Formal Methods in the Field (FMitF)

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

February 20, 2024

Third Tuesday in February, Annually Thereafter

IMPORTANT INFORMATION AND REVISION NOTES

REVISION NOTES

- Initially, the program limited the field areas to computer networks, embedded systems, operating/distributed systems, human centered computing, and machine learning. The scope of the program has now been expanded to include any field areas within computer and information science and engineering that stand to directly benefit from a grounding in formal methods.
- A new track for Education proposals has been added to the program with the objective of supporting the development and dissemination of education material to increase the accessibility of formal methods.
- The overall annual budget has been increased from $10,000,000 to $10,500,000, and the limit on the award amount for Track I proposals has been increased from $750,000 to $1,000,000.

Any proposal submitted in response to this solicitation should be submitted in accordance with the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) that is in effect for the relevant due date to which the proposal is being submitted. The NSF PAPPG is regularly revised and it is the responsibility of the proposer to ensure that the proposal meets the requirements specified in this solicitation and the applicable version of the PAPPG. Submitting a proposal prior to a specified deadline does not negate this requirement.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Formal Methods in the Field (FMitF)

Synopsis of Program:

The Formal Methods in the Field (FMitF) program aims to bring together researchers in formal methods with researchers in other areas of computer and information science and engineering to jointly develop rigorous and reproducible methodologies for designing and implementing correct-by-construction systems and applications with provable guarantees. FMitF encourages close collaboration between two groups of researchers. The first group consists of researchers in the area of formal methods, which, for the purposes of this solicitation, is broadly defined as principled approaches based on logic and mathematics to specification, modeling, design, analysis, implementation, abstraction, verification, synthesis, and optimization of systems, networks and applications. The second group consists of researchers in the "field," which, for the purposes of this solicitation, is defined as any area within computer and information science and engineering that would benefit from developing and applying formal methods in their research. All proposals must make a strong case for why formal methods is appropriate for the field area.

The FMitF program solicits three classes of proposals:

- **Track I: Research proposals:** Each proposal must have at least one Principal Investigator (PI) or co-PI with expertise in formal methods and at least one with expertise in the field area. Proposals are expected to address fundamental contributions to both formal methods and the respective field(s) and should include a proof of concept in the field along with a detailed evaluation plan that discusses intended scope of applicability, trade-offs, and limitations. Track I proposals must contain a detailed collaboration plan that clearly highlights and justifies the complementary expertise of the PIs/co-PIs in the designated areas and describes the mechanisms for continuous bi-directional interaction. Projects are limited to $1,000,000 in total budget, with durations of up to four years.
- **Track II: Transition to Practice (TTP) proposals:** The objective of this track is to support the ongoing development of extensible and robust formal methods research prototypes/tools to facilitate usability and accessibility to a larger and more diverse community of users. These proposals are expected to support the development, implementation, and deployment of later-stage successful formal methods research and tools into operational environments in order to bridge the gap between research and practice. A TTP proposal must include a project plan that addresses major tasks and system development milestones as well as an evaluation plan for the working system. Proposals are expected to identify a target user community or organization that will serve as an early adopter of the technology. Collaborations with industry are strongly encouraged. Projects are limited to $150,000 in total budget, with durations of up to two years.
- **Track III: Education proposals:** The objective of this track is to support the development and dissemination of education material to increase the accessibility of formal methods. These proposals are expected to develop new course material in formal methods either as a standalone course or as part of a course in a field area to which formal methods is applicable. An education proposal must include a project plan that addresses dissemination efforts and articulates the new communities that will be impacted through the effort. Collaborations with organizations that do not have strong formal methods education in the curriculum are strongly encouraged. Projects are limited to $250,000 in total budget, with durations of up to 36 months.

The Project Description can be **up to 15 pages for Track I proposals**, and **up to 7 pages for the Track II and Track III proposals**.

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.

- Pavithra Prabhakar, Program Director, CISE/CCF, telephone: (703) 292-8910, email: pprabhak@nsf.gov
- Alhussein A. Abouzeid, Program Director, CISE/CNS, telephone: (703) 292-8950, email: aabouzei@nsf.gov
- Anindya Banerjee, Program Director, CISE/CCF, telephone: (703) 292-7885, email: abanerje@nsf.gov
- Damian Dechev, Program Director, CISE/CCF, telephone: (703) 292-8910, email: ddechev@nsf.gov
- Sorin Draghici, Program Director, CISE/IIS, telephone: (703) 292-2232, email: sdraghic@nsf.gov
- Jason O. Hallstrom, Program Director, CISE/CNS, telephone: (703) 292-8950, email: jhallstr@nsf.gov
- Thomas Martin, Program Director, CISE/IIS, telephone: 703-292-2170, email: tmartin@nsf.gov
- Daniela Oliveira, Program Director, CISE/CNS, telephone: (703) 292-4352, email: doliveir@nsf.gov

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

- 47.070 --- Computer and Information Science and Engineering

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 18

Approximately 9 Track I awards of up to $1,000,000 per award with durations up to 4 years, 7 Track II awards of up to $150,000 per award with durations up to 24 months, and 2 Track III awards of up to $ 250,000 per award with durations up to 36 months are anticipated, subject to availability of funds and the quality of proposals received.

