Partnerships between Science and Engineering Fields and the NSF TRIPODS Institutes

TRIPODS + X

PROGRAM SOLICITATION

NSF 18-542

National Science Foundation

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

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

Directorate for Engineering
- Division of Civil, Mechanical and Manufacturing Innovation
- Engineering Education and Centers

Directorate for Geosciences
- Division of Atmospheric and Geospace Sciences
- Division of Earth Sciences
- Division of Ocean Sciences
- Office of Polar Programs

Directorate for Social, Behavioral & Economic Sciences
- Division of Social and Economic Sciences

Office of Integrative Activities

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

May 29, 2018

IMPORTANT INFORMATION AND REVISION NOTES

This is the first offering of the TRIPODS + X program. However, the TRIPODS Phase I solicitation contains relevant background information for this solicitation.

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 18-1), which is effective for proposals submitted, or due, on or after January 29, 2018.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Partnerships between Science and Engineering Fields and the NSF TRIPODS Institutes
TRIPODS + X

Synopsis of Program:

The National Science Foundation's (NSF's) Directorates for Computer & Information Science & Engineering (CISE) and Mathematical & Physical Sciences (MPS) recently launched the Transdisciplinary Research in Principles of Data Science (TRIPODS) Phase I program with the goal of promoting long-term, interdisciplinary research and training activities that engage theoretical computer scientists, statisticians, and mathematicians in developing the theoretical foundations of data science. Twelve TRIPODS Phase I Institutes were established in FY17 (see https://www.nsf.gov/news/news_summ.jsp?cntn_id=242888).

The *Partnerships between Science and Engineering Fields and the NSF TRIPODS Institutes (TRIPODS + X)* solicitation seeks to expand the scope of the TRIPODS program beyond the foundations community by engaging researchers across other NSF disciplines and the TRIPODS research teams in collaborative activities. TRIPODS + X projects will foster relationships between researchers in science & engineering domains and foundational data scientists by leveraging existing NSF investments in the TRIPODS organizations. Working in concert with a TRIPODS organization, a TRIPODS + X project would focus on data-driven research challenges motivated by applications in one or more science and engineering domains or other activities aimed at building robust data science communities.

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.

- Nandini Kannan, Program Director, Division of Mathematical Sciences, MPS/DMS, telephone: (703) 292-8104, email: nakannan@nsf.gov
- Tracy Kimbrel, Program Director, Division of Computing and Communication Foundations, CISE/CCF, telephone: (703) 292-7924, email: tkimbrel@nsf.gov
- Rahul T. Shah, Program Director, Division of Computing and Communication Foundations, CISE/CCF, telephone: (703) 292-2709, email: rshah@nsf.gov
- Christopher W. Stark, Program Director, Division of Mathematical Sciences, MPS/DMS, telephone: (703) 292-4869, email: cstark@nsf.gov
- Eva Campo, Program Director, Division of Materials Research, MPS/DMR, telephone: (703) 292-7010, email: ecampo@nsf.gov
- Darleen L. Fisher, Program Director, Division of Computer and Network Systems, CISE/CNS, telephone: (703) 292-4547, email: dlfisher@nsf.gov
- Lin He, Program Director, Division of Chemistry, MPS/CHE, telephone: (703) 292-4956, email: lhe@nsf.gov
- Kenneth Land, Program Director, Division of Social and Economic Sciences, SBE/SES, telephone: (703) 292-8760, email: kland@nsf.gov
- Alexis Lewis, Program Director, Division of Civil, Mechanical & Manufacturing Innovation, ENG/CMMI, telephone: (703) 292-2624, email: alewis@nsf.gov
- Eduardo A. Misawa, Program Director, Division of Engineering Education & Centers, ENG/EEC, telephone: (703) 292-5353, email: emisawa@nsf.gov
- Nigel A. Sharp, Program Director, Division of Astronomical Sciences, MPS/AST, telephone: (703) 292-4905, email: nsharp@nsf.gov
- Eva Zanzerkia, Program Director, Division of Earth Sciences GEO/EAR, telephone: (703) 292-4734, email: ezanzerk@nsf.gov
- Aidong Zhang, Program Director, Division of Information and Intelligent Systems, CISE/IIS, telephone: (703) 292-5311, email: azhang@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

Estimated Number of Awards: 30

Approximately 6-12 awards in each of three tracks are anticipated. The number of awards of each type will be based on quality of proposals, availability of funds, and responsiveness to priorities of the participating directorates/divisions.

