

Training-based Workforce Development for Advanced Cyberinfrastructure (CyberTraining)

PROGRAM SOLICITATION

NSF 19-524

REPLACES DOCUMENT(S):

NSF 18-516



National Science Foundation

Directorate for Computer & Information Science & Engineering
Office 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
Division of Astronomical Sciences
Division of Materials Research
Division of Physics

Directorate for Social, Behavioral & Economic Sciences

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

February 14, 2019

January 15, 2020

Third Wednesday in January, Annually Thereafter

IMPORTANT INFORMATION AND REVISION NOTES

The revisions are as follows:

- Three project classes have been defined: *Pilot*, *Implementation (Small or Medium)*, and *Large-scale Project Conceptualization*.
- The two solicitation goals have been clarified, and *Pilot* and *Implementation* projects may target one or both of the solicitation goals. *Large-scale Project Conceptualization* projects must address both goals.
- Separate submission tracks for *Cyberinfrastructure Contributors, Users, and Professionals* have been eliminated. However, there remains a focus on these scientific communities, and projects should target one or more of these communities.
- The limit on number of proposals per PI or co-PI has been updated to indicate an individual may serve as PI or co-PI on only one *Pilot* or *Implementation* proposal to the CyberTraining program per competition. The *Large-scale Project Conceptualization* projects are not included in this limit.
- The programmatic areas of interest have been updated with the current priorities of the participating directorates and divisions, with one additional directorate participating: the Directorate for Social, Behavioral and Economic Sciences (SBE).
- The list of additional solicitation specific review criteria has been updated. Proposals should address a subset of these criteria according to the project class and one or both chosen goal(s) of the 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 19-1)*, which is effective for proposals submitted, or due, on or after January 28, 2019.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Synopsis of Program:

This program seeks to prepare, nurture, and grow the national scientific *research* workforce for *creating, utilizing, and supporting* advanced cyberinfrastructure (CI) to enable and potentially transform fundamental science and engineering research and contribute to the Nation's overall economic competitiveness and security. The goals of this solicitation are to **(i) ensure broad adoption of CI tools, methods, and resources by the research community in order to catalyze major research advances and to enhance researchers' abilities to lead the development of new CI; and (ii) integrate core literacy and discipline-appropriate advanced skills in advanced CI as well as computational and data-driven science and engineering into the Nation's educational curriculum/instructional material fabric spanning undergraduate and graduate courses for advancing fundamental research.** *Pilot* and *Implementation* projects may target one or both of the solicitation goals, while *Large-scale Project Conceptualization* projects must address both goals. For the purpose of this solicitation, advanced CI is broadly defined as the set of resources, tools, methods, and services for advanced computation, large-scale data handling and analytics, and networking and security for large-scale systems that collectively enable potentially transformative fundamental research.

This solicitation calls for innovative, scalable training, education, and curriculum/instructional materials—targeting one or both of the solicitation goals—to address the emerging needs and unresolved bottlenecks in scientific and engineering research workforce development, from the postsecondary level to active researchers. The funded activities, spanning targeted, multidisciplinary communities, will lead to transformative changes in the state of research workforce preparedness for advanced CI-enabled research in the short- and long-terms. As part of this investment, this solicitation also seeks to broaden CI access and adoption by (i) increasing or deepening accessibility of methods and resources of advanced CI and of computational and data-driven science and engineering by a wide range of *scientific disciplines* and *institutions* 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.

There are three project classes as defined below:

- *Pilot* Projects: up to \$300,000 total budget with durations up to two years;
- *Implementation* Projects: *Small* (with total budgets of up to \$500,000) or *Medium* (with total budgets of up to \$1,000,000) for durations of up to four years; and
- *Large-scale Project Conceptualization* Projects: up to \$500,000 total budgets with durations up to 2 years.

Section II. Program Description provides a more complete description of the project classes. Section V.A. Proposal Preparation Instructions describes the proposal elements required for the various project classes in order to address the suitable set of solicitation-specific review criteria.

The CyberTraining program is led by the Office of Advanced Cyberinfrastructure (OAC) in the Directorate for Computer and Information Science and Engineering (CISE) and has participation from several directorates and divisions as described in Section II. Program Description, *Programmatic Areas of Interest*. Not all directorates/divisions are participating at the same level and some have specific research and education priorities. The appropriate contact for the CyberTraining program in any directorate/division is the Cognizant Program Officer (PO) for the respective directorate/division/office/program listed.

