technologies, which will serve a research community of substantial size and disciplinary breadth. For example, the outcomes of a Community Software Cyberinfrastructure go beyond the software itself, including the development infrastructure and process, successfully responding to science and engineering challenges, and enabling transformative new science and engineering. These Community Cyberinfrastructures will provide expertise, processes and architectures, resources and implementation mechanisms 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. Community Cyberinfrastructure proposals will bring together multidisciplinary teams of domain scientists and engineers, computer scientists, software and data engineers, and technologists and educators.

This particular CSSI solicitation offers only the Elements and Framework Implementations classes of awards (items 1 and 2 above). NSF anticipates future solicitations that address items 3 and 4 above, namely, Planning Grants for Community Cyberinfrastructure and Community Cyberinfrastructure Implementations. Table 1 below shows the lineage of various types of proposals within the CSSI program.

Table 1: CSSI classes of investments

Proposal categories accepted by this solicitation			
Proposal Category	Data	Software	Budget
Elements	<i>Data Elements (were DIBBs Pilot Demonstrations)</i>	<i>Software Elements (were Scientific Software Elements, SSE)</i>	Up to \$600,000 for 3 years

Framework Implementations	<i>Data Framework Implementations (were DIBBs Early Implementations)</i>	<i>Software Framework Implementations (were Scientific Software Integration, SSI)</i>	\$600,000-\$5M for 3-5 years (\$200,000-\$1M) per year)
Proposal categories anticipated in future solicitations			
Planning Grants for Community Cyberinfrastructure	<i>Planning Grants for Community Data Cyberinfrastructure Grants (new)</i>	<i>Planning Grants for Community Software Cyberinfrastructure Grants (were Software Conceptualizations)</i>	Will be specified in future solicitations
Community Cyberinfrastructure Implementations	<i>Community Data Cyberinfrastructure Implementations (new, and will be specified in future solicitations)</i>	<i>Community Software Cyberinfrastructure Implementations (were Scientific Software Innovation Institutes, S²I)</i>	Will be specified in future solicitations

For 2018, this solicitation welcomes proposals in two classes of awards:

1. Elements (either *Data Elements* or *Software Elements*); and
2. Framework Implementations (either *Data Framework Implementations* or *Software Framework Implementations*).

Proposers are asked to identify whether their proposal is an "Elements" or "Framework" proposal in the proposal title. Proposers are also asked to identify whether the proposal is a "Data" proposal or a "Software" proposal within the title, based on whether the proposed cyberinfrastructure will *primarily* support data-driven research or software-driven research. OAC recognizes that proposal submissions will span a continuum of cyberinfrastructure possibilities. Therefore, researchers with questions as to how their proposal should be classified should not hesitate to contact the cognizant program officers listed in this solicitation.

A competitive proposal will:

- Identify science and engineering challenges where the proposed cyberinfrastructure enables fundamental new science and engineering advances, and describe how the proposed project fosters partnerships and community development that will have a significant impact on science and engineering research;
- Indicate how the proposed cyberinfrastructure builds capability, capacity and cohesiveness of a national CI ecosystem; and
- Provide a compelling discussion of the cyberinfrastructure's potential use by a wider audience and its contribution to a national cyberinfrastructure.

NSF encourages participation by industry and international collaborators in all classes of awards where such participation 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 institutions. However, NSF funds may be used for integral travel expenses for U.S. scientists, engineers, and students, or for integral international collaborators to participate in activities in the U.S. For those who plan to submit a proposal with international counterparts, please contact the NSF Office of International Science and Engineering (OISE) program officer who covers that country: <https://www.nsf.gov/od/oise/country-list.jsp>.

OAC recognizes that software and data infrastructure constitute fundamental infrastructure that cross-cuts 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 & Award Policies & Procedures Guide (PAPPG)*.

Programmatic Areas of Interest

Successful proposals are expected to be of interest to multiple directorates/offices participating in the CSSI program, and are expected to be responsive to programmatic areas of interest for these participating directorates/offices. Below are programmatic areas of interest for 2018.

The **Directorate for Biological Sciences (BIO)** is primarily interested in the CSSI program as a means to collaborate with other NSF directorates to support proposals that impact a multidisciplinary community that includes BIO-supported researchers. PIs wishing to submit projects that focus primarily on biological sciences should submit to the Advances in Biological Informatics program (ABI; see [NSF 15-582](#)).

