Training-based Workforce Development for Advanced Cyberinfrastructure (CyberTraining)

PROGRAM SOLICITATION
NSF 17-507

National Science Foundation

Directorate for Computer & Information Science & Engineering
    Division of Advanced Cyberinfrastructure
    Division of Computing and Communication Foundations

Directorate for Engineering

Directorate for Geosciences

Directorate for Education & Human Resources
    Division of Graduate Education

Directorate for Mathematical & Physical Sciences

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

January 18, 2017

October 09, 2017

Second Monday in October, Annually Thereafter

IMPORTANT INFORMATION AND REVISION NOTES

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 16-1), which is effective for proposals submitted, or due, on or after January 25, 2016.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Training-based Workforce Development for Advanced Cyberinfrastructure (CyberTraining)

Synopsis of Program:

The overarching goal of this program is to prepare, nurture and grow the national scientific workforce for *creating, utilizing,* and *supporting* advanced cyberinfrastructure (CI) that enables cutting-edge science and engineering and contributes to the Nation's overall economic competitiveness and security. For the purpose of this solicitation, advanced CI is broadly defined as the resources, tools, and services for advanced computation, data handling, networking and security. The need for such workforce development programs are highlighted by the (i) *National Strategic Computing Initiative* announced in 2015 (NSCI), which is co-led by NSF and aims to advance the high-performance computing ecosystem and develop workforce essential for scientific discovery; (ii) 2016 National Academies' report on *Future Directions for NSF Advanced Computing Infrastructure to Support U.S. Science and Engineering in 2017-2020;* and (iii) *Federal Big Data Research and Development Strategic Plan*, which seeks to expand the community of data-empowered experts across all domains.

This solicitation calls for developing innovative, scalable training programs to address the emerging needs and unresolved bottlenecks in scientific and engineering workforce development of targeted, multidisciplinary communities, at the postsecondary level and beyond, leading to transformative changes in the state of workforce preparedness for advanced CI in the short and long terms. A primary goal is to broaden CI access and adoption by (i) increasing or deepening accessibility of methods and resources of advanced CI and of computational and data science and engineering by a wide range of *institutions* and *scientific communities* with lower levels of CI adoption to date; and (ii) harnessing the capabilities of larger segments of diverse underrepresented groups. Proposals from and in partnership with the aforementioned communities are especially encouraged. For student training, a key concern is not to increase the time to degree; hence the emphasis shall be on out-of-class, informal training.

Prospective principal investigators (PIs) are encouraged to engage all relevant stakeholders by forging alliances, and forming backbones for *collective impact,* which is particularly necessary in order to address unresolved bottlenecks (John Kania & Mark Kramer, "Collective Impact," *Stanford Social Innovation Review*, Winter 2011). PIs may seek public-private partnerships for relevance, enrichment, pursuit of national and international dimensions, and sustainability. All projects shall include training activities. In the short term, the projects shall result in innovative, scalable, informal training models and pilot activities, complementing and leveraging the state of art in curricular offerings, material, and best practices in academia and elsewhere. In the long term, the projects should

contribute to the larger goals of an educational ecosystem enabling "Computational and Data Science for All," with an understanding of computation as the third pillar (*President's Information Technology Advisory Committee Report, Computational Science: Ensuring America's Competitiveness*, 2005) and data-driven science as the fourth pillar of the scientific discovery process (*2016 National Academies report*), in addition to the traditional first and second pillars, respectively, of theory and experimentation. Furthermore, in the long term, projects should contribute toward an ubiquitous educational cloud infrastructure for online, dynamic, personalized lessons and certifications in CI and other multidisciplinary areas (Continuous Collaborative Computational Cloud in Higher Education, Chapter 1, *NSF Advisory Committee for Cyberinfrastructure Task Force on Cyberlearning and Workforce Development Report,* 2011).

There are three tracks for submissions:

(i) **CI Professionals (CIP):** aimed at the training and career pathway development of research cyberinfrastructure and professional staff who develop, deploy, manage, and support effective use of advanced CI for research;

(ii) **Domain science and engineering (DSE):** aimed primarily at the communities of *CI Contributors* and sophisticated *CI Users, and* aligned with the research and education priorities of the participating domain directorates; and

(iii) **Computational and data science literacy (CDL):** aimed at the *CI User* community at the undergraduate level.