Anticipated Funding Amount:

$6,500,000 to $10,710,000

Proposers may request up to $600,000 total for Research Track awards; $200,000 total for Visioning Track awards; $200,000 total for Education Track awards. For each track, the duration may be up to three years.

Eligibility Information

Who May Submit Proposals:

The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG), Chapter I.E.

Who May Serve as PI:

At least one PI or co-PI must represent a discipline other than mathematics, statistics, and theoretical computer science. At least one PI or co-PI must be a PI, co-PI, or Senior Personnel of one of the 12 TRIPODS Phase I Institute projects initiated in FY 2017 pursuant to NSF solicitation NSF 16-615 (see https://www.nsf.gov/news/news_summ.jsp?cntn_id=242888).

Participation of PIs and co-PIs at institutions other than the TRIPODS awardee organizations is particularly encouraged and will receive priority consideration. This collaboration can be via sub-awards or via NSF's collaborative proposal mechanism, regardless of which institution is designated as the lead.

These eligibility constraints will be strictly enforced in order to treat everyone fairly and consistently. Proposals that do not meet these requirements will be returned without review. No exceptions will be made.

Limit on Number of Proposals per Organization: 5

Each TRIPODS Phase I organization may participate in at most five proposals. Each TRIPODS Phase I organization may participate in at most three proposals in any of the three tracks.

These eligibility constraints will be strictly enforced in order to treat everyone fairly and consistently. In the event that a TRIPODS Phase I organization exceeds this limit, proposals received within the limit will be accepted based on earliest date and time of proposal submission (i.e., the first five proposals received will be accepted and the remainder will be returned without review or the first three proposals submitted to a particular track will be accepted and the remainder will be returned without review). No exceptions will be made.

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

There are no restrictions or limits.

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):

  May 29, 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:

Standard NSF award conditions apply.

Reporting Requirements:

Standard NSF reporting requirements apply.

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I. INTRODUCTION

The National Science Foundation's Ten Big Ideas identify bold, long-term research and process ideas that identify areas for future investment at the frontiers of science and engineering. The Big Ideas represent unique opportunities to position our Nation at the cutting edge of global science and engineering leadership and to invest in fundamental research and processes that advance U.S. prosperity, security, health, and well-being. At the nexus of two of these Big Ideas – **Harnessing the Data Revolution (HDR)** and **Growing Convergent Research at NSF (GCR)** – the Transdisciplinary Research in Principles of Data Science (TRIPODS) program was designed to facilitate long-term, interdisciplinary research and training activities addressing the theoretical foundations of data science.

Via this solicitation, NSF seeks to expand the scope of the TRIPODS program beyond the foundations community to involve researchers across other NSF disciplines (referred to as "Field X" or "domain science & engineering" in this solicitation). TRIPODS + X represents a new, unique framework for collaboration, synergy, and transdisciplinarity that deepens the connection between HDR and GCR. It enables vital collaboration to address important problems in science and engineering through data-driven approaches, while further advancing the foundations of data science.

II. PROGRAM DESCRIPTION

Ensuring that foundational research and education in data science are relevant to applications and that data-driven science & engineering are grounded in solid theoretical foundations requires coordination and collaboration among researchers and educators representing these different communities. With this solicitation, NSF encourages the submission of proposals to facilitate this coordination. Proposals should aim to engender partnerships between domain science & engineering and foundational data science that benefit and strengthen both communities, not only through significant exchange of ideas and methods, but also through true collaborative efforts with lasting impacts. TRIPODS + X focuses on interdisciplinary research and training activities leading to advances in foundational data science knowledge, as well as solutions to data-driven challenges in other areas of science & engineering. While there will be continued benefit from collaborations with computer scientists, statisticians, and mathematicians, many research questions in science and engineering may require fundamentally new approaches, leading to new discoveries and the development of new theories and principles, and in some cases, completely new areas of research. The long-term goal of these activities is to develop robust data science communities across multiple scientific disciplines, reinforcing mechanisms that enable translational as well as foundational outcomes.

