

# Petascale Computing Resource Allocations (PRAC)

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## PROGRAM SOLICITATION

NSF 17-542

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## REPLACES DOCUMENT(S):

NSF 16-529

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**National Science Foundation**

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

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

November 06, 2017

## IMPORTANT INFORMATION AND REVISION NOTES

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This solicitation revises the previous Petascale Computing Resource Allocations (PRAC) solicitation (NSF 16-529) in the following ways:

- Added a restriction that the maximum allowable project duration is one year; and
- Revised the maximum funding amount for each award to \$15,000.

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:**

Petascale Computing Resource Allocations (PRAC)

**Synopsis of Program:**

In 2013, a new NSF-funded petascale computing system, Blue Waters, was deployed at the University of Illinois at Urbana-Champaign. The goal of this project and system is to open up new possibilities in science and engineering by providing computational capability that makes it possible for investigators to tackle much larger and more complex research challenges across a wide spectrum of domains. The purpose of this solicitation is to invite research groups to submit requests for allocations of resources on the Blue Waters system. Proposers must show compelling science or engineering challenges that require petascale computing resources. Proposers must also be prepared to demonstrate that they have science or engineering research problems that require and can effectively exploit the petascale computing capabilities offered by Blue Waters. Proposals from or including junior researchers are encouraged, as one of the goals of this solicitation is to build a community capable of using petascale computing.

**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.*

- Edward Walker, CISE/OAC, telephone: (703) 292-4863, email: [edwalker@nsf.gov](mailto:edwalker@nsf.gov)

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

- 47.070 --- Computer and Information Science and Engineering
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## Award Information

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**Anticipated Type of Award:** Standard Grant

**Estimated Number of Awards:** 12 to 15

up to \$15,000 for each award, pending availability of funds.

**Anticipated Funding Amount:** \$180,000 to \$225,000

total annually across all funded projects, pending availability of funds.

## Eligibility Information

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### 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:

There are no restrictions or limits.

### Limit on Number of Proposals per Organization:

There are no restrictions or limits.

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

An individual may be PI or co-PI on no more than one proposal that responds to this solicitation per deadline. In the event that an individual exceeds this limit, any proposal submitted to this solicitation with this individual listed as a PI or co-PI after the first proposal is received at NSF will be returned without review. No exceptions will be made. There is no limit on the number of proposals with which an individual may be associated in other capacities, such as senior personnel.

## 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=papppg](https://www.nsf.gov/publications/pub_summ.jsp?ods_key=papppg).
  - 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

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

November 06, 2017

## 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:**

Additional award conditions apply. Please see the full text of this solicitation for further information.

**Reporting Requirements:**

Standard NSF reporting requirements apply.

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**I. INTRODUCTION**

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In recent decades, the development of powerful computing and data resources has been driven, in part, by the need to solve challenging questions in science and engineering with significant impacts on knowledge about the natural world, on industrial competitiveness, and on national security. At the same time, as researchers in more and more areas of science and engineering have developed techniques for using computation to advance their grand challenges, there has been a steady expansion in the breadth of the research frontiers at which large-scale computation with increasingly large amounts of data has become an essential tool. These frontiers include materials science, nano-engineering, fluid dynamics, climate and earth system dynamics, cosmology and astrophysics, chemistry and biochemistry, sustainability, health information technologies, cybersecurity, economics and social science, neuroinformatics and bioinformatics, as well as many different topics within physics, engineering, and increasingly in cross-disciplinary sciences.

In 2013, researchers began to access Blue Waters which is deployed at the University of Illinois at Urbana-Champaign and funded by NSF. Blue Waters is an extremely powerful heterogeneous computing and storage system capable of delivering sustained performance in excess of one petaflop/s on a broad range of calculation types. It is designed to complement existing NSF-funded resources and services including providing larger allocations than is typical for other NSF-supported resources. An allocation is accompanied by dedicated application and system expertise from the Blue Waters project.

Because of the expense of acquiring and operating Blue Waters, allocation of time on this resource represents a considerable investment by NSF. The purpose of this solicitation is to solicit requests for resource allocations on the Blue Waters system so that these requests can be reviewed by the scientific community in a timely fashion and research groups can have sufficient time to prepare

for optimal use of the Blue Waters system. Successful proposals will receive allocations to access Blue Waters to support the research that they have planned, along with limited travel funds to support technical coordination with the Blue Waters project team and with other research teams with allocations on Blue Waters. Note that, this program does **not** provide funds for the research itself or for the development of models or analysis tools.