The foundational research divisions within the **Directorate for Computer and Information Science and Engineering (CISE)** – Computing and Communication Foundations (CCF), Computer and Network Systems (CNS), and Information and Intelligent Systems (IIS) – are interested in software or data engineering and infrastructure projects that support research in all areas that sustain progress in the CISE field or that advance and adapt CISE research to impact the data and software sustainability needs of other scientific and engineering disciplines.

The **Directorate for Education and Human Resources (EHR)** is interested in fostering novel, transformative, multidisciplinary approaches that address the use of large data sets and/or learning analytics to create actionable knowledge for improving STEM teaching and learning environments (formal and informal) in the medium term, and to revolutionize learning in the longer term.

The **Directorate for Engineering (ENG)** seeks proposals for innovative software and data infrastructure that enable major advances in fundamental discovery in the research areas of its Divisions of Chemical, Bioengineering, Environmental, and Transport Systems (CBET); Civil, Mechanical and Manufacturing Innovation (CMMI); and Electrical, Communications and Cyber Systems (ECCS). ENG will support proposals that give the engineering research community broad and sustained access to HPC and data platforms and technologies that support emerging research opportunities.

The following are division-specific CSSI priorities within ENG:

- *CMMI* seeks proposals that define scalable approaches to building and sustaining data and software infrastructure that address challenges in software development and implementation, and the data capture and characterization, curation, storage, management, and sharing of experimental and computational data, models, research codes and algorithms that will advance potentially transformative fundamental research in any program areas supported by the division. Topics of special interest include:
 - Processing, design, characterization and/or manufacturing of engineering materials; and
 - The design and operation of integrated human and technological elements of interdependent critical infrastructure systems. (Note: Only projects with meaningful integration will be considered for funding).
- *CBET* seeks proposals outlining potentially transformative and extensible approaches to establish data and software infrastructure that advance fundamental research in areas of division interest. Successful proposals will directly address the myriad challenges research communities face in harnessing advanced computing infrastructure and the associated data handling required to solve engineering problems; challenges include, but are not limited to: (1) the availability of robust methods for experimental and computational data generation, analysis, and storage, as well as straightforward approaches for sharing and curation; and/or (2) model, code, and software development or modernization. Topics of special interest include:
 - The development of enhanced modeling and data analysis tools and software for applications related to: (1) water resources; (2) metagenomics and applied environmental microbiology; (3) Earth systems; (4) built environments; (5) sustainable manufacturing; (6) energy conversion processes; (7) food systems; (8) material flows; (9) turbulent flows and flows of complex fluids and suspensions; (10) thermal transport processes; (11) combustion; (12) nanoparticle interactions; (13) industrially-relevant biomolecular recognition mechanisms and reactions or regulatory metabolic pathways; (14) tissue and organ system processes; (15) disease or injury diagnostic, monitoring, and treatment systems; or (16) characterization and restoration of human function and cognition;
 - The design of open-source, dynamic data and/or software infrastructure to facilitate multiscale modeling approaches that bridge the gap between molecular-, micro-, and macro-length and time scale phenomena;
 - Archival-quality data handling tools and repository development, with integrated relevant metadata, to provide effortless, sustained access to community-generated research data; and
 - The development of tools that improve predictive accuracy of computational methods and/or error assessment, including uncertainty analysis.
- *ECSS* seeks proposals with innovative approaches to establish data and software infrastructure that will advance the fundamental research areas supported by the division. Examples of topics of interest include, but are not limited to:
 - Data and software infrastructure to support innovations in devices, circuits, and systems for sensing, communications, and control;
 - Large-scale, real-time machine learning and dynamic data analytics to advance national infrastructure, e.g., wireless communication infrastructure or electrical power grid; and
 - Data and software infrastructure to support networked engineering cyber-physical testbeds that are remotely accessible.

The **Directorate for Geosciences (GEO)** is interested in the following research fields: atmospheric and geospace science, earth science, ocean science, and polar science. The directorate welcomes proposals that focus on the development and implementation of automated, executable, and optimized workflows that:

- are capable of real- and near-real-time archiving and manipulation of sensor and other field-based data, including experimental and/or simulation data;
- promote seamless discovery, access, and transfer of data and metadata across data resources and centers that are supported by GEO;
- “leverage-through-sharing” of existing investments in university, federal, and commercial computing and infrastructure;
- engage community models for the assimilation and use of data for initialization, state estimation, or sensitivity analysis; and
- encourage the development or reuse of computational techniques (i.e., high-performance distributed computing, machine learning, cloud computing, etc.) without which simulations would be difficult to conduct or large volumes of data could not be manipulated, analyzed, and transferred. The proposed computational techniques must be framed as sub-tasks within the proposed workflow.

