

# Computing and Communication Foundations (CCF): Core Programs

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## PROGRAM SOLICITATION NSF 17-571

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### REPLACES DOCUMENT(S): NSF 16-578

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National Science Foundation

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

**Submission Window Date(s)** (due by 5 p.m. submitter's local time):

September 20, 2017 - September 27, 2017

MEDIUM

November 01, 2017 - November 15, 2017

SMALL

## IMPORTANT INFORMATION AND REVISION NOTES

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This is a revision of NSF 16-578, the solicitation for the CISE/CCF Core Programs. The revisions include:

- A checklist summarizing the requirements for submission.
- CCF is not accepting Large proposals through this solicitation.
- Additional information is included for Broadening Participation. For Medium proposals, this requires a specific section to be included in the proposal on PI plans.
- Clarification of restrictions regarding foreign campuses/offices of US universities.
- Removal of "breakthrough" proposals as a separate class.
- Removal of the information about related programs, such as Algorithms in the Field, Collaborative Research in Computational Neuroscience, etc.
- Removal of the "annually thereafter" from the submission windows. This does not reflect a change in policy, but rather a simplification to avoid confusion.
- Collaborators and Other Affiliations are collected using a template spreadsheet for each senior project personnel on a proposal, which Fastlane will combine into a PDF document. Project leads need not collect and combine collaborator lists.

The following recent revisions to the Proposal & Award Policies & Procedures Guide (PAPPG) will be closely observed for all submissions to this solicitation:

- PAPPG Chapter II.C.2.d.i requires that, "The Project Description must contain, as a separate section within the narrative, a section labeled "Broader Impacts"."
- PAPPG Chapter II.C.2.f clarifies the requirements for Biographical Sketch(es).
- PAPPG Chapter II.C.2.h revises requirements for reporting Current and Pending Support.
- PAPPG Chapter II.C.2.j Special Information and Supplementary Documentation, specifies the proper scope for letters of collaboration.

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) ([NSF 17-1](#)), which is effective for proposals submitted, or due, on or after January 30, 2017.

## SUMMARY OF PROGRAM REQUIREMENTS

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### General Information

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**Program Title:**

Computing and Communication Foundations (CCF): Core Programs

## Synopsis of Program:

CISE's Division of Computing and Communication Foundations (CCF) supports research and education projects that develop new knowledge in three core programs:

- The Algorithmic Foundations (AF) program;
- The Communications and Information Foundations (CIF) program; and
- The Software and Hardware Foundations (SHF) program.

Proposers are invited to submit proposals in two project classes, which are defined as follows:

- Small Projects - up to \$500,000 total budget with durations up to three years; and
- Medium Projects - \$500,001 to \$1,200,000 total budget with durations up to four years.

A more complete description of the two project classes can be found in section *II. Program Description* of this document.

*CCF proposals must be in the Small or Medium classes only.*

## 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.*

- Almadena Y. Chtchelkanova, Point of Contact, Software and Hardware Foundations (SHF), 1115, telephone: (703) 292-8910, email: [achtchel@nsf.gov](mailto:achtchel@nsf.gov)
- Tracy Kimbrel, Point of Contact, Algorithmic Foundations (AF), 1115, telephone: (703) 292-8910, email: [tkimbrel@nsf.gov](mailto:tkimbrel@nsf.gov)
- Phillip Regalia, Point of Contact, Communications and Information Foundations (CIF), 1115, telephone: (703) 292-8910, email: [pregalia@nsf.gov](mailto:pregalia@nsf.gov)

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

- 47.070 --- Computer and Information Science and Engineering

## Award Information

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### Anticipated Type of Award:

Standard Grant or Continuing Grant

**Estimated Number of Awards:** 170 to 250

**Anticipated Funding Amount:** \$100,000,000

Dependent on the availability of funds.

## Eligibility Information

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### Who May Submit Proposals:

Proposals may only be submitted by the following:

- Universities and Colleges - Universities and two- and four-year colleges (including community colleges) accredited in, and having a campus located in, the US acting on behalf of their faculty members. Such organizations also are referred to as academic institutions.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.

### Who May Serve as PI:

PIs, co-PIs or other senior project personnel must hold primary, full-time, paid appointments in research or teaching positions at US-based campuses/offices of eligible organizations.

### Limit on Number of Proposals per Organization:

There are no restrictions or limits.

### Limit on Number of Proposals per PI or Co-PI: 2

In any contiguous September through November period, an individual may participate as PI, Co-PI or Senior Personnel in **no more than two Small, Medium, or Large** proposals submitted in response to the *coordinated solicitation* (where *coordinated solicitation* is defined to include the *Computing and Communication Foundations (CCF): Core Programs, Information and Intelligent Systems (IIS): Core Programs*, and the *Computer and Network Systems (CNS): Core Programs* solicitations). For example, between September 2017 and November 2017, an individual may participate as PI, co-PI or Senior Personnel in one proposal submitted to a core program in CCF and in a second proposal submitted to a core program in CNS, or an individual may participate as PI, co-PI or Senior

Personnel in two proposals submitted to an IIS core program, etc.