The communities of *CI Professionals, Contributors, and Users* supported by the above three tracks are defined in Section I - Introduction.

Each CyberTraining award shall range from $300,000 to $500,000 per award and shall be up to 3 years in duration. Based on the community response and needs, the CyberTraining solicitation may be expanded to accommodate larger projects in the future.

Programmatic Areas of Interest

The CyberTraining program includes all divisions within the Directorates of Engineering (ENG), Geosciences (GEO), and Mathematical and Physical Sciences (MPS), as well as the Divisions of Advanced Cyberinfrastructure (ACI) and Computing and Communication Foundation (CCF) in the Directorate for Computer and Information Science and Engineering (CISE), and the Division of Graduate Education (DGE) in the Directorate for Education and Human Resources (EHR). The appropriate contact for the CyberTraining program in any directorate/division is the Cognizant Program Officer (PO) for the respective directorate/division listed.

All projects must advance cyberinfrastructure training and education goals as described in the full text of this solicitation, in addition to addressing specific domain needs. Not all directorates/divisions are participating at the same level and some have specific research and education priorities as described below. Prospective PIs are **strongly encouraged** to contact the Cognizant Program Officers in CISE/ACI **and** in the participating directorate/division(s) relevant to the proposal to ascertain whether the focus and budget of the proposed activities are appropriate for this solicitation. Such consultations should be completed at least one month in advance of the submission deadline**.** PIs should include the names of the Cognizant Program Officers consulted in their Project Summary as described in Section V(A) - Proposal Preparation Instructions.

The Directorate for **Education and Human Resources** (EHR) supports the development of a diverse and well-prepared workforce of scientists, technicians, engineers, mathematicians and educators. EHR is interested in engaging the CI and education research communities to use advanced cyberinfrastructure and other approaches to analyze, visualize, and harness data to better understand issues of workforce development in science and engineering. Topics of particular interest include preparation of the workforce in areas of data security and privacy in connection with EHR's investment in the CyberCorps(R): Scholarships for Service (SFS) and Secure and Trustworthy Cyberspace (SaTC) programs, as well as the other aspects associated with preparation of the technical workforce for proficiency in using advanced cyberinfrastructure, which is supported by EHR's Advanced Technological Education (ATE) program. In this context, EHR is interested in supporting: (a) innovations in formal and informal educational settings that lead to the broadest participation by all learners; (b) advances in pedagogical curricular design, and introduction of research and internship opportunities; and (c) assessments of training, learning and program evaluation. Prospective PIs may wish to separately submit proposals to the EHR Core Research (ECR) program, which welcomes proposals seeking to advance basic research on the learning of challenging CI content in formal and informal settings, exploring the evaluation of models for broadening participation such as *collective impact,* and studying the development of the STEM professional workforce.

The Directorate for **Engineering** (ENG) is interested in training students, postdocs and educators in the areas of reusable, sustainable high-performance computing software tools, models and algorithms; Big Data management and analytics tools to advance research across the domain areas of ENG; fluidic processes and materials; catalysis and biocatalysis; and those supported by the Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS), Understanding the Brain (UtB), and Nanoscale Science and Engineering (NSE) programs. Proposals are also invited to address training and education needs in advanced multi-scale, multi-physics computational models and simulations for engineering for natural hazards mitigation suitable for community sharing on the Natural Hazards Engineering Research Infrastructure (NHERI) cyberinfrastructure (http://designsafe-ci.org/). In support of the broader goals of this solicitation, proposals for workshops and summer institutes are encouraged; lectures, problem sessions, and hands-on activities are expected to achieve the intended impact.

The Directorate for **Mathematical and Physical Sciences** (MPS) is interested in supporting workshops and summer schools focused on training students and postdocs in computational methods on advanced computing architectures. High-performance computing and data analytics methods are to be introduced in the context of specific scientific applications relevant to the MPS communities. Lectures must be accompanied by problem sessions and hands-on activities on the actual machines. Online sharing of workshop materials and recorded presentations on dedicated websites is strongly encouraged.