## II. PROGRAM DESCRIPTION

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This solicitation seeks proposals to make use of Blue Waters for breakthrough research in any domain supported by the National Science Foundation or any other federal agency.

Blue Waters constitutes the largest NSF-funded system and staff dedicated to supporting a small number of projects at the frontiers of computational science. The system is a heterogeneous Cray XE6/XK7 consisting of more than 22,000 XE6 compute nodes (each containing two AMD Interlagos processors) augmented by more than 4000 XK7 compute nodes (each containing one AMD Interlagos processor and one NVIDIA GK110 "Kepler" accelerator) in a single high-speed *Gemini* interconnection fabric. This configuration enables sustained petascale simulations on hundreds of thousands of traditional CPUs for science and engineering discovery, while also supporting development and optimization of cutting-edge applications capable of leveraging the compute power of thousands of GPUs. The system incorporates extremely large memory and a tightly integrated I/O subsystem and is suitable for both integer and floating-point computations with very large data requirements. The system is also designed to directly support visualization of large-scale datasets produced by computations that use the system. A large amount of archival storage is associated with the system. The system design responds to input from researchers in a broad range of science and engineering disciplines. Additional non-proprietary details of the system design may be obtained at <https://bluewaters.ncsa.illinois.edu/hardware-summary>.

Trends in HPC architectures are such that current and anticipated production systems typically consist of hundreds of thousands to millions of processor cores with each core capable of executing multiple threads, and, often, arithmetic units that support small vector instructions. These features present a programmer with a variety of mechanisms to exploit the levels of parallelism within algorithms. Optimizing performance involves a number of challenges, including discovering and exploiting parallelism within codes and overlapping different types of operations. Multi-level caches, local and remote main memory, intra-nodal and inter-nodal communication networks and parallel I/O interfaces offer an increasingly deep hierarchy of latency within computing systems. In addition, increasingly, commercial HPC system designs such as Blue Waters are hybrid systems offering general-purpose processors coupled with specialized co-processors, either on-chip or separate. Recent and ongoing developments attempt to simplify the challenge of developing scientific and engineering computer codes that scale.

To effectively use computation at sustained rates of a petaflop/s or more, with memory-resident data of order one petabyte and correspondingly large I/O datasets is a considerable computational science challenge in itself. Some algorithms readily scale across large numbers of processing elements. In general, though, the design and implementation of computing codes that can harness all of the resources of a system like Blue Waters to address complex science and engineering problems that are not readily pursued by other means is not trivial. It is anticipated that research groups may require several years of preparation before being ready to exploit a sustained petaflop/s system.

The purpose of this solicitation is to identify groups that require petascale computing for groundbreaking science or engineering research, that have a need for the unique resource that Blue Waters represents, and that are able to use Blue Waters effectively. In particular, proposals are encouraged that broaden the areas of scientific research that are actively being conducted using Blue Waters - see <https://bluewaters.ncsa.illinois.edu/science-teams> for details. Because of the intrinsic value of the Blue Waters resource a research group will only be granted significant access to the production system after its request for a resource allocation has been successful in a competitive merit review managed by NSF. Successful proposers to this solicitation will be granted an allocation of Blue Waters resources together with a small amount of funds to cover travel costs. The Blue Waters project team will offer consulting support and assistance to each project team that is granted access through this solicitation. This consulting support includes assistance in performance analysis and prediction.

## III. AWARD INFORMATION

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Anticipated Type of Award: Standard Grant

Estimated Number of Awards: 12 to 15

Anticipated Funding Amount: \$180,000 to \$225,000 total annually across all funded projects, pending availability of funds.

For information on past awards of computing resources see <https://bluewaters.ncsa.illinois.edu/status-usage>.

Estimated program budget, number of awards and average award size are subject to the availability of funds and computing resources. The maximum award duration is one year.

The primary purpose of this solicitation is to identify research projects for large allocations of Blue Waters computing resources. Note that this solicitation does **not** provide direct funding support for the research associated with such projects: instead, it is intended to provide indirect support for research projects requiring petascale computing resources on the Blue Waters system. It is anticipated that the Blue Waters team will provide consulting support to projects that are successful under this solicitation to help those projects prepare to make effective use of the Blue Waters system. To facilitate a project's interaction with the Blue Waters team, funding of up to \$15,000 will be provided to support travel by members of the project team and/or the Blue Waters team.