**These eligibility constraints will be strictly enforced in order to treat everyone fairly and consistently.** In the event that an individual exceeds this limit, proposals involving the individual that are received within the limit will be accepted based on earliest date and time of proposal submission (i.e., the first two proposals received will be accepted and the remainder will be returned without review). **No exceptions will be made.**

The limit on the number of proposals per PI, co-PI or Senior Personnel applies only to the *coordinated solicitation*.

## Proposal Preparation and Submission Instructions

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

Other budgetary limitations apply. Please see the full text of this solicitation for further information.

### C. Due Dates

- **Submission Window Date(s)** (due by 5 p.m. submitter's local time):
  - September 20, 2017 - September 27, 2017  
MEDIUM
  - November 01, 2017 - November 15, 2017  
SMALL

## Proposal Review Information Criteria

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### 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

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### Award Conditions:

Standard NSF award conditions apply.

### Reporting Requirements:

Standard NSF reporting requirements apply.

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## I. INTRODUCTION

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The Division of Computing and Communication Foundations (CCF) supports transformative research and education projects that explore the foundations of computing and communication. The Division seeks advances in computing and communication theory, algorithm design and analysis, and the architecture and design of computers and software. CCF-supported projects also investigate revolutionary computing models and technologies based on emerging scientific ideas and integrate research and education activities to prepare future generations of computer science and engineering workers.

## II. PROGRAM DESCRIPTION

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CCF supports three core programs as described below - Algorithmic Foundations (AF), Communications and Information Foundations (CIF), and Software and Hardware Foundations (SHF).

### Algorithmic Foundations (AF)

The Algorithmic Foundations (AF) program supports potentially transformative research and education projects advancing design and analysis of algorithms and characterized by algorithmic thinking accompanied by rigorous analysis. Research on algorithms for problems that are central to computer science and engineering, as well as new techniques for the rigorous analysis of algorithms, are of interest. AF supports theoretical research that bounds the intrinsic difficulty of problems to determine the measures of complexity in formal models of computation, classical or new. The goal is to understand the fundamental limits of resource-bounded computation and to obtain efficient algorithms operating within those limits. The time and space complexity of finding exact and approximate solutions in deterministic and randomized models of computation is a central concern of the program; research on resources other than time and space, such as communication and energy, is also encouraged. In addition to the traditional, sequential computing paradigm, AF supports research on the design and analysis of novel algorithms in parallel and distributed models, in particular, in heterogeneous multi-core and many-core machines; the computational models and algorithms that capture essential aspects of computing over massive data sets; and alternative forms of computation and information processing, including quantum computing and biological models of computation.

The program supports research in algorithms needed in all areas, both within and outside computer science. Algorithmic research with applications in databases, machine learning, data mining, networks, communications, operating systems, languages, compilers, and machine abstractions is supported. New techniques for the design and analysis of algorithms in areas such as optimization, cryptography, computational geometry, computational biology, game theory, social networks, and numeric, symbolic, and algebraic computing are appropriate for this program. Relevance to application areas is important and collaborations with researchers in those areas are encouraged. However, research funded by this program must advance the study of algorithms. When accompanied by rigorous analysis of computational resource requirements and/or algorithmic performance measures, projects with an implementation component are also considered.

Research that incorporates significant activity in both theory and practice is generally supported through other (cross-cutting) programs. For example, consider NSF cross-cutting programs on Critical Techniques, Technologies, and Methodologies for Advancing Foundations and Applications of Big Data Sciences & Engineering (BIGDATA); Integrative Strategies for Understanding Neural and Cognitive Systems (NSF-NCS); National Robotics Initiative (NRI-2.0); Secure and Trustworthy Cyberspace (SaTC); and Smart &

Connected Health (SCH). A full list of such programs appears at [https://www.nsf.gov/funding/pgm\\_list.jsp?org=CISE](https://www.nsf.gov/funding/pgm_list.jsp?org=CISE).

More information on topics appropriate for the Algorithmic Foundations program is available at: [https://www.nsf.gov/cise/ccf/af\\_pgm12.jsp](https://www.nsf.gov/cise/ccf/af_pgm12.jsp)

### **Communications and Information Foundations (CIF)**

The Communications and Information Foundations (CIF) program supports potentially transformative research that addresses the theoretical underpinnings of information acquisition, transmission, and processing in communications and information processing systems. As a result, CIF research and education projects strengthen the intellectual foundations of communications, information theory, signal processing, and statistical learning in a variety of types of networks such as wireless and multimedia networks, sensor networks, social networks, and biological and quantum networks. Research outcomes are expected to lead to more secure and reliable communications and advanced mathematical capabilities that are applicable throughout science and engineering.

The program supports basic research in communication theory, information theory, and signal processing. Included in the CIF program is the reliable transmission of information in the presence of a variety of resource constraints (e.g., energy, bandwidth, computation, time, and privacy) and channel impairments (e.g., noise, multipath, interference, and eavesdroppers). CIF likewise has a strong interest in the role of signal processing, coding, and information theory in distributed processing systems handling massive amounts of data and impacting the control, operation and robustness of real-time devices and networks, including human-in-the-loop modeling, processing, and learning.

The CIF program also supports fundamental research in networking including network information theory and cross-layer research at the lower layers. The CIF program in networking emphasizes research in which the physical-layer attributes play an important role in overall network design and performance. This includes cross-layer approaches that consider the impact of physical-layer characteristics on higher network layers. Examples include secure communication, sensor networks with applications including environmental monitoring, crowd-sourcing, and smart grids, and other application scenarios that feature massive data aggregation from distributed sensing, such as the Internet of Things.