All projects are expected to clearly articulate how they address important community needs and will provide resources that will be widely available to and usable by the research community. **Prospective principal investigators (PIs) are strongly encouraged to contact the Cognizant Program Officers in CISE/OAC and in the participating directorate/division relevant to the proposal to ascertain whether the focus and budget of their 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 a Single Copy Document as described in Section V.A. Proposal Preparation Instructions. The intent of the CyberTraining program is to stimulate co-funding between OAC and one or more "domain" directorates/divisions. (For this purpose, units of CISE other than OAC are considered "domain" divisions.) To ensure relevance to community needs and to facilitate adoption, those proposals of interest to one or more domain divisions **must** include at least one PI/co-PI with expertise relevant to the targeted research discipline. All proposals shall include at least one PI/co-PI with expertise relevant to OAC.

Prospective PIs contemplating submissions that primarily target communities relevant to 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.

- Alan Sussman, CISE/OAC, telephone: (703) 292-7563, email: alassussm@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: vp Piotrow@nsf.gov
- Chun-Hsi (Vincent) Huang, EHR/DGE, telephone: (703) 292-7877, email: chuang@nsf.gov
- Joanne D. Culbertson, ENG/CMMI, telephone: (703) 292-4602, email: jculbert@nsf.gov

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

- Christina Payne, ENG/CBET, telephone: (703) 292-2895, email: cpayne@nsf.gov
- Anthony Kuh, ENG/ECCS, telephone: (703) 292-2210, email: akuh@nsf.gov
- Eva Zanzerkia, GEO, telephone: (703) 292-4734, email: ezanzerk@nsf.gov
- Nigel A. Sharp, MPS/AST, telephone: (703) 292-4905, email: nsharp@nsf.gov
- Daryl W. Hess, MPS/DMR, telephone: (703) 292-4942, email: dhess@nsf.gov
- Bogdan Mihaila, MPS/PHY, telephone: (703) 292-8235, email: bmihaila@nsf.gov
- Sara Kiesler, SBE, telephone: (703) 292 8643, email: skiesler@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
- 47.075 --- Social Behavioral and Economic Sciences
- 47.076 --- Education and Human Resources

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant or Cooperative Agreement

Estimated Number of Awards: 12 to 18

Up to 4 *Pilot*, 8 *Small* and 3 *Medium Implementation*, and 3 *Large-scale Project Conceptualization* awards are anticipated.

Anticipated Funding Amount: \$6,000,000

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 *NSF Proposal & Award Policies & Procedures Guide (PAPPG)*, Chapter I.E.

Who May Serve as PI:

To ensure relevance to community needs and to facilitate adoption, those proposals of interest to one or more domain divisions **must** include at least one PI/co-PI with expertise relevant to the targeted research discipline. All proposals shall include at least one PI/co-PI with expertise relevant to OAC.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

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

Pilot and Implementation Project proposals: An individual may serve as PI or co-PI **on only one *Pilot or Implementation* proposal** submitted to the CyberTraining program per 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.

Large-scale Project Conceptualization Project proposals: 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.
- o Full Proposals submitted via Research.gov: NSF Proposal and Award Policies and Procedures Guide (PAPPG) guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.
 - o Full Proposals submitted via Grants.gov: *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov* guidelines apply (Note: The *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide).

B. Budgetary Information

- **Cost Sharing Requirements:**

Inclusion of voluntary committed cost sharing is prohibited.

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

Not Applicable

- **Other Budgetary Limitations:**

Not Applicable

C. Due Dates

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

February 14, 2019

January 15, 2020

Third Wednesday in January, 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.

TABLE OF CONTENTS

Summary of Program Requirements

I. Introduction

II. Program Description

III. Award Information

IV. Eligibility Information

V. Proposal Preparation and Submission Instructions

- A. Proposal Preparation Instructions
- B. Budgetary Information
- C. Due Dates
- D. FastLane/Grants.gov Requirements

VI. NSF Proposal Processing and Review Procedures

- A. Merit Review Principles and Criteria
- B. Review and Selection Process

VII. Award Administration Information

- A. Notification of the Award
- B. Award Conditions
- C. Reporting Requirements

VIII. Agency Contacts

IX. Other Information

I. INTRODUCTION

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 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, education, and research. The CyberTraining program intends to address emerging skills required in preparation and career growth of the *scientific and engineering research workforce* for innovation, development, maintenance, and utilization of such an *advanced CI ecosystem*.