All workflows must be designed to overcome significant bottlenecks to solving compelling Earth science questions.

Programmatic areas of interest within GEO include:

- The *Office of Polar Programs (OPP)* is interested in activities that advance understanding of the current and future states of high latitude ocean circulation, atmospheric conditions, marine and terrestrial ecosystems, and biogeochemistry, and the mechanisms that drive the seasonal evolution of sea and land ice melt. OPP welcomes interdisciplinary research that focuses on how the components of the polar regions (land, atmosphere, ocean, sea and land ice, etc.) interact as a system, with feedbacks and unanticipated emergent properties. OPP also welcomes proposals related to polar astrophysics and geospace research. Investigators who are interested in Arctic social science research are encouraged to also read the SBE Programmatic Areas of Interest below, and to contact the cognizant OPP and SBE program officers.
- The *Division of Atmospheric and Geospace Sciences (AGS)* is interested in answering fundamental science questions related to atmospheric and geospace research, including a wide variety of important processes that impact humans and society, such as space weather, tropospheric weather, physical and dynamic meteorology, climate, and air quality.
- The *Division of Earth Sciences (EAR)* is interested in improving our understanding of the structure, composition, and evolution of the Earth, the interaction with life, and the processes that govern the formation and behavior of the Earth's materials. EAR interests include the fields of “solid-earth” science (geology and paleontology, geochemistry, geophysics, continental hydrology, geomorphology, tectonics, and geobiology).
- The *Division of Ocean Sciences (OCE)* is interested in activities that advance understanding of all aspects of the global oceans and ocean basins, including their interactions with people and the integrated Earth system.

The **Directorate for Mathematical and Physical Sciences (MPS)** appreciates that software and data cyberinfrastructure enable scientific advances and discovery across MPS. In all MPS disciplines, there is need for cyberinfrastructure to support innovative scientific inquiry based on software and data that are findable, accessible, reusable, provenance traceable, and sustainably

maintainable. Data cyberinfrastructure may additionally combine the elements of algorithms, software, computation, networks, task automation, or custom hardware to support data-centric approaches to MPS science. Data may be derived from experiment, observation, or computation, and may be diverse in kind consistent with science across MPS.

The following are division-specific CSSI priorities within MPS:

- The *Division of Astronomical Sciences (AST)* is interested in proposals to support the development and dissemination of sustainable software and tools for data handling and computational activities that enable progress on key questions in astronomy and astrophysics.
- The *Division of Chemistry (CHE)* encourages proposals that focus on innovative software tools and data infrastructure that enable advances in CHE research areas and at the interface of chemistry and other research domains, including software to enable scientific advances in NSF priority areas. CHE is particularly interested in the development of data and software tools that support modeling of multiple and diverse interactions in complex systems and/or enable data-driven discovery in molecular science.
- The *Division of Materials Research (DMR)* encourages proposals that focus on innovative software tools and data cyberinfrastructure 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 and data CI to enable and support research that integrates digital data with experiment, computation, and theory, such as Designing Materials to Revolutionize and Engineer our Future (DMREF; [NSF 16-613](#)). DMR encourages proposals to further develop and to address gaps in the emerging community-wide "materials innovation data cyberinfrastructure network" to support discovery at all scales of research activities. This solicitation provides opportunities to include data developed through DMR-supported National Facilities and Instrumentation (NaFI), Materials Innovation Platforms (MIP), DMREF projects, Materials Research Science and Engineering Centers (MRSEC), and Partnerships in Research and Education in Materials (PREM). A priority is the development of data CI to support and stimulate the creation of innovative data-centric approaches in materials research which may require new paradigms.
- The *Division of Mathematical Sciences (DMS)* welcomes proposals that either (a) build computational and graphical tools that have broad application in mathematical sciences and related areas, or (b) translate significant and recently-developed mathematical and statistical models, algorithms, and methods into software tools that address substantial problems or data sets in fields outside the mathematical sciences.
- 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 software and data cyberinfrastructure, for example, through proposals that include visitor support, postdoctoral opportunities, or short training courses that increase interactions of domain scientists and software and/or cyberinfrastructure specialists. MPS welcomes innovative educational activities to train next-generation creators of cyberinfrastructure, and to train the community at all levels on using cyberinfrastructure in ways that broaden participation.