In addition to the contemporary signal processing topics that have enabled the information revolution, there is growing interest within the CIF program in new paradigms that enlarge the scope of signal processing and information theory such as advances in statistical learning and inference, signal processing on graphs, distributed processing for multi-terminal communication problems, information-theoretic security, the all-pervasive role of geometric methods in signal processing and machine learning, new mathematical frameworks for addressing new problems, communication-theoretic challenges in terahertz and millimeter-wave frequencies, and machine learning for network optimization. Research that will develop efficient power-aware and hardware-friendly algorithms and research on signal/information processing algorithms for the new network science of distributed, decentralized, and cooperative algorithms is encouraged. The derivation of efficient algorithms and fundamental limits for extracting information from massive and possibly corrupted data sets, including compressive sampling/sensing and active learning, and exploring new application domains, also promise advances in the field, especially in the face of information overload, where one has too much information rather than too little.

The CIF program is particularly interested in the study of signal/information processing in complex systems, as signal processing and information theory may be viewed more broadly and holistically by other areas in machine learning and data science. Some examples of complex systems and applications include monitoring the Nation's critical infrastructures, signal processing and information theory in biological systems, and information flow in socio-technical networks. While advances in these areas have the potential for broad societal impact, the study of these and other emerging application domains is expected to lead to new insights in the underlying theory by posing new constraints and challenges and leading to the reexamination of old questions and assumptions, e.g., new mathematical approaches to deep learning.

More information on topics appropriate for this program is available at: [https://www.nsf.gov/cise/ccf/cif\\_pgm12.jsp](https://www.nsf.gov/cise/ccf/cif_pgm12.jsp).

### **Software and Hardware Foundations (SHF)**

All fields of science and engineering - and society at large - depend on fundamental advances in scientific foundations and engineering methods for computer hardware and software. The SHF program supports research and education projects on the design, verification, operation, utilization, and evaluation of computer hardware and software through novel approaches, robust theories, high-leverage tools, and lasting principles. Such advances may offer formal methods, languages, logics, novel software and/or hardware artifacts, or algorithms to enable new or enhanced functionality, verification, usability, and scale.

The SHF program supports all aspects of the science and engineering of software, seeking transformative ideas that reformulate the relationships between requirements, design and evolution of software, and software-intensive systems. SHF supports research projects focusing on program analysis and synthesis, compositionality, verifiability and adaptability of software, as well as research on software analysis and testing techniques for all stages of the software life cycle. SHF also seeks research to increase the automation of software engineering capabilities to attain significant advances in quality and sustainability of software, which may require new representations and processes. Empirical research that increases understanding of software and software creation is also in scope.

SHF supports fundamental research on formal and semi-formal methods for the specification, development and verification of software and hardware systems. This includes, but is not limited to, abstraction, compositional, refinement-based, and probabilistic methods for the modeling and validation of systems involving discrete and continuous behavior. SHF seeks proposals that enhance the applicability, usability, and efficiency of techniques such as abstract interpretation, model checking, theorem proving, automated decision procedures, and constraint solving. Research topics involving the semantics, logics, verification, and analysis of concurrent systems are in scope. SHF supports foundations, algorithms, and tools for software and hardware synthesis.

SHF supports the entire range of programming languages research, from foundations to design to implementation. Fundamental research in both science and engineering of programming languages is highly encouraged. Topics of interest include, but are not limited to, language semantics and type theory, design and implementation of advanced languages and language features, compilers and runtime systems for advanced languages, program analysis and optimization, design and implementation of domain-specific languages, and implementation issues related to locality, synchronization and communication. Research in programming languages and models that go beyond mainstream practice, such as concurrent, functional, logic programming and probabilistic languages, are particularly encouraged. Foundational research that exposes novel synergies between programming languages and other areas of computing, such as distributed systems, is also encouraged.

SHF seeks proposals that address foundational issues in computer architecture and the key challenges in computer hardware and systems design, including, but not limited to, performance, energy efficiency, reliability, scalability, concurrency, and heterogeneity. The program supports fundamental and transformative research in processors, interconnects, memory and storage architectures. SHF seeks research that takes holistic and cross-layer approaches to fully harness the promises and address the challenges of new and emerging substrate technologies and materials as well as considering emerging trends in application environments including computation-intensive, data-intensive, and I/O-intensive applications.

SHF supports foundational research in high-performance computing that is aware of, driven by, and inspired by applications, as well as heterogeneity-aware and architecture-aware. SHF does not support research in domain applications. SHF seeks novel research on enabling technologies and tools to balance and optimize performance goals including scalability, power, productivity, repeatability, reliability, and validity.

SHF supports all topics in design automation including, but not limited to logical, physical, behavioral, and high level synthesis methods, interplay between synthesis and verification, design methodologies for scalable, low power and energy efficient circuits, and physical design in silicon technologies. Also of interest is pre- and post-silicon validation, possibly by using a blend of techniques from testing and verification. SHF seeks research in emerging technologies, including optical interconnects, quantum computing, optical computing, bio-computing, bio-inspired devices, nanotubes and nanophotonics, which have the potential to take computation beyond Moore's Law. Implementation of novel non-silicon CMOS emerging devices in non-von Neumann architectures, e.g., neuromorphic architectures, oscillator arrays, etc., is a new direction currently being explored.