The need for such research workforce development programs has been highlighted by a number of recent activities and reports, including the (i) National Strategic Computing Initiative (NSCI), which is co-led by NSF and aims to advance the high-performance computing (HPC) ecosystem and develop the 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. As envisioned by the [NSCI Strategic Plan](#), for advanced CI to be effective, it must be easily accessible to, and usable by, the broadest range of researchers. This requires skills training and outreach to new users, coupled with applications and a variety of innovative technologies as well as creative approaches, to ensure that overall productivity of an advanced CI-enabled science and engineering ecosystem is maximized and sustained. The 2017 [Request for Information on Future Needs for Advanced Cyberinfrastructure to Support Science and Engineering Research \(NSF CI 2030\)](#) also resulted in a substantial number of responses identifying the need for training, education, and curricular updates related to advanced CI.

The goals of this solicitation are to (i) ensure *broad adoption* of CI tools, methods, and resources by the research community in order to catalyze major research advances and to enhance researchers' abilities to lead the development of new CI; and (ii) integrate core literacy and discipline-appropriate advanced skills in advanced CI as well as computational and data-driven science and engineering into the Nation's educational *curriculum/instructional material fabric* spanning undergraduate and graduate courses for advancing fundamental research. In the short term, projects must either catalyze potentially transformative fundamental research in specific NSF-supported disciplines with innovative, scalable, informal/formal training and educational activities; or result in curriculum/instructional material that is integrated into undergraduate and graduate courses, serving as templates for adoption by other institutions and informing best practices and institutional and disciplinary curriculum/instructional material. In the long term, projects should contribute to the larger goals of an educational ecosystem enabling computational and data-driven science for all scientists and engineers, with an understanding of computation as the third pillar and data-driven science as the fourth pillar of the scientific discovery process ([Future Directions for NSF Advanced Computing Infrastructure to Support U.S. Science and Engineering in 2017-2020](#)), in addition to the traditional first and second pillars of theory and experimentation, respectively. 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 that enable broad use by the NSF research communities of advanced CI tools and resources and catalyze potentially transformative fundamental research ([NSF Advisory Committee for Cyberinfrastructure Task Force on Cyberlearning and Workforce Development Report](#), Chapter 1, Continuous Collaborative Computational Cloud in Higher Education, 2011).

The CyberTraining program focuses on three scientific communities, and projects should target one or more of these communities:

- I. **CI Professionals (CIP):** This is the community of research CI and professional staff who deploy, manage, and support effective use of research CI. A CIP-specific project is for technical and research CI professional skills development of future *CI professionals*, including undergraduate and graduate students, postdoctoral fellows, and research scientists, and for skills refinement and career development of current *CI professionals*.
- II. **CI Contributors (CIC):** This is the community of computational, data, and domain scientists and engineers who research and develop new CI capabilities, approaches, and methods. A CIC-specific project is for contributor-level CI skills and advanced domain skills development; the target population spans graduate and undergraduate students, postdoctoral fellows, and researchers who are current and future *CI Contributors*.
- III. **CI Users (CIU):** This is the community of domain scientists and engineers who effectively exploit advanced CI capabilities and methods for research. A CIU-specific project is for user-level core literacy in advanced CI as well as computational and data-driven science and engineering skills; the target population spans undergraduate and graduate students, postdoctoral fellows, and researchers who are current and future *CI Users*.

CI Professionals include the information technology professionals, scientists, and engineers who work closely with the computational and data-enabled scientific and engineering researchers at colleges and universities, supercomputing and other centers, and research laboratories. These include but are not limited to CI system administration and CI research support staff and may include computational research scientists and engineers and non-tenure-track faculty.

CI Contributors include both computing as well as domain faculty and research scientists and engineers, including their undergraduate and graduate students and postdoctoral fellows, who develop new knowledge in the design, development, and utilization of robust research CI. *CI Contributors* explore all aspects of advanced CI including new scalable models and simulations as well as architecture and middleware for extreme-scale systems, scalable algorithms and applications, software at various levels of the scientific software stack, and a robust advanced CI ecosystem to enable major advances in potentially transformative fundamental research.

CI Users include the much larger, diverse group of domain science and engineering faculty and researchers, including their

undergraduate and graduate students and postdoctoral fellows, who are the current and potential users of new advanced CI capabilities for their research activities.

NSF anticipates proposals for informal/formal training and education, including retraining and cross-training, or for curricular activities, on topics related to methods and resources of advanced CI as well as computational and data-driven science and engineering. These proposals are anticipated to span all levels, from basic literacy to advanced, and focus on addressing the emerging needs of fundamental research communities and resolving the outstanding bottlenecks. 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 and education, a key concern is not to increase the time to degree.