With recent advances in technology and computing infrastructure, many fields of science & engineering now have access to vast amounts of data, enabling data-driven innovation and leading to new data-driven research challenges. The challenges posed by complex data elements such as images, text, and networks; unstructured and heterogeneous data formats; streaming and dynamic data; complex dependence structures; missing, uncertain, and noisy information; sparsity; and information hidden at the noise level will require research that (a) addresses the core algorithmic, mathematical, and statistical principles; and (b) leads to new approaches, computational tools, and software for data-driven discovery within and across these science & engineering domains. Examples of data-driven research challenges include:

- Understanding the correlation between microstructures and physical properties of materials;
- Understanding the correlations between synthesis, microstructures, and physical properties of materials through data science;
- Data-driven discoveries to advance fundamental understanding of chemical systems;
- Data-driven understanding of manufacturing that enables new processes and systems with enhanced capabilities, predictability and productivity;
- Anonymization of proprietary and personal data streams essential to fundamental research on manufacturing, health care, smart cities, and disaster response;
- Environmental sustainability analyses driven by massive Life Cycle Assessment (LCA) and energy systems datasets;
- Modeling, simulation, and feedback control of complex dynamical systems subject to uncertainty and computationally efficient approaches to model validation;
- Continued improvement in the performance, cost-effectiveness, and security of computer and network systems driven by data analysis;
- Understanding massively-scaled and fundamentally new social and economic interactions enabled by ubiquitous connectivity and data collection;
- Applications in the geosciences including atmospheric and geospace, Earth science, ocean science and research in the polar regions;
- Leveraging of EarthCube's registry of data resources and capabilities to address challenges facing the geosciences community from the space-atmosphere boundary to the inner core of the planet;
- Detection of singular phenomena and/or patterns in massive experimental data sets such as those produced by the Large Synoptic Survey Telescope (LSST); and
- Methodologies to improve fairness and accountability in scientific and societal applications of data science.
- Algorithmic, mathematical, and statistical approaches for applications in the life sciences.

We emphasize that the list above is illustrative only, and is not meant to limit the scope of potential topic areas for research, visioning, and education efforts.

Projects in areas supported by the participating NSF directorates/divisions (noted at the top of this solicitation) will be given priority. PIs are strongly encouraged to discuss their planned research with the cognizant program officer from the respective NSF directorate/division before submitting the proposal.

While we expect projects to result in software and systems development resulting from foundational challenges in areas of science & engineering, those projects focused solely on the development of a software and data cyberinfrastructure ecosystem should consider the Cyberinfrastructure for Sustained Scientific Innovation (CSSI) program NSF 18-531 (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf18531).

Projects, not affiliated with a TRIPODS organization, focused on foundations and innovative applications related to Big Data may consider the Critical Techniques and Technologies for Advancing Foundations and Applications of Big Data Science & Engineering (BIGDATA) program NSF 18-539 (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf18539). Similarly, projects focused primarily on new computational and data analysis approaches may consider the Computational and Data-Enabled Science and Engineering (CDS&E) program (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504813).

Programmatic Areas of Interest

While proposals spanning all domain science & engineering areas supported by NSF are welcome, priority will be given to those traditionally supported by the participating directorates/divisions. Additionally, in the case of two of the participating directorates/divisions, please consider the following emphasis areas:

The Division of Chemistry (CHE) is particularly interested in research topics identified in the Dear Colleague Letter: Data-Driven Discovery Science in Chemistry (D3SC) (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf17112) CHE will support only projects submitted to the Research Track.

The Division of Engineering Education and Centers (EEC) is interested in proposals that will fundamentally advance the research and education in the Engineering Research Centers (ERC) through new close collaborations between the ERC researchers and data scientists who have been working on foundational challenges in areas of science & engineering.

Types of Proposals

Principal investigators (PIs) are encouraged to submit proposals in response to three tracks:

- **Research Track**: research activities motivated by applications in one or more science & engineering domains;
- **Visioning Track**: workshops and conferences, innovation labs, and other community-building and direction-setting activities; and
- **Education Track**: curriculum development and other education- and training-related activities.