The **Directorate of Geosciences** (GEO), and the Divisions of Advanced Cyberinfrastructure (ACI) and Computing and Communication Foundation (CCF) in the **Directorate for Computer and Information Science and Engineering** (CISE) are not highlighting specific areas in the context of this solicitation. Rather, they welcome proposals that broadly enhance the communities of CI Professionals, Contributors, and Users in consultation with the Cognizant POs.

Investments through this solicitation at the undergraduate and graduate levels complement NSF's Improving Undergraduate STEM Education (IUSE) and graduate education strategic frameworks, respectively. IUSE is NSF's

comprehensive, Foundation-wide framework for an integrated vision of the agency's investments in undergraduate science, technology, engineering, and mathematics (STEM) education. Similarly, NSF has recently published a Strategic Framework for Investments in Graduate Education (https://www.nsf.gov/pubs/2016/nsf16074/nsf16074.pdf).

Prospective PIs contemplating submissions that primarily target communities relevant to those directorates/divisions that are not participating in this solicitation are directed to instead explore the education and workforce development programs of the respective directorates/divisions.

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.

- Sushil K. Prasad, CISE/ACI, telephone: (703) 292-5059, email: sprasad@nsf.gov

- Almadena Y. Chtchelkanova, CISE/CCF, telephone: (703) 292-8910, email: achtchel@nsf.gov

- Victor P. Piotrowski, EHR/DGE, telephone: (703) 292-8670, email: vpiotrow@nsf.gov

- Ronald Joslin, ENG/CBET, telephone: (703) 292-7030, email: rjoslin@nsf.gov

- Joanne D. Culbertson, ENG/CMMI, telephone: (703) 292-4602, email: jculbert@nsf.gov

- Chengshan Xiao, ENG/EECS, telephone: (703) 292-4753, email: cxiao@nsf.gov

- Eva Zanzerkia, GEO, telephone: (703) 292-4734, email: ezanzerk@nsf.gov

- Bogdan Mihaila, MPS, telephone: (703) 292-8235, email: bmihaila@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
- 47.076 --- Education and Human Resources

Award Information

Anticipated Type of Award: Standard Grant

Estimated Number of Awards: 10 to 15

Each CyberTraining award shall range from $300,000 to $500,000 per award and shall be up to 3 years in duration. The number of awards will be based on quality of proposals, availability of funds, and responsiveness to the priorities of the participating directorates/divisions.

Anticipated Funding Amount: $4,500,000

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

Eligibility Information

Who May Submit Proposals:

The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the Grant Proposal Guide, Chapter I, Section E.

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 serve as Lead Principal Investigator (PI) or Co-PI on only one proposal submitted to the CyberTraining program per annual competition. In the event that an individual exceeds this limit, proposals will be accepted based on earliest date and time of proposal submission, i.e., the first proposal will be accepted and the remainder will be returned without review. No exceptions will be made.

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, Part I: Grant Proposal Guide (GPG) Guidelines apply. The complete text of the GPG is available electronically on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg.

- 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: http://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):

  January 18, 2017

  October 09, 2017

  Second Monday in October, Annually Thereafter

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

Advanced computing and big data analytics are increasingly at the center of scientific and engineering innovation and economic prosperity. In the near future, access to advanced cyberinfrastructure (CI) resources within a comprehensive and highly interoperable ecosystem will be commonplace. Ubiquitous cloud-based services will provide tailored access to application-specific heterogeneous resources, including resources for training and education. The CyberTraining program intends to address the innovations required in preparation and career growth of the *scientific workforce* that constitutes the backbone for development, maintenance and utilization of such an advanced cyberinfrastructure ecosystem. For the purpose of this solicitation, advanced cyberinfrastructure is broadly defined as the resources, tools, and services for advanced computation, data handling, networking and security.

There are three communities of concern for the CyberTraining program. These are

- i. *CI Professionals:* research cyberinfrastructure and professional staff who develop, deploy, manage and support effective use of research CI;
- ii. *CI Contributors:* computational and data scientists and engineers who are researchers and developers of new CI capabilities; and
- iii. *CI Users:* scientists and engineers who effectively exploit the advanced CI capabilities and methods.

CI Professionals include the non-faculty information technology professionals, scientists, and engineers who provide support to the computational and data-enabled scientific research and development enterprises at various universities, supercomputing and other centers, and research laboratories. *CI Contributors* include both computing as well as domain faculty and other scientists and engineers who develop new scalable models and simulations, as well as algorithms, software at various levels of scientific software stack, and robust capabilities related to data, hardware, networking, and security aspects of CI.