II. PROGRAM DESCRIPTION

NSF invites proposals that identify the emerging and outstanding community needs in training and education that require significant innovations and will result in transformative changes – including the challenge of broadening CI access and adoption by those disciplines and institutions with low CI adoption as well as underrepresented groups. These proposals should engage the relevant set of partners required as investigators, collaborators, expert advisors, resource providers, or early adopters, and include plans for effective outreach to the stakeholder communities. For projects targeting the first goal of the solicitation, potentially eligible activities range from training (e.g., workshops) for active researchers in a specific field on the role of CI in addressing fundamental knowledge gaps and enabling CI tools and concepts; training and education that give students the foundation to understand the key research challenges in a given field and how they would use CI to effectively advance new knowledge; or training and education for CI professionals on the role of CI in advancing fundamental research and how to facilitate effective collaborations between researchers and CI experts. Such projects are expected to demonstrate a strong collaboration between CI experts and domain scientists to enable a specific research community to advance the frontiers of knowledge in that field. For projects targeting the second goal of the solicitation, a key challenge to be addressed is how to design or update relevant curriculum/instructional material so that it will receive buy-in from the broader community of stakeholders as relevant, it will be of high quality and adoptable, and it can inform best practices and institutional and disciplinary curriculum/instructional material. Such proposals shall articulate well-designed programs with potential for significant impacts, including serving as templates and providing curriculum/instructional material that can be adopted by other institutions, communities, or disciplines.

Prospective principal investigators are *encouraged* to engage the relevant stakeholders, to the extent possible, by forging alliances and forming backbones employing “collective impact” or an alternative strategy; this is necessary for projects addressing the second goal of the solicitation in order to inform forward-looking curriculum/instructional material development for the Nation’s science and engineering workforce (John Kania & Mark Kramer, “*Collective Impact*,” *Stanford Social Innovation Review*, 2011). PIs may seek public and private partnerships to increase relevance, enrichment, sustainability, and pursuit of national and international dimensions. Stakeholders may include colleges and universities (e.g., educators, researchers, and professional staff); supercomputing centers and related entities; professional/disciplinary associations; non-governmental organizations responsible for curriculum/instructional material development, accreditation, or professional examinations; public and private institutions; government and industry research labs; industry; authors and publishers; and federal, state, and local agencies. Stakeholders may also cross national boundaries. However, NSF funds may only be used to support US-based researchers. At a minimum, **each project (except Pilot projects) must have a board of expert advisors or a network of funded/unfunded collaborators that is representative of the stakeholder communities** to provide periodic oversight and help refine the project methods or the curriculum/instructional material, or to help inform professional associations and non-governmental organizations responsible for curriculum, accreditation, or professional examination.

As investigators conceive of novel training and educational activities or curriculum/instructional materials, they are challenged to explore one or more of the following aspects for short-term impacts: (i) preparing a better scientific research workforce for advanced CI-enabled research, enhancing research productivity and enabling NSF researchers to effectively address complex societal problems; (ii) broadening adoption and accessibility both as users and contributors of institutional, regional, and national shared computing and data resources by various disciplines, categories of institutions, and underrepresented groups; (iii) developing or updating curriculum/instructional material to feed into undergraduate and graduate courses, and in collaboration with key stakeholders, strategically advancing the goal of informing disciplinary or general education core curriculum/instructional material, or informing discipline-appropriate curriculum/instructional material for advancing skill sets in CI and computational and data-driven science and engineering that will enable major advances in fundamental research; (iv) creating alliances and backbones for “collective impact” or alternative strategies; (v) providing on-demand, personalized accessibility; (vi) exploring innovative ways of drawing students into computational studies (“X+Computing” and “Computing+X”); and (vii) leveraging and contributing to NSF-funded CI and research projects [such as the eXtreme Science and Engineering Discovery Environment (XSEDE), NanoHub, Laser Interferometer Gravitational-wave Observatory (LIGO), and Natural Hazards Engineering Research Infrastructure (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-driven science for all scientists and engineers with understanding of computation as the third pillar and data-driven science as the fourth pillar of scientific discovery; (ii) lead to re-envisioning the advanced CI ecosystem as an integral and enabling element of a broader, richer, and dynamic scientific and engineering research enterprise; (iii) establish deeper engagement with and impact on various disciplines, institutions, and underrepresented groups; (iv) establish clear career pathways and employment opportunities for the scientific and engineering research communities of concern; and (v) 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, in addition to formal classroom education models. Examples of informal methods include but are not limited to: (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.

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.

Evaluation of a project is another crucial element. A project should include plans to evaluate its success, including the attainment of the planned short- and long-term goals. The PI team should identify the expected competencies, curriculum/instructional material, and outcomes, along with measures of success and an evaluation timetable. There must be mechanisms for regular feedback from an **independent evaluator**, trainees, advisors, and early adopters to the PI team and for feedback to inform further project progress. Proposers may consult [The 2010 User-Friendly Handbook for Project Evaluation](#) for guidance on the elements of a good evaluation plan.