1. **Research Track**: In this track, we welcome convergent, interdisciplinary projects bringing together members of the TRIPODS disciplines and other fields of inquiry, with demonstrated value on both sides of the partnership. Scientists and engineers should bring new data-driven challenges and/or data sets for consideration by TRIPODS researchers. The partnership should lead to the development of innovative algorithms and working solutions with relevance for the practitioner communities. Projects should also describe the potential for new foundational research motivated by these challenges. The feedback loop thus created should help set the stage for long-term synergy as envisioned by the TRIPODS Phase I program, leading to the planned TRIPODS Phase II activity. Co-advising and/or exchange of students and postdoctoral researchers is encouraged.
2. **Visioning Track:** In this track, we welcome projects that foster relationships between research communities via workshops and conferences, innovation labs, and other community-building and direction-setting activities. Goals may range from defining common terminology and methods to translating challenging problems in science and engineering into a data-centric approach to setting specific convergent research agendas for harnessing the data revolution to address the nation's most pressing challenges.
3. **Education Track:** In this track, we welcome projects to develop and pilot approaches to define and address curricula and workforce development needs related to data science, at any or all educational levels. While these activities may naturally focus primarily on a particular field of domain science & engineering, broad applicability of foundational concepts should be considered. Projects may also focus on training activities, including bootcamps for graduate students and junior researchers and development of material for short courses.

   Proposals submitted to the Research Track may include visioning and educational activities as part of the research agenda.

   For all tracks, proposals must describe how the project fits into and furthers the overall aims of the TRIPODS program as described in the TRIPODS Phase I solicitation NSF 16-615. For all tracks, budgets should be commensurate with the scope and extent of the proposed activities.

III. AWARD INFORMATION

Anticipated Type of Award: Standard Grant

Estimated Number of Awards: 30

Approximately 6-12 awards in each of three tracks are anticipated. The number of awards of each type will be based on quality of proposals, availability of funds, and responsiveness to priorities of the participating directorates/divisions.

Anticipated Funding Amount: $6,500,000 to $10,710,000

Proposers may request up to $600,000 total for Research Track awards; $200,000 total for Visioning Track awards; $200,000 total for Education Track awards. For each track, the duration may be up to three years.

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

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG), Chapter I.E.

Who May Serve as PI:

At least one PI or co-PI must represent a discipline other than mathematics, statistics, and theoretical computer science. At least one PI or co-PI must be a PI, co-PI, or Senior Personnel of one of the 12 TRIPODS Phase I Institute projects initiated in FY 2017 pursuant to NSF solicitation NSF 16-615 (see https://www.nsf.gov/news/news_summ.jsp?cntn_id=242888).

Participation of PIs and co-PIs at institutions other than the TRIPODS awardee organizations is particularly encouraged and will receive priority consideration. This collaboration can be via sub-awards or via NSF's collaborative proposal mechanism, regardless of which institution is designated as the lead.

These eligibility constraints will be strictly enforced in order to treat everyone fairly and consistently. Proposals that do not meet these requirements will be returned without review. No exceptions will be made.

Limit on Number of Proposals per Organization: 5

Each TRIPODS Phase I organization may participate in at most five proposals. Each TRIPODS Phase I organization may participate in at most three proposals in any of the three tracks.

These eligibility constraints will be strictly enforced in order to treat everyone fairly and consistently. In the event that a TRIPODS Phase I organization exceeds this limit, proposals received within the limit will be accepted based on earliest date and time of proposal submission (i.e., the first five proposals received will be accepted and the remainder will be returned without review or the first three proposals submitted to a particular track will be accepted and the remainder will be returned without review). No exceptions will be made.

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

There are no restrictions or limits.

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.

Proposal Title: For Research Track proposals, the proposal title must begin with "TRIPODS+X:RES:". For Visioning Track proposals, the proposal title must begin with "TRIPODS+X:VIS:". For Education Track proposals, the proposal title must begin with "TRIPODS+X:EDU:". Titles of collaborative proposals should be prepared in a similar manner, but should also include "Collaborative Research" immediately after the track. For example, the title of a Research Track collaborative proposal would be "TRIPODS+X:RES: Collaborative Research: Title.

Project Description: For proposals submitted to the Visioning Track, the project description should not exceed 8 pages. For Research and Education Track projects, the standard 15-page limits apply.

Results of Prior NSF Support: For the PI or co-PI(s) from a TRIPODS Institute, the Project Description must include a section describing the results from the TRIPODS project, including educational and training activities. Standard NSF guidance for reporting Results of Prior NSF Support applies to PIs and co-PIs from outside the TRIPODS Institutes.

Supplementary Documents: Supplementary documents are limited to the specific types of documentation listed in the PAPPG, with exceptions specified below. Proposals containing special information or supplementary documentation that has not been explicitly allowed in the PAPPG or this solicitation, such as article reprints or preprints, or appendices, will be returned without review. Simultaneously submitted collaborative proposals, and proposals that include subawards, are a single unified project. Supplementary documents for such proposals should only be provided in the proposal submitted by the lead institution. See below for specific instructions for each supplementary document type.

a. Project Coordination Plan - Required of all proposals (page limit: 2 pages).