Proposals on parallelism and scalability that promises to lead to a new era of parallel computing are supported through a separate program, Scalable Parallelism in the Extreme (SPX). SPX is particularly interested in "clean-slate" approaches that re-evaluate and possibly re-design the traditional hardware and software stack.

Proposals that address hardware and/or software security and thus provide the basis for designing, building, and operating a cyberinfrastructure with improved resistance to malicious behavior may be in scope for the SaTC program.

Investigators interested in the SHF program may also wish to consider the Computer Systems Research (CSR) program in the CNS division, which focuses on advances in system computing and system programming that are particular to an application domain or a specific hardware platform.

More information on topics appropriate for the Software and Hardware Foundations program is available at: [https://www.nsf.gov/cise/ccf/shf\\_pgm12.jsp](https://www.nsf.gov/cise/ccf/shf_pgm12.jsp).

## PROJECT CLASSES

Proposals submitted to this solicitation must be consistent with one of two project classes defined below. Proposals will be considered for funding within their project classes.

- **SMALL Projects**

**Small Projects, with total budgets up to \$500,000 for durations of up to three years**, are well suited to one or two investigators (PI and one co-PI or other Senior Personnel) and at least one student and/or postdoc. A collaboration plan (up to 2 pages) may be provided under Supplementary Documentation. Please see Proposal Preparation Instructions Section V.A for additional submission guidelines.

- **MEDIUM Projects**

**Medium Projects, with total budgets ranging from \$500,001 to \$1,200,000 for durations up to four years**, are well suited to one or more investigators (PI, co-PI and/or other Senior Personnel) and several students and/or postdocs. Medium project descriptions must be comprehensive and well-integrated, and should make a convincing case that the collaborative contributions of the project team will be greater than the sum of each of their individual contributions. Rationale must be provided to explain why a budget of this size is required to carry out the proposed work. Since the success of collaborative research efforts are known to depend on thoughtful coordination mechanisms that regularly bring together the various participants of the project, a **Collaboration Plan is required for any Medium project with more than one investigator**, even when the investigators are affiliated with the same institution. Up to 2 pages are allowed for Collaboration Plans and they must be submitted as a document under Supplementary Documentation. The length of and level of detail provided in the Collaboration Plan should be commensurate with the complexity of the proposed project. Collaboration plans and proposed budgets should demonstrate that key personnel, and especially lead PIs, have allocated adequate time for both their individual technical contributions and the leadership of collaborative activities necessary to realize the synergistic effects of larger-scale research. **If a Medium project with more than one investigator does not include a Collaboration Plan, that proposal will be returned without review.** Please see *Proposal Preparation Instructions* Section V.A for additional submission guidelines.

- **LARGE Projects**

**Large proposals may not be submitted to the CCF core programs in FY 2018. Large proposals submitted simultaneously to any other CISE core program and a CCF core program will be returned without review (RWR).**

## BROADENING PARTICIPATION

CISE is committed to enhancing the community's awareness of and overcoming barriers to Broadening Participation in Computing (BPC), and to providing information and resources to principal investigators (PIs) so that they can develop interest, skills, and activities in support of BPC at all levels of the CISE community (K-12, undergraduate, graduate, and postgraduate). Indeed, CISE supports meaningful actions that address the longstanding underrepresentation of various populations including women, minorities (African Americans/Blacks, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians, Native Pacific Islanders, and persons from economically disadvantaged backgrounds), and persons with disabilities, in the computing field. Towards this end, with this solicitation, CISE is initiating a pilot BPC effort. Beginning with submissions to this solicitation, all PIs are strongly encouraged to include meaningful BPC plans in the Broader Impacts sections of their submitted proposals, and/or to begin preparing to include such plans in future proposal submissions. More information, including examples of meaningful BPC activities and metrics, can be found on the CISE

BPC webpage: <https://www.nsf.gov/cise/bpc>.

## PROPOSALS FOR CONSIDERATION BY MULTIPLE CISE PROGRAMS

Proposals that intersect more than one CISE research program are welcome. In such cases, PIs must identify the most relevant programs in the proposal submission process (for information about submission and how to identify such proposals, see *Proposal Preparation Instructions* later in this document). CISE Program Officers will ensure that these proposals are co-reviewed as appropriate.

## IMPORTANT PROJECT CHARACTERISTICS

The submission of far-reaching, creative research and education projects is encouraged. Funds will be used to support potentially transformative research with high-impact potential. In this way, CISE will catalyze exciting new research activities with the potential to make significant advances in the state-of-the-art.

Interdisciplinary, international and/or academic-industry collaborations that promise to result in major science or engineering advances are welcome. The directorate hopes to attract proposals from faculty at a broad range of academic institutions, including faculty at minority-serving and predominantly undergraduate institutions.

Proposals submitted should demonstrate that rich learning experiences will be provided for a diverse population of students and may propose the development of innovative curricula or educational materials that advance literacy about and expertise in areas supported by CISE.

Scientific progress often results by considering a special case of a general problem. If your research falls into this category, you can help the reviewers and NSF staff better understand the intellectual merit and/or broader impacts of your proposal by discussing to what extent the findings are likely to generalize.