Project Classes

Proposals submitted to this solicitation must be consistent with one of the project classes defined below. Proposals will be considered for funding within their project classes. The project classes are based on the scope and effort required and the level of impact intended. Section V.A. Proposal Preparation Instructions describes the components required for various project classes to address the additional solicitation specific review criteria.

- **PILOT Projects**

Pilot projects, with total budgets of up to \$300,000 and with durations of up to two years, are exploratory activities that may lead to *Implementation* projects.

- **IMPLEMENTATION Projects**

Implementation projects can be either *Small* (with total budgets of up to \$500,000) or *Medium* (with total budgets of up to \$1,000,000) for durations of up to four years. Implementation projects make CI training and educational activities or curriculum/instructional materials broadly accessible to a significant portion of a community for one or more disciplines. These projects collaborate with other CyberTraining awards and with other appropriate NSF-funded projects. *Medium Implementation* projects also foster a community to catalyze the adoption of advanced CI methods or incorporate training resources and materials into the curriculum.

- **LARGE-SCALE PROJECT CONCEPTUALIZATION Projects**

Large-scale Project Conceptualization projects, with total budgets of up to \$500,000 and durations of up to two years, are planning grants for potential future large-scale (at the level of institutes) CyberTraining projects. The product of a *Conceptualization* project will be a strategic plan that is expected to serve as the conceptual design upon which a subsequent large-scale CyberTraining proposal could be based. The resulting strategic plan will be freely available to the community.

NSF anticipates future large-scale CyberTraining projects will be capable of serving the training, educational, and curricular needs and emerging challenges of well-defined communities. These large-scale projects will provide a long-term community network and information hub; enhance collaboration among CyberTraining projects and serve as repositories for NSF-funded CI educational and curricular resources in the discipline(s); support and guide the CyberTraining and other projects; and spur community adoption of advanced CI tools and resources and inform curriculum standards. Over time, these center-scale projects will be self-sustaining. Award of a Large-Scale Project Conceptualization proposal does not guarantee a future large-scale project.

Programmatic Areas of Interest

The CyberTraining program includes the Office of Advanced Cyberinfrastructure (OAC—lead for the program) and the Division of Computing and Communication Foundations (CCF) within the Directorate for Computer and Information Science and Engineering (CISE); Directorate for Engineering (ENG); Division of Graduate Education (DGE) within the Directorate for Education and Human Resources (EHR); Directorate for Geosciences (GEO); Divisions of Astronomical Sciences (AST), Materials Research (DMR), and Physics (PHY) within the Directorate for Mathematical and Physical Sciences (MPS); and the Directorate for Social, Behavioral, and Economic Sciences (SBE). All projects must advance CI training and education goals for CI-enabled fundamental research, in addition to addressing specific domain needs. Not all directorates/divisions/programs are participating at the same level and some have specific research and education priorities as described below.

OAC supports all three communities of *CI Professionals*, *CI Contributors*, and *CI Users*, both current and future generations. OAC encourages proposals on technical and research CI professional skills development of future *CI Professionals* as well as on skill refinement and career development of current *CI Professionals*. These include technical skills such as network engineering, cybersecurity of advanced research CI and scientific workflows, and software installation and maintenance, as well as research support skills such as porting legacy scientific research software and workflows to HPC and cloud platforms, advanced visualization, supporting scientific gateways, and required domain knowledge. OAC also encourages proposals, relevant to the domain directorates, for training as well as cross-training of the computational and data scientists and engineers who are current and future *CI Contributors* in contributor-level CI topics such as scalable algorithms and scientific software development, big data analytics methods, modeling and simulation, and computer architecture and middleware, and in advanced domain topics such as domain-specific tools, datasets, and models. OAC is also interested in the larger goal of preparing the Nation's scientific and engineering research workforce—well-versed in basic CI and computational and data-driven science and engineering literacy—with an understanding of computation as the third pillar and data-driven science as the fourth pillar of the scientific discovery process. This *CI User* workforce preparation starts with undergraduate students across all disciplines, and continues to graduate students and postdoctoral fellows, particularly in disciplines and areas with low levels of CI adoption. OAC also encourages relevant proposals of overlapping concerns with other OAC programs such as Big Data Regional Innovation Hubs (BD Hubs), Campus Cyberinfrastructure (CC*), Cyberinfrastructure for Sustained Scientific Innovation (CSSI), and Cybersecurity Innovation for Cyberinfrastructure (CICI) programs.