NSF anticipates proposals for informal training, retraining, cross-training and related activities on topics related to methods and resources of advanced cyberinfrastructure and of computational and data science and engineering, at levels ranging from basic literacy to advanced, focused on addressing the emerging needs and outstanding bottlenecks. The target communities at various stages of their career pipelines comprise *CI Professionals* as well as the undergraduate and graduate students, post-docs, research scientists and faculty researchers and educators from both the *CI Contributor* and *CI User* communities. The activities can include retraining and cross-training of the faculty mentors and course instructors themselves to keep up with the dynamic knowledge landscape, as one of the ways for obtaining a multiplier effect. For student training, a key concern is not to increase the time to degree. For this solicitation, relevant to the aforementioned communities, there are three tracks for submissions:

- i. **CI Professionals (CIP),** aimed at the *CI Professionals* community*;*
- ii. **Domain science and engineering (DSE)**, aimed primarily at the communities of *CI Contributors* and sophisticated *CI Users,* and aligned with the research and education priorities of the domain directorates; and
- iii. **Computational and data science literacy (CDL)**, aimed at the *CI User* community at the undergraduate level.

II. PROGRAM DESCRIPTION

To meet the workforce development goals and challenges described in the Synopsis of Program and Introduction sections, NSF invites proposals that identify the emerging and outstanding community needs in training and education outside the classroom that require significant innovations - including the challenge of broadening CI access and adoption by those communities and institutions with low CI adoption as well as underrepresented groups. These proposals shall engage the relevant set of partners required as investigators, collaborators, resource providers, and early adopters, and include plans for effective outreach to the stakeholder communities. Proposals shall articulate well-designed programs with potential for significant impacts, which can serve as templates and provide curricular material and supporting resources to be adopted by other institutions and potentially by sub-communities/sub-disciplines. A key challenge is to design or update suitable training curriculum that will receive buy-in from the larger community of stakeholders as relevant, high quality and adoptable.

As investigators conceive of novel training models and activities, they are challenged to explore the following aspects for short-term impacts: (i) preparing a better scientific workforce for advanced CI; (ii) broadening adoption and accessibility both as users and contributors of institutional, regional, and national shared computing and data resources by various disciplines, institutions, and groups; (iii) complementing and leveraging the state of art in curricular offerings and material in academia, industry and elsewhere; (iv) creating alliances and backbones for *collective impact;* (v) providing on-demand, personalized accessibility*;* (vi) exploring innovative ways of drawing students into computational disciplines (X+Computing and Computing+X); (vii) identifying areas of workforce demand and career pathways; (viii) innovating in training/certification models, curriculum, educational material and activities, and their sustainability; and (ix) leveraging and contributing to NSF cyberinfrastructure and research projects (such as XSEDE, NanoHub, CyVerse, LIGO, and NHERI).

In the longer term, investigators should explore how their project contributes to one or more of the following program goals: (i) lead to an educational ecosystem enabling "Computational and Data Science for All" with understanding of computation as the third pillar and data-driven science as the fourth pillar of scientific discovery*;* (ii) establish deeper engagement with and impact on various disciplines, institutions, and groups*;* (iii) develop or update curriculum and instructional material that will feed into undergraduate courses and be formally adopted into the disciplinary or general education *core* curriculum*,* or guide best practices in teaching pedagogy and standards formulations for *minimum skill sets* in collaborations with key stakeholders; (iv) establish clear career pathways and employment opportunities for the scientific communities of concern; and (viii) result in an ubiquitous and scalable educational cloud infrastructure for online, dynamic, personalized lessons and certifications.

Investigators may explore various training modes and informal education models that may build upon and go beyond the following examples: (i) summer institutes hosting participants for a few weeks employing logistics similar to Research Experiences for Undergraduates (REU) sites (note that the CyberTraining solicitation will not accept submissions for REU sites); (ii) intensive, short-duration training workshops; (iii) workshop and conference training/tutorial tracks; (iv) massive open online courses, small private online courses, and online self-paced training; (v) collaboratively taught courses with remote and local instruction; and (vi) programming and other competitions and awards. PIs are encouraged to engage all stakeholders, including forging alliances and forming backbones for *collective impact*. Stakeholders may include academia (educators, researchers, and professional staff), supercomputing centers and related entities, public and private institutions, professional/disciplinary associations, government and industry research labs, industry, authors and publishers, and federal, state and local agencies, and may cross national boundaries

(however, NSF funds may only be used to support US-based researchers).