## EMBEDDED REU SUPPLEMENTS

The *Research Experiences for Undergraduates (REU): Sites and Supplements* solicitation ([NSF 13-542](#)) gives instructions for embedding a request for an REU Supplement in a proposal. Proposers are invited to embed a request for an REU Supplement in the typical amount **for one year only** according to normal CISE guidelines (detailed below). The amounts of the REU Supplements **do not** count against the budget limitations described in this solicitation for the Small and Medium project classes.

For single investigator projects, CISE REU supplemental funding requests should typically be for no more than two students for one year. Research teams funded through multi-investigator projects may request support for a larger number of students, commensurate with the size and nature of their projects. For example, for projects involving two principal investigators, REU supplemental funding is typically requested for about four undergraduates for one year. Requests for larger numbers of students should be accompanied by detailed justifications.

CISE expects to provide up to \$8,000 per student per year through the REU supplemental support mechanism. As described in the REU program solicitation ([NSF 13-542](#)), indirect costs (F&A) are not allowed on Participant Support Costs in REU Site or REU Supplement budgets.

REU stipend support is one way to retain talented students in undergraduate education, while providing meaningful research experiences. The participation of students from groups underrepresented in computing -underrepresented minorities, women and persons with disabilities -is strongly encouraged. In addition, CISE encourages REU supplements that specifically afford US veterans an opportunity to engage in meaningful research experiences.

CISE REU supplemental funding requests must describe results of any previous such support, including students supported, papers published, etc. Other factors influencing supplemental funding decisions include the number of REU requests submitted by any one principal investigator across all of her/his CISE grants.

Investigators are encouraged to refer to the current REU program solicitation ([NSF 13-542](#)) for detailed information concerning submission requirements. Grantees with questions may also contact one of the Cognizant Program Officers listed in this solicitation.

## III. AWARD INFORMATION

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Up to \$100 million each year will support up to 250 awards, pending the availability of funds.

## IV. ELIGIBILITY INFORMATION

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### Who May Submit Proposals:

Proposals may only be submitted by the following:

- Universities and Colleges - Universities and two- and four-year colleges (including community colleges) accredited in, and having a campus located in, the US acting on behalf of their faculty members. Such organizations also are referred to as academic institutions.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.



#### Who May Serve as PI:

PIs, co-PIs or other senior project personnel must hold primary, full-time, paid appointments in research or teaching positions at US-based campuses/offices of eligible organizations.

#### Limit on Number of Proposals per Organization:

There are no restrictions or limits.

#### Limit on Number of Proposals per PI or Co-PI: 2

In any contiguous September through November period, an individual may participate as PI, Co-PI or Senior Personnel in **no more than two Small, Medium, or Large** proposals submitted in response to the *coordinated solicitation* (where *coordinated solicitation* is defined to include the *Computing and Communication Foundations (CCF): Core Programs, Information and Intelligent Systems (IIS): Core Programs*, and the *Computer and Network Systems (CNS): Core Programs* solicitations). For example, between September 2017 and November 2017, an individual may participate as PI, co-PI or Senior Personnel in one proposal submitted to a core program in CCF and in a second proposal submitted to a core program in CNS, or an individual may participate as PI, co-PI or Senior Personnel in two proposals submitted to an IIS core program, etc.

**These eligibility constraints will be strictly enforced in order to treat everyone fairly and consistently.** In the event that an individual exceeds this limit, proposals involving the individual that are received within the limit will be accepted based on earliest date and time of proposal submission (i.e., the first two proposals received will be accepted and the remainder will be returned without review). **No exceptions will be made.**

The limit on the number of proposals per PI, co-PI or Senior Personnel applies only to the *coordinated solicitation*.

#### Additional Eligibility Info:

For US universities and two- and four-year colleges and non-profit, non-academic organizations with overseas campuses/offices, this solicitation restricts eligibility to research activities using the facilities, equipment, and other resources of the campuses/offices located in the US only.

Further, subawards are not permitted to overseas campuses/offices of US-based proposing organizations.

## V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

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### A. Proposal Preparation Instructions

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**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](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](mailto: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](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](mailto: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 information SUPPLEMENTS (note that it does NOT replace) the guidelines provided in the PAPPG.

**Cover Page:** PIs submitting Grant Opportunities for Academic Liaison with Industry (GOALI) proposals should select "GOALI" from the Type of Proposal drop down list in the Proposal Preparation module in FastLane or Grants.gov. Please see Chapter II.E.4 of the PAPPG for additional information about preparing a GOALI proposal:



#### Proposal Titles:

Proposal titles must begin with an acronym that indicates the most relevant core program. Select an acronym from the following list:

- Algorithmic Foundations: AF
- Communications and Information Foundations: CIF
- Software and Hardware Foundations: SHF

The acronym should be followed with a colon, then the project class followed by a colon, then the title of your project. For example, if you are submitting a Medium proposal to the Algorithmic Foundations core program, then your title would be **AF: Medium: Title**.

Proposals which cross the CCF core programs, should begin with the acronyms for the programs, then the project class followed by a colon, then the proposal title, e.g., **AF: CIF: Small: Title**.

If a proposal is submitted as part of a set of collaborative proposals, the title of the proposal should begin with the acronym that indicates the most relevant core program followed by a colon, then the project class followed by a colon, then "Collaborative Research" followed by a colon, and the title. For example, if you are submitting a collaborative set of proposals for a Small project to the CIF core program, the title of each would be **CIF: Small: Collaborative Research: Title**.