The **Directorate for Social, Behavioral, and Economic Sciences (SBE)** is interested in proposals that support the directorate's research priorities, such as those outlined in [SBE 2020](#). SBE is particularly interested in using CSSI to support projects building on other infrastructure activities such as Metadata for Long-standing Large-Scale Social Science Surveys ([META-SSS](#)) and Resource Implementations for Data Intensive Research in the Social, Behavioral and Economic Sciences ([RIDIR](#)). SBE also welcomes innovative approaches to big data problems in SBE-focused domains consistent with NSF's HDR Big Idea. SBE encourages proposals that further the goals of SBE and at least one other participating NSF directorate.

Important Note: Any prospective PIs should consult with program officers from the list of Cognizant Program Officers in the relevant research area(s) prior to submitting a proposal, to ascertain that the focus and budget of the proposed work are appropriate for this solicitation.

III. AWARD INFORMATION

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

Elements awards shall not exceed a total of \$600,000 and 3 years duration.

Framework Implementations awards shall range from \$200,000 to \$1M 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.

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 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:

- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for

International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.

- 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.
- NSF-sponsored federally funded research and development centers (FFRDCs) may apply, provided that they are not including costs for which federal funds have already been awarded or are expected to be awarded.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI: 1

An individual may participate as PI, co-PI, or other Senior Personnel on at most one proposal across the Elements and Framework Implementations for this solicitation. Thus, if an individual participates on an Elements proposal, he or she may not participate on a Framework Implementations proposal, and vice versa. Note that 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 any 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.

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:

- **NSF Unit of Consideration:** The "Divisions" section should automatically be selected. Select one class from the drop-down list in FastLane as the program(s) to consider the proposal. For example, Data Elements or Data Frameworks proposals should choose "DATANET" as the Program. Software Elements or Software Frameworks should choose "Software Institutes" as the Program. Grants.gov users should refer to Section VI.1.2. of the NSF Grants.gov Application Guide for specific

instructions on how to designate the NSF Unit of Consideration.

- **Proposal Title:** Provide a short informative title for the proposed project. To assist NSF staff in sorting proposals for review, proposal titles should begin with "Elements:" or "Framework:", followed by "Data" or "Software". Proposals that are to be considered as responsive to the NSCI should additionally prefix their title with "NSCI". Proposals that are to be considered as responsive to HDR should additionally prefix their title with "HDR".
- **International Partners:** If your project involves international partners, check the international activities box and list the countries involved. The system allows one PI and at most four co-PIs to be designated for each proposal. 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 project, the innovative 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 infrastructure 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):

The Project Description should define an agenda that will lead to sustainable software and data cyberinfrastructure capable of enabling transformative, robust, and reliable science and engineering. In addition to the guidance specified in the PAPPG, the Project Description should explicitly address the following items:

- **Science-driven:** How will the project outcomes fill well-recognized science and engineering needs of the research community, and advance research capability within a significant area or areas of science and engineering? What are the broader impacts of the project, such as benefits to science and engineering communities beyond initial targets, under-represented communities, and education and workforce development? The Project Description should provide a compelling discussion of the potential to benefit its intended as well as broader communities.
- **Innovation:** What innovative and transformational capabilities will the project bring to its target communities, and how will the project integrate innovation and discovery into the project activities, such as through empirical research embedded as an integral component of the project activities? Such research might encompass reproducibility, provenance, effectiveness, usability, and adoption of the components, adaptability to new technologies and to changing requirements, and the development of lifecycle processes used in the project.
- **Close collaborations among stakeholders:** How will the project activities engage CI experts, specialists, and scientists and engineers working in concert with the relevant domain scientists and engineers who are users of CI?
- **Building on existing, recognized capabilities:** How will the project activities build on and leverage existing NSF and national cyberinfrastructure investments, as appropriate?
- **Project plans, and system and process architecture:** The Project Description should include high-quality management plans. The proposal should include user interactions and a community-driven approach, and provide a timeline including a proof-of-concept demonstration of the key components. The proposal must include a list of tangible metrics to be used to measure the success of the project activities, and describe how progress will be measured along the way. If the outcome of the project is software or data cyberinfrastructure, the architecture of the CI and the 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, all must be sufficiently described. The description of the CI architecture and processes should explain how security, trustworthiness, provenance, reproducibility, and usability will be addressed by the project and integrated into the proposed system and the engineering process, and how adaptability to new technologies and changing requirements will be addressed by the project and built into the proposed system, as appropriate.
- **Sustained and sustainable impacts:** The Project Description should address how the project outcomes and its activities will have long-term impacts, and how these will be sustained beyond the lifetime of the award, as appropriate. If the outcome of the project is software or data cyberinfrastructure, the proposal should identify what license will be used for the released CI, and why this license has been chosen. PIs who have been previously funded under previous CI awards should show quantifiable evidence of the use, impact and sustainability of the previously funded work (and include a citation to the published CI in their biographical sketches as one of their relevant products, if appropriate).