The overall quality of the recruitment and selection processes for the trainees (and trainers) will be important. The recruitment plan should include the types of institutions from which trainees will be recruited, along with the plan to reach out to individuals from disciplines and institutions with lower levels of CI adoption as well as from underrepresented groups.

Assessment of the project is another crucial element. Projects should include plans to evaluate the success of the training and the attainment of the planned short- and long-term goals. PIs should identify the expected competencies and outcomes along with performance measures and an evaluation timetable. There must be mechanisms for regular feedback from the evaluator and the trainees to the PI team and for feedback to inform practice. Proposers may consult *The 2010 User-Friendly Handbook for Project Evaluation* for guidance on the elements of a good evaluation plan.

A sample project may include a planning/coordination workshop of key stakeholder communities and partners to crystallize needs and create a robust roadmap, creation/gathering of curricular topics and training material, followed by a series of summer training workshops -- with feedback loops among the phases, and complementary activities for community engagement, dissemination, adoption, new partnerships, and backbone formation and strengthening. Some example projects, serving only to exemplify the nature of the three submission tracks, are as follows:

i.   **CI Professionals** track: (a) Training and certification of *CI Professionals* in cybersecurity technology and management; and (b) Working with neuroscientists to effectively use advanced CI to share software and data;
ii. **Domain science and engineering** track: (a) Training geoscience graduate students to develop scalable, parallel, and distributed software for high-performance computing; and (b) Cross-training of computing and engineering students and faculty in advanced manufacturing; and
iii. **Computational and data science literacy** track: (a) Instructor training for computational science literacy across all science, technology, engineering, and mathematics (STEM) disciplines in minimum core topics; and (b) Software and data literacy for natural science undergraduates.

III. AWARD INFORMATION

Each CyberTraining award shall range from $300,000 to $500,000 per award and shall be up to 3 years in duration. The number of awards will be based on quality of proposals, availability of funds, and responsiveness to the priorities of the participating directorates/divisions. 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 Grant Proposal Guide, Chapter I, Section E.

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 serve as Lead Principal Investigator (PI) or Co-PI on only one proposal submitted to the CyberTraining program per annual competition. In the event that an individual exceeds this limit, proposals will be accepted based on earliest date and time of proposal submission, i.e., the first proposal will be accepted and the remainder will be returned without review. No exceptions will be made.

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 Grant Proposal Guide (GPG). The complete text of the GPG is available electronically on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg. Paper copies of the GPG 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: (http://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. Chapter II, Section D.5 of the Grant Proposal Guide provides additional information on collaborative proposals.

See Chapter II.C.2 of the GPG 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 GPG instructions.

The following supplements guidance contained in the PAPPG or NSF Grants.gov Application Guide.

Cover Sheet: A short informative title that begins with "CyberTraining:CIP:", "CyberTraining:DSE:", or "CyberTraining:CDL:", corresponding to one of the three tracks of CI Professionals, Domain science and engineering, and Computational and data science literacy, respectively, and identifying the main thrust of the project.

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, including the need for the activity and its short- and long-term goals for training, education, and workforce development; broadening CI access and adoption goals; innovative aspects; and target communities. Include (i) **4-5 keywords** that specify the disciplines and/or themes targeted, and (ii) Names of **Cognizant Program Officers Consulted prior to submission** pursuant to the instructions above. The summary should be written in a manner that will be informative to STEM professionals working in the same or related fields, and understandable to a scientifically literate lay reader.

Project Description (15-page limit): The project description should explicitly address the following additional items that will also be employed as Program-specific Review Criteria:

1. Challenges addressed in training, education, and workforce development;
2. Short- and long-term impacts;
3. Challenges addressed in broadening access and adoption with respect to the Nation's scientific and engineering workforce and advanced CI;
4. Efforts to engage stakeholders, leverage prior work, and forge partnerships for collective impact;
5. Scalability in the long term;
6. Sustainability of key activities beyond NSF funding; and
7. Plans for recruitment and assessment.