Proposals from PIs in institutions that have RUI (Research in Undergraduate Institutions) eligibility should have a proposal title that begins with the acronym that indicates the most relevant core program acronym, followed by a colon then the project class, followed by a colon then "RUI", followed by a colon and then the title, for example, **SHF: Medium: RUI: Title**.

PIs submitting GOALI proposals should have a proposal title that begins with the acronym that indicates the most relevant core program acronym, followed by a colon then the project class, followed by a colon then "GOALI", followed by a colon and then the title, for example, **AF: Small: GOALI: Title**.

Proposals that extend beyond the scope of one CISE core program or area are welcome. Proposals should be submitted in response to the solicitation for the CISE division (CCF, CNS or IIS) that includes the most relevant core program. In such cases, PIs should identify the acronym for the **most relevant** core program or area, followed by any other relevant program acronym(s) separated by colons (for example, **SHF: CHS: Medium: Title**). In this case, the proposal would be submitted to the CCF solicitation but would be considered by CCF/SHF and IIS/Cyber-Human Systems (CHS). CISE Program Officers will work with their NSF and CISE colleagues to ensure that these proposals are appropriately reviewed and considered for funding. Please see the coordinated CNS and IIS solicitations for information on other CISE core programs and the corresponding acronyms.

#### Project Summary:

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.

Please provide between 2 and 6 sets of keywords at the end of the overview in the Project Summary. CISE personnel will use this information in implementing the merit review process. The keywords should describe the main scientific/engineering areas explored in the proposal. Keywords should be prefaced with "Keywords" followed by a colon and each keyword set should be separated by semi-colons. Keywords should be of the type used to describe research in a journal submission, and may include technical areas of expertise necessary to review the proposal. They should be included at the end of the overview in the project summary and might appear, for example, as **Keywords: energy-aware computing; formal logic; graph theory; sensor networks; information visualization; privacy**.

#### Project Description:

**Length of Project Description** - Describe the research and education activities to be undertaken in **up to 15 pages for Small and Medium proposals. Proposals that exceed these limits will be returned without review.**

Proposers are reminded that, as specified in [PAPPG Chapter II.C.2.d](#):

- The Project Description must contain, as a separate section within the narrative, a section labeled "Broader Impacts." This section should include a discussion of the broader impacts of the proposed activities. **Proposals without this clearly-identifiable section will be returned without review.**
- Results from Prior NSF Support: If any PI or co-PI identified on the proposal has received NSF funding with a start date in the past five years (including any current funding and no-cost extensions), information on the award is required for each PI and co-PI, regardless of whether the support was directly related to the proposal. In cases where the PI or co-PI has received more than one award (excluding amendments), they need only report on the one award most closely related to the proposal. Funding includes not just salary support, but any funding awarded by NSF. Please refer to the PAPPG for details about the information that must be provided. Further requirements for this section of the proposal are in the PAPPG. **Note that these results from prior NSF support must be separately described under two distinct headings, "Intellectual Merit" and "Broader Impacts."**

#### Supplementary Documents:

In the Supplementary Documents Section, upload the following information where relevant:

(1) *A list of Project Personnel and Partner Institutions (Note: In collaborative proposals, the lead institution should provide this information for all participants):*

Provide current, accurate information for all personnel and institutions involved in the project. NSF staff will use this information in the merit review process to manage conflicts of interest. The list should include all PIs, Co-PIs, Senior Personnel, paid/unpaid Consultants or Collaborators, Subawardees, Postdocs, and project-level advisory committee members. This list should be numbered and include (in

this order) Full name, Organization(s), and Role in the project, with each item separated by a semi-colon. Each person listed should start a new numbered line. For example:

1. Mary Smith; XYZ University; PI
2. John Jones; University of PQR; Senior Personnel
3. Jane Brown; XYZ University; Postdoc
4. Bob Adams; ABC Community College; Paid Consultant
5. Susan White; DEF Corporation; Unpaid Collaborator
6. Tim Green; ZZZ University; Subawardee

(2) *Collaboration Plans for Medium projects (if applicable. Note: In collaborative proposals, the lead institution should provide this information for all participants):*

Since the success of collaborative research efforts are known to depend on thoughtful coordination mechanisms that regularly bring together the various participants of the project, **all Medium projects that include more than one investigator must include a Collaboration Plan of up to 2 pages.** The length of and degree of detail provided in the Collaboration Plan should be commensurate with the complexity of the proposed project. Where appropriate, the Collaboration Plan might include: 1) the specific roles of the project participants in all organizations involved; 2) information on how the project will be managed across all the investigators, institutions, and/or disciplines; 3) identification of the specific coordination mechanisms that will enable cross-investigator, cross-institution, and/or cross-discipline scientific integration (e.g., yearly workshops, graduate student exchange, project meetings at conferences, use of the grid for videoconferences, software repositories, etc.); and 4) specific references to the budget line items that support collaboration and coordination mechanisms. **If a Medium project with more than one investigator, does not include a Collaboration Plan of up to 2 pages, that proposal will be returned without review.**

(3) *Data Management Plan (required):*

Proposals must include a supplementary document of no more than two pages labeled "Data Management Plan." This supplementary document should describe how the proposal will conform to NSF policy on the dissemination and sharing of research results.