CISE's CCF division supports research and education projects that develop new knowledge in four core programs: Algorithmic Foundations; Communications and Information Foundations; Foundations of Emerging Technologies; and Software and Hardware Foundations. CCF is not highlighting specific areas in the context of this solicitation. Rather, it welcomes proposals that broadly enhance the CCF-relevant communities of *CI Professionals*, *CI Contributors*, and *CI Users* in consultation with the Cognizant Program Officer.

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 CI 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 CI, which is supported by EHR's Advanced Technological Education (ATE) program. In this context, EHR is interested in supporting: (a) innovations in formal/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. CyberTraining especially welcomes proposals that will pair well with the efforts of NSF INCLUDES to develop STEM talent from all sectors and groups in our society. Collaborations are encouraged between CyberTraining proposals and existing INCLUDES projects, provided these collaborations strengthen both the CyberTraining and INCLUDES projects. Prospective PIs may wish to separately submit proposals to the EHR Core Research (ECR) program, which welcomes proposals seeking to advance fundamental research on the learning of challenging CI content in formal/informal settings, exploring the evaluation of models for broadening participation such as *collective impact*, and studying the development of the STEM professional workforce.

ENG is interested in supporting the training of students, postdoctoral fellows, and researchers in the areas of HPC software tools; advanced multi-scale, multi-physics computational models and algorithms; and data management and data analytics tools to advance fundamental research across the domain areas of ENG. Proposals should align with the engineering research domain's readiness in CI adoption and focus on training both in the development and use of CI tools as well as the integration of these tools and methods with the engineering domain research. Proposals are encouraged from all ENG research domains that address CI training needs. In support of the broader goals of this solicitation, proposals for workshops and summer institutes are encouraged, including those aimed at upper-level graduate students, postdoctoral fellows, and faculty. Examples of training topics may include effective use of parallel computing methods; effective integration of different models in multi-scale modeling; model validation and coupling models and experimental data; uncertainty quantification; an effective software development process; development of data tools, resources, and infrastructure to ensure accessibility, ease of use, and sustainability; effective data mining techniques and integration of different types of data; efficient extraction of dynamic models and real-time model updating using very large data sets; and/or real-time, finite, horizon-constrained optimal control (model-predictive control systems) for complex dynamic systems.

ENG's Division of Chemical, Bioengineering, Environmental and Transport Systems (CBET) has a special interest in proposals focused on (i) developing multi-scale models that enable fundamental understanding of the relationships between molecular-level and macroscopic chemical, biological, and physical phenomenon; (ii) establishing workflows and/or best practices for data generation, analysis, and storage that address the long-standing issues of reproducibility and uncertainty quantification; and (iii) effective implementation of advanced computational methods (e.g., machine learning) toward solving relevant engineering problems.

ENG's Division of Civil, Mechanical, and Manufacturing Innovation (CMMI) encourages proposals on any topics that would enable the research community to more effectively use CI to make new advances in potentially transformative fundamental research in any CMMI-funded fields or to lead in the development of new CI to catalyze major research discoveries in CMMI-funded fields. For example, specific opportunities for enhanced use of CI by the CMMI community may include the following: proposals in collaboration with the National Hazards Engineering Research Infrastructure (NHERI) DesignSafe Cyberinfrastructure, focused on training to (i) create holistic computational models for future, adaptive buildings for which experimental data and computational models for components are available at different scales, and sharing these models on the NHERI DesignSafe Cyberinfrastructure; and (ii) create workflows that link computational building models with simulation codes and visualizations, and make them accessible to enable next-generation researchers on the NHERI DesignSafe Cyberinfrastructure.

ENG's Division of Electrical, Communications, and Cyber Systems (ECCS) has a special interest in proposals focused on (i) machine learning and big data analytics to enable real-time, efficient data learning and feature extraction from massive noisy data; (ii) secure communication and intelligent systems which facilitate real-time, distributed data processing and multi-level decisions in heterogeneous infrastructures; and (iii) hardware innovations including smart sensors as well as secure and reliable communication and control systems that are reconfigurable for rapid deployment in dynamic environments.

GEO supports fundamental research that advances the frontiers of knowledge and drives technological innovation while improving our understanding of the many processes that affect the global environment. These processes include the role of the atmosphere and oceans in our climate, the planetary water cycle, and ocean acidification. GEO supports interdisciplinary studies that contribute directly to national research priorities such as understanding, adapting to, and mitigating the impacts of global change; developing and deploying integrated ocean observing capabilities to support ecosystem-based management; and understanding future availability of freshwater. GEO is not highlighting specific areas in the context of this solicitation. Rather, it welcomes proposal that broadly enhance the GEO-relevant communities of *CI Professionals*, *CI Contributors*, and *CI Users* in consultation with the Cognizant Program Officer.