All proposals must include a supplementary document of no more than two pages labeled "Project Coordination Plan", which must include:

1. the roles and administrative, technical, and scientific responsibilities for the project or program should be delineated for the PIs

and other collaborators; for the purpose of this solicitation, PIs must make the case that they have expertise in the selected field;
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-discipline scientific integration, e.g., workshops, graduate student exchanges, project meetings at conferences, use of videoconferencing and other communication tools, software repositories, etc.; and
4. a detailed timeline of project activities/milestones.

b. Letter of Collaboration from TRIPODS Lead PI - Required of all proposals.

The lead PI of the participating TRIPODS team must submit a letter of collaboration in the format described in the PAPPG (NSF 18-1).

c. Letters of Collaboration.

Any substantial collaboration with individuals not included in the budget should be described in the Facilities, Equipment and Other Resources section of the proposal and documented in a Letter of Collaboration from each collaborator. Such letters should be provided in the supplementary documents section of the proposal and follow the format instructions specified in the PAPPG. Collaborative activities that are identified in the budget should follow the instructions in the PAPPG.

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."

The documents listed above are **in addition** to those required by the PAPPG (NSF 18-1).

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Budget Preparation Instructions:

Domain science PIs will be encouraged to attend the annual TRIPODS PI meetings and should consider including funds for this purpose in their budget preparation.

C. Due Dates

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

  May 29, 2018

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

Convergence/Synergy: Is the project transdisciplinary, bringing together domain scientists and engineers with data science foundations researchers to address emerging data-driven research challenges and/or educational needs? Is there synergy among the different groups? Does the project demonstrate the potential for intellectual merit on both sides of the partnership, long-term synergy, and added value for all proposed fields of study? Does the project include plans to disseminate results of the research to communities on both sides of the partnership?

Quality and Value of Collaboration: Is the expertise of the PIs complementary and well-suited to the activities described in this proposal? Are the specific roles of each collaborating investigator clear? Does the collective team have expertise representing field X and the foundations? Is the resource allocation adequate to support activities on both sides of the partnership?

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.

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:

- Nandini Kannan, Program Director, Division of Mathematical Sciences, MPS/DMS, telephone: (703) 292-8104, email: nakannan@nsf.gov
- Tracy Kimbrel, Program Director, Division of Computing and Communication Foundations, CISE/CCF, telephone: (703) 292-7924, email: tkimbrel@nsf.gov
- Rahul T. Shah, Program Director, Division of Computing and Communication Foundations, CISE/CCF, telephone: (703) 292-2709, email: rshah@nsf.gov
- Christopher W. Stark, Program Director, Division of Mathematical Sciences, MPS/DMS, telephone: (703) 292-4869, email: cstark@nsf.gov
- Eva Campo, Program Director, Division of Materials Research, MPS/DMR, telephone: (703) 292-7010, email: ecampo@nsf.gov
- Darleen L. Fisher, Program Director, Division of Computer and Network Systems, CISE/CNS, telephone: (703) 292-4547, email: dlfisher@nsf.gov
- Lin He, Program Director, Division of Chemistry, MPS/CHE, telephone: (703) 292-4956, email: lhe@nsf.gov
- Kenneth Land, Program Director, Division of Social and Economic Sciences, SBE/SES, telephone: (703) 292-8760, email: kland@nsf.gov
- Alexis Lewis, Program Director, Division of Civil, Mechanical & Manufacturing Innovation, ENG/CMMI, telephone: (703) 292-2624, email: alewis@nsf.gov
- Eduardo A. Misawa, Program Director, Division of Engineering Education & Centers, ENG/EEC, telephone: (703) 292-5353, email: emisawa@nsf.gov
- Nigel A. Sharp, Program Director, Division of Astronomical Sciences, MPS/AST, telephone: (703) 292-4905, email: nsharp@nsf.gov
- Eva Zanzerkia, Program Director, Division of Earth Sciences GEO/EAR, telephone: (703) 292-4734, email: ezanzerk@nsf.gov
- Aidong Zhang, Program Director, Division of Information and Intelligent Systems, CISE/IIS, telephone: (703) 292-5311, email: azhang@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.

Related Programs:

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 (FASED) 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:

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