See Chapter II.C.2.j of the [PAPPG](#) for full policy implementation.

For additional information on the Dissemination and Sharing of Research Results, see: <https://www.nsf.gov/bfa/dias/policy/dmp.jsp>.

For specific guidance for Data Management Plans submitted to the Directorate for Computer and Information Science and Engineering (CISE) see: [https://www.nsf.gov/cise/cise\\_dmp.jsp](https://www.nsf.gov/cise/cise_dmp.jsp).

(4) *Documentation of collaborative arrangements of significance to the proposal through Letters of Collaboration:*

There are two types of collaboration, one involving individuals/organizations that are included in the budget, and the other involving individuals/organizations that are not included in the budget. Collaborations that are included in the budget should be described in the Project Description. Any substantial collaboration with individuals/organizations not included in the budget should be described in the Facilities, Equipment and Other Resources section of the proposal (see PAPPG Chapter II.C.2.i). In either case, whether or not the collaborator is included in the budget, **a letter of collaboration from each named participating organization other than the submitting lead, non-lead, and/or subawardee institutions should be provided at the time of submission of the proposal. Such letters should explicitly state the nature of the collaboration, appear on the organization's letterhead and be signed by the appropriate organizational representative. These letters must not otherwise deviate from the restrictions and requirements set forth in the PAPPG, Chapter II.C.2.j.**

**Please note that letters of support may not be submitted.** Such letters do not document collaborative arrangements of significance to the project, but primarily convey a sense of enthusiasm for the project and/or highlight the qualifications of the PI or co-PI. **Reviewers will be instructed not to consider these letters of support in reviewing the merits of the proposal.**

(5) *Other specialized information:*

RUI Proposals: PIs from predominantly undergraduate institutions should include a Research in Undergraduate Institutions (RUI) Impact Statement and Certification of RUI Eligibility in this section.

GOALI proposals: PIs submitting GOALI proposals should include industry-university agreement letters on intellectual property in this section.

**No other Supplementary Documents, except as permitted by the NSF PAPPG, are allowed.**

#### **Single Copy Documents:**

*Collaborators and Other Affiliations Information: In lieu of the instructions specified in the PAPPG, Collaborators and Other Affiliations Information should be submitted as follows:*

For this solicitation, the Collaborators & Other Affiliations (COA) information specified in the PAPPG should be submitted using the spreadsheet template found at <https://www.nsf.gov/bfa/dias/policy/coa.jsp>. For each proposal, a completed spreadsheet for each PI, co-PI, and Senior Personnel should 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 COA information has a common, searchable format. *Submitters using grants.gov may upload this document as a PDF.*

#### **Submission Checklist:**

In an effort to assist proposal preparation, the following checklists are provided as a reminder of the items that should be checked before submitting an AF or CIF or SHF proposal to this solicitation. These are a summary of the requirements described above. For the items marked with (RWR), the proposal will be returned without review if the required item is noncompliant at the submission deadline. Note that there are four checklists: (1) for all proposals, unique to this solicitation; (2) for all proposals, selected items from the PAPPG; (3) additional requirements for Small proposals; and (4) additional requirements for Medium proposals.

For all proposals, regardless of size:

- Letters of Collaboration are permitted as Supplementary Documents. *Letters of Support are not allowed; reviewers will be instructed not to consider these letters in reviewing the merits of the proposal.*
- Should include Collaborators & Other Affiliations (COA) for each PI, co-PI, and Senior Personnel, using the spreadsheet template to upload as Single Copy COA Documents.
- The last line of the Project Summary should consist of the word "Keywords" followed by a colon and between 2-6 keyword sets, separated by semi-colons.

The following items are not specific to this solicitation, but are included as reminders, and apply to all NSF proposals unless otherwise noted by the solicitations (see the PAPPG for further information). **This is a summary of key items, but does not replace the complete set of requirements in the PAPPG.**

- (RWR) Within the Project Description, a section labeled "Broader Impacts".
- (RWR) Within the Project Description, a description of "Results from Prior NSF Support", including intellectual merit and broader impacts (or a specific statement indicating that the PI has no prior NSF support).
- (RWR) If the budget includes postdoctoral researchers, a one-page Postdoctoral Researcher Plan must be included as a Supplementary Document.
- (RWR) A Data Management Plan, not to exceed two pages, must be included.

For Small proposals:

- The proposal title should comply with the requirements under Proposal Preparation Instructions.
- In addition to the above title prefixes, proposals from PIs in institutions that have RUI (Research in Undergraduate Institutions) eligibility should include "RUI:" immediately before the proposal title, for example, **CHS: Small: RUI: Title**, and should include a Research in Undergraduate Institutions Impact Statement and Certification of RUI Eligibility. Similarly, PIs submitting Grant Opportunities for Academic Liaison with Industry (GOALI) proposals should select "GOALI" from the Type of Proposal drop down list in the Proposal Preparation module in FastLane or Grants.gov; and include "GOALI:" immediately before the proposal title, for example, **RI: Small: GOALI: Title**.
- (RWR) Maximum budget shown on the cover page and on the budget sheets must not exceed \$500,000, plus funds for embedded REU supplements.
- (RWR) The Project Description is limited to no more than 15 pages.
- A collaboration plan (up to 2 pages) **may** be provided as a supplementary document.