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 Documents:

In addition to the guidance specified in the PAPPG, the following Supplementary Documents should be included (if required):

1. **Management and Coordination Plan** (Framework Implementations only; 3-page limit, to be submitted as a Supplementary Document): Every Framework Implementation 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-disciplinary scientific integration (e.g., yearly workshops, graduate student exchanges, 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. **Letters of Collaboration** (optional): Include documentation of funded or unfunded collaborative arrangements of significance to the proposal through Letters of Collaboration. [See [PAPPG Chapter II.C.2.d\(iv\)](#) for details.] 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 the 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.

3. Project Personnel and Partner Institutions (required for all award categories): Provide current, accurate information for all personnel and institutions involved in the project. 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:

- o Mary Smith; XYZ University; PI
- o John Jones; University of PQR; Senior Personnel
- o Jane Brown; XYZ University; Postdoc
- o Bob Adams; ABC Inc.; Paid Consultant
- o Mary White; Welldone Institution; Unpaid Collaborator
- o Tim Green; ZZZ University; Subawardee

Single Copy Documents:

Collaborators and Other Affiliations Information: Proposers should follow the guidance specified in [Chapter II.C.1.e](#) of the NSF PAPPG.

Note the distinction to item 3, 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 Supplementary Document (item 5) who 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):

April 18, 2018

Elements

- *Data Elements*
- *Software Elements*

Framework Implementations

- *Data Frameworks*
- *Software Frameworks*

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.

- **Science-driven:** To what extent is the proposed project science-driven? How will the project outcomes fill well-recognized science and engineering needs of the research community, and advance research capability within a significant area or areas of science and engineering? What will be the broader impacts of the project, such as, its benefits to science and engineering communities beyond its initial targets, under-represented communities, and education and workforce development? The Project Description should provide a compelling discussion of the potential to benefit its intended as well as broader communities.
- **Innovation:** To what extent is the proposed project innovative? What innovative and transformational capabilities will the project bring to its target communities? How will the project integrate innovation and discovery into the project activities, such

as through empirical research embedded as an integral component of the project activities? Such research might encompass reproducibility, provenance, effectiveness, usability, and adoption of the components, its adaptability to new technologies and to changing requirements, and the development lifecycle processes used in the project.

- **Close collaborations among stakeholders:** To what extent does the proposed project involve close collaborations among stakeholders? How will the project activities engage CI experts, specialists, and scientists and engineers working in concert with the relevant domain scientists and engineers who are users of CI?
- **Building on existing, recognized capabilities:** To what extent does the proposed project build on existing, recognized capabilities? How will the project activities build on and leverage existing NSF and national cyberinfrastructure investments, as appropriate?
- **Project plans, and system and process architecture:** How well-described are the project plans, and system and process architecture? The Project Description should include high-quality management plans. The proposal should include user interactions and a community-driven approach, and provide a timeline including a proof-of-concept demonstration of the key components. The proposal must include a list of tangible metrics to be used to measure the success of the project activities, and must describe how progress will be measured along the way. If the outcome of the project is software or data cyberinfrastructure, the architecture of the CI and the 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, all must be sufficiently described. The description of the CI architecture and processes should explain how security, trustworthiness, provenance, reproducibility, and usability will be addressed by the project and integrated into the proposed system and the engineering process, and how adaptability to new technologies and changing requirements will be addressed by the project and built into the proposed system, as appropriate.
- **Sustained and sustainable impacts:** How well does the project address the achievement of sustained and sustainable impacts? The Project Description should address how the project outcomes and its activities will have long-term impacts, and how these will be sustained beyond the lifetime of the award, as appropriate. If the outcome of the project is software or data cyberinfrastructure, the proposal should identify what license will be used for the released CI, and why this license has been chosen. PIs who have been previously funded under previous CI awards should show quantifiable evidence of the use, impact, and sustainability of the previously funded work (and include a citation to the published CI in their biographical sketches as one of their relevant products, if appropriate).