MPS's Division of Astronomical Sciences (AST) welcomes proposals, in all classes, that emphasize wide utility and demonstrate a broad base of community support.

MPS's Division of Materials Research (DMR) supports fundamental research focused on advancing materials discovery, design, synthesis, and characterization, materials-related phenomena, and associated new states of matter. DMR will consider *Pilot* and *Implementation* projects involving materials research-relevant *CI Users*, *CI Contributors*, and *CI Professionals*. The division is interested in CI training projects that lead to the infusion of CI-enabled or CI-enhanced research into the materials research community, particularly in support of research that integrates digital data with experiment, computation, and theory, such as through the Designing Materials to Revolutionize and Engineer our Future (DMREF) program. Training in the use of community CI at all career levels and training the next generation of CI Contributors able to create the CI needed to engage the frontiers of the field are activities that advance CI-enabled and CI-enhanced materials research. Valuable experiences may be afforded by workshop, conference, and summer institute tracks designed to address specific needs of the DMREF community, promote the adoption and use of materials-related CI tools and methods in industrial research, and establish the use of computational materials tools, methods, and resources in the materials research workforce more broadly. DMR appreciates advancing CI and its utilization in areas of DMR interests associated with the Big Ideas of Quantum Leap, Harnessing the Data Revolution, and Understanding the Rules of Life, and more broadly to energize transformative research across all facets of the materials research community involving individual investigators, centers, and facilities. It is vital to sustain the creation, adoption, and utilization of advanced CI in materials research, such as through fostering efficient and effective community processes for rapidly developing and integrating CI tools, methods, and resources to enable innovative research across the frontiers of materials research. Educational materials developed in the context of CI training should be advertised, findable, accessible, and available for reuse across the materials research community.

MPS's Division of Physics (PHY) is interested in supporting workshops and summer schools focused on training students and postdoctoral fellows 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.

SBE supports rigorous methods to discover fundamental principles of human behavior at levels ranging from cells to society, from neurons to neighborhoods, and across space and time. The SBE directorate supports research that advances computational social science and analytic methods using social network, sensor, text, video, administrative, and other big data. SBE seeks proposals that will advance training for research communities of *CI Professionals* and *CI Users*. SBE welcomes proposals that address research training challenges, such as educating SBE scientists for understanding and promoting economic opportunity, security, civic and political engagement, health, and well-being in different regions and populations, many of which require interdisciplinary sociotechnical collaborations and team science.

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 STEM education. Similarly, NSF has published a [Strategic Framework for Investments in Graduate Education](#).

III. AWARD INFORMATION

Up to 4 *Pilot*, 8 *Small* and 3 *Medium Implementation*, and 3 *Large-scale Project Conceptualization* awards are anticipated. 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 *NSF Proposal & Award Policies & Procedures Guide* (PAPPG), Chapter I.E.

Who May Serve as PI:

To ensure relevance to community needs and to facilitate adoption, those proposals of interest to one or more domain divisions **must** include at least one PI/co-PI with expertise relevant to the targeted research discipline. All proposals shall include at least one PI/co-PI with expertise relevant to OAC.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

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

Pilot and Implementation Project proposals: An individual may serve as PI or co-PI **on only one *Pilot or Implementation* proposal** submitted to the CyberTraining program per 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.

Large-scale Project Conceptualization Project proposals: 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.

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

Cover Sheet: The projects will have a short informative title that begins with "CyberTraining: Pilot:", "CyberTraining: Implementation: Small:", "CyberTraining: Implementation: Medium:", or "CyberTraining: Conceptualization:" based on the project class chosen.

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 research workforce development; broadening CI access and adoption goals, or curriculum/instructional material goals; innovative aspects; size and nature of target CI communities; and estimated number of students. The overview also includes **6-7 keywords** that specify the CI community (i.e., *Professionals, Contributors, Users*), level of students, disciplines, topics, and themes targeted. The Project 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 a subset of the following additional items, according to the project class, with emphasis suitable to the proposed work and chosen goal(s) of the solicitation (note that this information will also be employed as additional solicitation-specific review criteria; see Section VI.A. for details):

1. Challenges for Research Workforce Development;
2. Solicitation Goal(s) Targeted (at least one goal for *Pilot* and *Implementation* proposals, and both goals for *Large-scale Conceptualization* Project proposals):
 1. Broadening Adoption of Advanced CI; or
 2. Integration of CI Skills into Curriculum/Instructional Material Fabric;
3. Scalability and Sustainability;
4. Recruitment and Evaluation;
5. "Collective Impact" Strategy: Coordination network and Backbone organization (or an alternative strategy);
6. Fostering Community;
7. Information Hub and Repository Infrastructure; and
8. Support and Guide for other CyberTraining and relevant projects, and the community.