For Medium proposals:

- The proposal title should comply with the requirements under Proposal Preparation Instructions.
- In addition to the above title prefixes, proposals from PIs in institutions that have RUI (Research in Undergraduate Institutions) eligibility should include "RUI:" immediately before the proposal title, for example, **CHS: Medium: RUI: Title**, and should include a Research in Undergraduate Institutions Impact Statement and Certification of RUI Eligibility. Similarly, PIs submitting Grant Opportunities for Academic Liaison with Industry (GOALI) proposals should select "GOALI" from the Type of Proposal drop down list in the Proposal Preparation module in FastLane or Grants.gov; and include "GOALI:" immediately before the proposal title, for example, **RI: Medium: GOALI: Title**.
- (RWR) The budget shown on the cover page and on the budget sheets be \$500,001 to \$1,200,000, plus funds for embedded REU supplements.
- (RWR) The Project Description is limited to no more than 15 pages.
- (RWR) If there is more than one investigator, a collaboration plan (up to 2 pages) **must** be provided as a supplementary document, even if all investigators are affiliated with the same institution.

**Proposals that do not comply with the requirements marked as RWR will be returned without review.**

## B. Budgetary Information

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### Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

### Other Budgetary Limitations:

Budgets must comply with the range limitations specified for each project class.

## C. Due Dates

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- **Submission Window Date(s)** (due by 5 p.m. submitter's local time):

September 20, 2017 - September 27, 2017

MEDIUM

November 01, 2017 - November 15, 2017

SMALL

## D. FastLane/Grants.gov Requirements

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### 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](mailto: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](mailto: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

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Proposals received by NSF are assigned to the appropriate NSF program for acknowledgment 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/](https://www.nsf.gov/bfa/dias/policy/merit_review/).

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

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

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

### A. Merit Review Principles and Criteria

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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

For relevant Medium proposals, reviewers will be asked to:

- Comment on the extent to which the project scope justifies the level of investment requested, and the degree to which the Collaboration Plan (if required) adequately demonstrates that the participating investigators will work synergistically to accomplish the project objectives.
- Comment on whether key personnel, and especially lead PIs, have allocated adequate time for both their individual technical contributions and the leadership of collaborative activities necessary to realize the synergistic effects of larger-scale research.

## B. Review and Selection Process

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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

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### A. Notification of the Award

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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

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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](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](mailto:nsfpubs@nsf.gov).

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

### C. Reporting Requirements

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

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



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

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

## VIII. AGENCY CONTACTS

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*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:

- Almadena Y. Chtchelkanova, Point of Contact, Software and Hardware Foundations (SHF), 1115, telephone: (703) 292-8910, email: [achtchel@nsf.gov](mailto:achtchel@nsf.gov)
- Tracy Kimbrel, Point of Contact, Algorithmic Foundations (AF), 1115, telephone: (703) 292-8910, email: [tkimbrel@nsf.gov](mailto:tkimbrel@nsf.gov)
- Phillip Regalia, Point of Contact, Communications and Information Foundations (CIF), 1115, telephone: (703) 292-8910, email: [pregalia@nsf.gov](mailto:pregalia@nsf.gov)

For questions related to the use of FastLane, contact:

- FastLane Help Desk, telephone: 1-800-673-6188; e-mail: [fastlane@nsf.gov](mailto: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](mailto:support@grants.gov).

In addition to the Program Officers identified as program points of contact above, the following CCF Program Officers also support CCF core programs as indicated below:

Algorithmic Foundations (AF)

- Mitra Basu, (703) 292-8910, [mbasu@nsf.gov](mailto:mbasu@nsf.gov), Room 1115
- Rahul Shah, (703) 292-2709 [rshah@nsf.gov](mailto:rshah@nsf.gov), Room 1115
- Jack Snoeyink, (703) 292-7178, [jsnoeyin@nsf.gov](mailto:jsnoeyin@nsf.gov), Room 1115
- Dmitry Maslov, (703) 292-8910, [dmaslov@nsf.gov](mailto:dmaslov@nsf.gov), Room 1115

Communications and Information Foundations (CIF)

- D. Richard Brown, (703) 292-8910, [ribrown@nsf.gov](mailto:ribrown@nsf.gov), Room 1115
- John Cozzens, (703) 292-8910, [jcozzens@nsf.gov](mailto:jcozzens@nsf.gov), Room 1115

Software and Hardware Foundations (SHF)

- Nina Amla, (703) 292-7991, [namla@nsf.gov](mailto:namla@nsf.gov), Room 1110
- Anindya Banerjee, (703) 292-7885, [abanerje@nsf.gov](mailto:abanerje@nsf.gov), Room 1160
- Sankar Basu, (703) 292-8910, [sabasu@nsf.gov](mailto:sabasu@nsf.gov), Room 1114
- Sol Greenspan, (703) 292-8910, [sgreensp@nsf.gov](mailto:sgreensp@nsf.gov), Room 1108
- Tao Li, (703) 292-8910, [taoli@nsf.gov](mailto:taoli@nsf.gov), Room 1115

## IX. OTHER INFORMATION

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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>.

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

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- **Location:** 4201 Wilson Blvd. Arlington, VA 22230
- **For General Information** (NSF Information Center): (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
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