## IV. ELIGIBILITY INFORMATION

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### 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:

There are no restrictions or limits.

### Limit on Number of Proposals per Organization:

There are no restrictions or limits.

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

An individual may be PI or co-PI on no more than one proposal that responds to this solicitation per deadline. In the event that an individual exceeds this limit, any proposal submitted to this solicitation with this individual listed as a PI or co-PI after the first proposal is received at NSF will be returned without review. No exceptions will be made. There is no limit on the number of proposals with which an individual may be associated in other capacities, such as senior personnel.

## 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.

### PROJECT SUMMARY

In addition to the information described in the PAPPG, the summary should state the total requested node-hours and the associated storage, if greater than the default storage allocation. See <https://bluewaters.ncsa.illinois.edu/storage> for additional detail.

### PROJECT DESCRIPTION

Proposers should note that the Project Description section is limited to no more than 15 pages in length.

In addition to any sections required in the PAPPG, the Project Description must include the following seven sections:

- Target Problem;
- Intellectual Merit;
- Broader Impacts;
- Description of the Computational Codes to be used;
- Development Plan;
- Source(s) of Development Funding and Development Resources; and
- Resources Required.

**Target Problem:** A detailed description of one or more specific research questions that the resources requested will be used to answer. Include an explanation of why a petascale resource of the leading-edge capability that Blue Waters represents is necessary to address this research. If you believe that this research will be transformative, please describe why.

**Intellectual Merit:** A description of the intellectual merit associated with the targeted research problem. If there is substantial intellectual merit associated with the work necessitated by preparations to use the Blue Waters system effectively, this may be described in addition to, but not in place of, the intellectual merit of the specific research topic.

**Broader Impacts:** The broader impacts of this work, where broader impacts are defined in the description of NSF's second primary review criterion. (See Section VI.A, below.)

**Description of the Computational Codes to be used:** Describe the structure of the application codes that you intend to use. These may either currently exist but perhaps require enhancement, or they may be in development. Include descriptions of any novel computational or data-driven approaches. Include details about the algorithms involved and the approach that you intend to use to ensure that the code scales effectively on the Blue Waters architecture. Describe how your code will use each of the major system elements: the memory hierarchy, communications network, computational elements, GPU nodes, and I/O subsystem. Identify which system element(s) is (are) likely to be the main bottlenecks and how the design of your application minimizes the impact of these bottlenecks. Describe the data requirements and how you intend to analyze the output resulting from your use of Blue Waters. Describe any planned visualization. **IMPORTANT:** Please describe any specific libraries or software required.

**Development Plan:** Describe the current state of readiness of the application codes that you intend to use and your plans, with milestones, for developing these to the point at which they would be ready to run in production mode on the Blue Waters system. Estimate the type of access that you will need, for development purposes, to the Blue Waters system; and to systems that are smaller than Blue Waters but that are still relatively large-scale systems, such as NSF's XD (eXtreme Digital) or NCAR (National Center for Atmospheric Research) systems. Describe the topics requiring consulting help from the Blue Waters project team. Proposers are encouraged to contact the Blue Waters project team before submitting a proposal to obtain a better understanding of the type of help that it can provide: <https://bluewaters.ncsa.illinois.edu>.

**Source(s) of Development Funding and Development Resources:** Identify the source(s) (award number and agency), amount and duration of funding that will be used to conduct the described research and to develop the necessary methods or algorithms.

**Resources Required:** Describe the Blue Waters resources required to complete research on the Target Problem and the basis for the estimation. This description should include the number and type of system nodes needed for your runs, anticipated memory usage, expected number and duration of runs required for each phase of the research, total number of node-hours required, anticipated I/O requirements, and amount of data that you anticipate transferring to or from Blue Waters. Please see the following to assist in calculating node-hours: [https://bluewaters.ncsa.illinois.edu/node\\_core\\_comparison](https://bluewaters.ncsa.illinois.edu/node_core_comparison). The request must also be summarized in a table entitled "Summary of Resources Required", with rows for each project year and the following columns: node-hours of CPU-only (XE) nodes; node-hours of GPU (XK) nodes; and required storage and type, if greater than default allocations. See <https://bluewaters.ncsa.illinois.edu/storage> for additional detail. Million node-hours and terabytes should be used as units and indicated in the table caption. As a reminder, state the grand total of this request in the Project Summary (described above).