Pilot project must address items 1 and 2. *Small Implementation* projects must address items 1-5, and *Medium Implementation* projects must address items 1-6. *Large-scale Project Conceptualization* projects must address all 8 items, including both solicitation goals.

Please note that, per guidance in the PAPPG, the Project Description must contain separate sections labeled "Intellectual Merit" and "Broader Impacts."

Supplementary Documents

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

1. **Management and Coordination Plan (2 pages):** Each proposal (optional for *Pilot* projects; required for *Implementation* and *Large-scale Project Conceptualization* projects) 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 the proposal, 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

- i. **Collaborators and Other Affiliations Information:** Proposers should follow the guidance specified in Chapter II.C.1.e of the *NSF PAPPG*.

- ii. Names of the Cognizant Program Officers consulted prior to submission, pursuant to the guidance above.

No other items, emails, or appendices are to be included. Full proposals containing items other than those required above or by PAPPG 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 proposed budget should be allocated for training, instructional, curricular, and outreach activities, and these and other activities should be budgeted as "Participant Support" to the extent allowable. In addition, each awardee is 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):

February 14, 2019

January 15, 2020

Third Wednesday in January, 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: <https://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 *Building the Future: Investing in Discovery and Innovation - NSF Strategic Plan for Fiscal Years (FY) 2018 – 2022*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

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

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

A. Merit Review Principles and Criteria

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

1. Merit Review Principles

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

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

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

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

2. Merit Review Criteria

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

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

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

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

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

1. What is the potential for the proposed activity to
 - a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
 - b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?
3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

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

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

Additional Solicitation Specific Review Criteria

All proposals should explicitly address a subset of the following additional items according to the project class, with emphasis suitable to the proposed work and chosen goal(s) of the solicitation, through well-identified proposal elements:

1. Rationale for challenges identified for research workforce development;
2. Strength of project's plan to address one or both solicitation goals as stated in the Synopsis of Program above, namely to (a) broaden the use of CI methods and resources by the research community, or (b) integrate CI skills into institutional and disciplinary curriculum/instructional material fabric (at least one goal for *Pilot* and *Implementation* proposals, and both goals for *Large-scale Conceptualization* Project proposals);
3. Potential for scalability and sustainability;
4. Soundness of recruitment and evaluation plan;
5. Effectiveness of proposed "collective impact" strategy to establish a coordination network and a backbone organization (or of an alternative strategy);
6. Soundness of plans for fostering a suitable community;
7. Feasibility of plans for serving as an information hub and for creating repository infrastructure; and
8. Strength of plans to support and guide other CyberTraining and relevant projects, and the community.

Pilot projects must address items 1 and 2. *Small Implementation* projects must address items 1-5, and *Medium Implementation* projects must address items 1- 6. *Large-scale Project Conceptualization* projects must address all 8 items, and both solicitation goals.

B. Review and Selection Process

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

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

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

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

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

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

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

B. Award Conditions

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

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

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

Special Award Conditions:

Awardees are expected to participate in annual PI meetings to be held in the Washington, DC, area 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 Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=papppg.

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:

- Alan Sussman, CISE/OAC, telephone: (703) 292-7563, email: alasusm@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
- Chun-Hsi (Vincent) Huang, EHR/DGE, telephone: (703) 292-7877, email: chuang@nsf.gov

- Joanne D. Culbertson, ENG/CMMI, telephone: (703) 292-4602, email: jculbert@nsf.gov
- Ronald Joslin, ENG/CBET, telephone: (703) 292-7030, email: rjoslin@nsf.gov
- Christina Payne, ENG/CBET, telephone: (703) 292-2895, email: cpayne@nsf.gov
- Anthony Kuh, ENG/ECCS, telephone: (703) 292-2210, email: akuh@nsf.gov
- Eva Zanzierka, GEO, telephone: (703) 292-4734, email: ezanzerk@nsf.gov
- Nigel A. Sharp, MPS/AST, telephone: (703) 292-4905, email: nsharp@nsf.gov
- Daryl W. Hess, MPS/DMR, telephone: (703) 292-4942, email: dhess@nsf.gov
- Bogdan Mihaila, MPS/PHY, telephone: (703) 292-8235, email: bmihaila@nsf.gov
- Sara Kiesler, SBE, telephone: (703) 292 8643, email: skiesler@nsf.gov

For questions related to the use of FastLane or Research.gov, contact:

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- FastLane Help Desk e-mail: fastlane@nsf.gov
- Research.gov Help Desk e-mail: rgov@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](#).

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