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=pappg.

Special Award Conditions:

- Awardees are expected to participate in annual PI meetings with travel costs supported by the award.
- Some awards, in particular Framework Implementations 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:

- Vipin Chaudhary, Program Director, CISE/OAC, telephone: (703) 292-2254, email: CSSIQueries@nsf.gov
- Amy Walton, Program Director, CISE/OAC, telephone: (703) 292-4538, email: CSSIQueries@nsf.gov
- Rajiv Ramnath, Program Director, CISE/OAC, telephone: (703) 292-4776, email: CSSIQueries@nsf.gov
- Peter H. McCartney, Program Director, BIO/DBI, telephone: (703) 292-8470, email: CSSIQueries@nsf.gov
- Almadena Y. Chchelkanova, Program Director, CISE/CCF, telephone: (703) 292-8910, email: CSSIQueries@nsf.gov
- Sol Greenspan, Program Director, CISE/CCF, telephone: (703) 292-8910, email: CSSIQueries@nsf.gov
- Sylvia Spengler, Program Director, CISE/IIS, telephone: (703) 292-8930, email: CSSIQueries@nsf.gov
- John C. Cherniavsky, Senior Advisor, EHR/DRL, telephone: (703) 292-5136, email: CSSIQueries@nsf.gov
- Ronald Joslin, Program Director, ENG/CBET, telephone: (703) 292-7030, email: CSSIQueries@nsf.gov
- Christina Payne, Associate Program Director, ENG/CBET, telephone: (703) 292-2895, email: CSSIQueries@nsf.gov

- Joanne D. Culbertson, Program Director, ENG/CMMI, telephone: (703) 292-4602, email: CSSIQueries@nsf.gov
- Jenshan Lin, Program Director, ENG/ECCS, telephone: (703) 292-7950, email: CSSIQueries@nsf.gov
- Subhashree (Shree) Mishra, Program Director, GEO/AGS, telephone: (703) 292-8521, email: CSSIQueries@nsf.gov
- Marc Stieglitz, Program Director, GEO/OPP, telephone: (703) 292-2461, email: CSSIQueries@nsf.gov
- Nigel A. Sharp, Program Director, MPS/AST, telephone: (703) 292-4905, email: CSSIQueries@nsf.gov
- Evelyn Goldfield, Program Director, MPS/CHE, telephone: (703) 292-2173, email: CSSIQueries@nsf.gov
- Lin He, Program Director, MPS/CHE, telephone: (703) 292-4956, email: CSSIQueries@nsf.gov
- Daryl W. Hess, Program Director, MPS/DMR, telephone: (703) 292-4942, email: CSSIQueries@nsf.gov
- Christopher W. Stark, Program Director, MPS/DMS, telephone: (703) 292-4869, email: CSSIQueries@nsf.gov
- Yong Zeng, Program Director, MPS/DMS, telephone: (703) 292-2301, email: CSSIQueries@nsf.gov
- Vyacheslav (Slava) Lukin, Program Director, MPS/PHY, telephone: (703) 292-7382, email: CSSIQueries@nsf.gov
- Bogdan Mihaila, Program Director, MPS/PHY, telephone: (703) 292-8235, email: CSSIQueries@nsf.gov
- Cheryl L. Eavey, Program Director, SBE/SES, telephone: (703) 292-7269, email: CSSIQueries@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.

General questions on the solicitation should be sent to CSSIQueries@nsf.gov, or to the following Program Officers:

- Vipin Chaudhary, Program Director, OAC, telephone: (703) 292-2254
- Amy Walton, Program Director, OAC, telephone: (703) 292-4538
- Rajiv Ramnath, Program Director, OAC, telephone: (703) 292-4776

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>.

ABOUT THE NATIONAL SCIENCE FOUNDATION

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:** 2415 Eisenhower Avenue, Alexandria, VA 22314
- **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
Alexandria, VA 22314

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