## SUPPLEMENTAL DOCUMENTS

**Current and Requested Computational Allocations:** For all involved project members, provide a list of all, including non-NSF, related, currently awarded and pending requests for computational allocations that exceed 5 million node-hours. For each entry, state the following: the amount of the allocation; award status (awarded or requested); award period; award number and awarding agency; PI; and brief justification of the additional request, if the supported science is related to the current proposal. If no current allocations of compute resources greater than 5 million node-hours exist or have been requested, state this fact. **Proposals that fail to appropriately disclose all relevant current and pending compute allocations (>5M node-hours) will be returned without review.**

**Data Management Plan:** Please see [https://www.nsf.gov/cise/cise\\_dmp.jsp](https://www.nsf.gov/cise/cise_dmp.jsp) for Data Management Plan Guidance. Note in particular the required content in the Data Management Plan.

## SINGLE COPY DOCUMENTS

### Collaborators and Other Affiliations Information:

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

The Collaborators and Other Affiliations are entered for each participant within each proposal and, as Single Copy Documents, are available only to NSF staff.

## B. Budgetary Information

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### Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

**Other Budgetary Limitations:**

To facilitate a project's interaction with the Blue Waters team, funding of up to \$15,000 will be provided to support travel by members of the project team and/or the Blue Waters team. Funding requests must not exceed \$15,000. Funds may only be requested in the following two budget categories: Travel (members of the project team) and/or Participant Support Costs (travel of the Blue Waters team).

**Budget Preparation Instructions:**

Budget requests must include funds for domestic travel for attendance by PIs or co-PIs at an annual PI meeting organized by the Blue Waters project, where progress and results will be shared and discussed.

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## C. Due Dates

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

November 06, 2017

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## 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](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.

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## 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/](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**

Reviewers will be asked to evaluate:

- If the research question(s) described represent breakthrough science and engineering research; and
- If the investigation requires petascale resources and will make efficient use of Blue Waters.

## **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).

#### **Special Award Conditions:**

PIs will be required to attend annual PI meetings.

## **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:

- Edward Walker, CISE/OAC, telephone: (703) 292-4863, email: [edwalker@nsf.gov](mailto:edwalker@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).

## **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>.

## ABOUT THE NATIONAL SCIENCE FOUNDATION

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The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861-75). The Act states the purpose of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering."

NSF funds research and education in most fields of science and engineering. It does this through grants and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the US. The Foundation accounts for about one-fourth of Federal support to academic institutions for basic research.

NSF receives approximately 55,000 proposals each year for research, education and training projects, of which approximately 11,000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships. The agency operates no laboratories itself but does support National Research Centers, user facilities, certain oceanographic vessels and Arctic and Antarctic research stations. The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

*Facilitation Awards for Scientists and Engineers with Disabilities (FASSED)* provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See the *NSF Proposal & Award Policies & Procedures Guide* Chapter II.E.6 for instructions regarding preparation of these types of proposals.

The National Science Foundation has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment or general information. TDD may be accessed at (703) 292-5090 and (800) 281-8749, FIRS at (800) 877-8339.

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

The National Science Foundation promotes and advances scientific progress in the United States by competitively awarding grants and cooperative agreements for research and education in the sciences, mathematics, and engineering.

To get the latest information about program deadlines, to download copies of NSF publications, and to access abstracts of awards, visit the NSF Website at <https://www.nsf.gov>

- **Location:** 4201 Wilson Blvd. Arlington, VA 22230
- **For General Information** (NSF Information Center): (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**
  - Send an e-mail to: [nsfpubs@nsf.gov](mailto:nsfpubs@nsf.gov)
  - or telephone: (703) 292-7827
- **To Locate NSF Employees:** (703) 292-5111

## PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

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The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, [NSF-50](#), "Principal Investigator/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004), and [NSF-51](#), "Reviewer/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004). Submission of the information is voluntary. Failure to provide full

and complete information, however, may reduce the possibility of receiving an award.

An agency may not conduct or sponsor, and a person is not required to respond to, an information collection unless it displays a valid Office of Management and Budget (OMB) control number. The OMB control number for this collection is 3145-0058. Public reporting burden for this collection of information is estimated to average 120 hours per response, including the time for reviewing instructions. Send comments regarding the burden estimate and any other aspect of this collection of information, including suggestions for reducing this burden, to:

Suzanne H. Plimpton  
Reports Clearance Officer  
Office of the General Counsel  
National Science Foundation  
Arlington, VA 22230

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