Please note that per guidance in the PAPPG, the Project Description must contain a separate section labeled "Broader Impacts."

Supplementary Documents

In addition to the Data Management Plan (please follow the CISE Data Management Guidance available at http://www.nsf.gov/cise/cise_dmp.jsp) and the Postdoctoral Research Mentoring Plan (if required), the following items are the only items permitted as supplementary documents:

1. **Management and Coordination Plan (2 pages):** Each proposal must contain a clearly-labeled Management and Coordination Plan that 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; and 4) pointers to the budget line items that support these management and coordination mechanisms.

2. **Letters of Collaboration:** Include documentation of funded or un-funded collaborative arrangements of significance to the proposal through letters of collaboration. 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 [insert the full name of the Principal Investigator] entitled [insert the proposal title] is selected for funding by NSF, it is my intent to collaborate and/or commit resources as detailed in the Project Description or the Facilities, Equipment or Other Resources section of the proposal." Scan your signed letters of collaboration, containing only text similar to that above, and upload them into the Supplementary Documents section of FastLane or Grants.gov, but do not send originals. *Do not submit letters of support*. For example, letters of endorsement and letters of a laudatory nature for the proposed project are not acceptable.

Single Copy Documents

1. **Collaborators and Other Affiliations Information**:

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

No other items, emails, or appendices are to be included. Full proposals containing items other than those required above or by the Grant Proposal Guide (GPG) will be returned without review.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Budget Preparation Instructions:

A significant portion of the budget should be allocated for training activities and these should be budgeted as "Participant Support" to the extent allowable. 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 proposed budget.

C. Due Dates

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

    January 18, 2017

    October 09, 2017

    Second Monday in October, Annually Thereafter

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 the GPG as Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: http://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. (GPG 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 GPG 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:

1. Are the training, education, and workforce challenges identified sound?
2. What is the potential to attain the proposed impacts in the short- and long-terms?
3. To what extent can the project meet its broadening access and adoption challenges with respect to the Nation's scientific workforce and advanced CI?
4. How well would the project engage the key stakeholders, leverage prior work, and forge partnerships for collective impact?
5. What is the potential for the project to scale in the longer term?
6. What is the potential for the key activities to be sustained beyond NSF funding?
7. Are the plans for recruitment and evaluation sound?
8. Are the plans for management and collaboration effective?

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 http://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 *Award & Administration Guide* (AAG) Chapter II, available electronically on the NSF Website at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

Special Award Conditions:

Awardees are expected to participate in annual PI meetings with travel costs supported by the award.

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 *Award & Administration Guide* (AAG) Chapter II, available electronically on the NSF Website at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

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:

- Sushil K. Prasad, CISE/ACI, telephone: (703) 292-5059, email: sprasad@nsf.gov

- Almadena Y. Chtchelkanova, CISE/CCF, telephone: (703) 292-8910, email: achtchel@nsf.gov

- Victor P. Piotrowski, EHR/DGE, telephone: (703) 292-8670, email: vpiotrow@nsf.gov

- Ronald Joslin, ENG/CBET, telephone: (703) 292-7030, email: rjoslin@nsf.gov

- Joanne D. Culbertson, ENG/CMMI, telephone: (703) 292-4602, email: jculbert@nsf.gov

- Chengshan Xiao, ENG/EECS, telephone: (703) 292-4753, email: cxiao@nsf.gov

- Eva Zanzerkia, GEO, telephone: (703) 292-4734, email: ezanzerk@nsf.gov

- Bogdan Mihaila, MPS, telephone: (703) 292-8235, email: bmihaila@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.

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 provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See Grant Proposal Guide Chapter II, Section D.2 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 http://www.nsf.gov

- **Location:** 4201 Wilson Blvd. Arlington, VA 22230

- **For General Information** (NSF Information Center)**:** (703) 292-5111

- **TDD (for the hearing-impaired):** (703) 292-5090

- **To Order Publications or Forms:**

   Send an e-mail to: nsfpubs@nsf.gov

   or telephone: (703) 292-7827

- **To Locate NSF Employees:** (703) 292-5111

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