Anticipated Funding Amount: $10,500,000 subject to availability of funds and quality of proposals received. Estimated program budget, number of awards and average award size/duration are subject to the availability of funds and quality of proposals received.

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Non-profit, non-academic organizations: Independent museums, observatories, research laboratories, professional societies and similar organizations located in the U.S. that are directly associated with educational or research activities.
- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members.

Who May Serve as PI:

By the submission deadline, any PI, co-PI, or other senior project personnel must hold either:

- a tenured or tenure-track position, *or*
- a primary, full-time, paid appointment in a research or teaching position

at a US-based campus of an organization eligible to submit to this solicitation (see above), with exceptions granted for family or medical leave, as determined by the submitting organization. Individuals with *primary* appointments at for-profit non-academic organizations or at overseas branch campuses of U.S. institutions of higher education are not eligible.

A project submitted to Track I must have at least one (co)-PI focusing on formal methods and at least one focusing on another area within computer and information science and engineering.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or co-PI: 3

An investigator may participate as PI, co-PI, or Senior Personnel in at most one proposal in each track per deadline in response to this solicitation.

These eligibility constraints will be strictly enforced in order to treat everyone fairly and consistently. In the event that an individual exceeds this limit, only the first submitted proposal in any category before the deadline will be accepted. **No exceptions will be made**.

Proposals submitted in response to this solicitation may not duplicate or be substantially similar to other proposals concurrently under consideration by NSF.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Not required
- **Preliminary Proposal Submission:** Not required
- **Full Proposals:**
  - Full Proposals submitted via Research.gov: *NSF Proposal and Award Policies and Procedures Guide* (PAPPG) guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.
  - Full Proposals submitted via Grants.gov: *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov* guidelines apply (Note: The *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide).

B. Budgetary Information

- **Cost Sharing Requirements:**

  Inclusion of voluntary committed cost sharing is prohibited.

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

  Not Applicable

- **Other Budgetary Limitations:**

  Not Applicable

C. Due Dates

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

    February 20, 2024

    Third Tuesday in February, Annually Thereafter

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria. Additional merit review criteria apply. Please see the full text of this solicitation for further information.

Award Administration Information

Award Conditions:

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

Reporting Requirements:

Standard NSF reporting requirements apply.

TABLE OF CONTENTS

I. INTRODUCTION

Computing and communication networks and systems impact all aspects of our daily lives, from our economic and societal infrastructure to national security. These networks and systems are complex and notoriously hard to design and analyze, and they often come with significant performance expectations and challenging physical constraints. To complicate matters further, many critical applications that run on these systems and networks are increasingly dependent on machine learning to make important data-driven predictions or decisions and may require interactions with the physical world or humans to be "in the loop." It is not surprising that this complex computing ecosystem leads to error-prone systems, networks, and applications that lack critical correctness and safety guarantees, with potentially catastrophic consequences. There is, therefore, an urgent need to move the needle on ensuring reliability and resilience at all levels of the computing and communication stack. Formal methods include principled approaches based on logic and mathematics for specification, modeling, design, analysis, implementation, abstraction, verification, synthesis, and optimization of systems, networks, and applications. These serve as the foundation for all aspects of information, communication, and control technologies. While formal methods have been used in areas like distributed systems, cyber-physical systems, software development, and robotics, there remain many other research areas that could benefit from their principled application.

The objective of the Formal Methods in the Field (FMitF) program is to build a community of researchers who will work symbiotically on integrating formal methods into the design and development of critical systems to enable correctness by construction. Inspired by Robin Milner's double thesis[1] that "the design of computing systems can only properly succeed if it is well grounded in theory, and that the important concepts in a

theory can only emerge through protracted exposure to application," the FMitF program aims to bring together researchers in formal methods with those in other areas of computer and information science and engineering to jointly develop rigorous and reproducible methodologies for designing and implementing systems and applications with provable correctness guarantees.

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[1] Inaugural lecture "Is Computing an Experimental Science?", Robin Milner, 1986

II. PROGRAM DESCRIPTION

FMitF program posits the need for close and continuous collaboration between two groups of researchers. The first group consists of researchers in the area of formal methods, which, for the purposes of this solicitation, is broadly defined as principled approaches based on logic and mathematics to specification, modeling, design, analysis, implementation, abstraction, verification, synthesis, and optimization of systems, networks and applications. The second group consists of researchers in the "field," which, for the purposes of this solicitation, is defined as any area within computer and information science and engineering that would benefit from developing and applying formal methods in their research. Initially, the program limited the field areas to computer networks, embedded systems, operating/distributed systems, human centered computing, and machine learning. The scope of the program has now been expanded to include any field areas within computer and information science and engineering that stand to directly benefit from a grounding in formal methods.

Today, these two groups of researchers operate largely independently of one another, leading to a significant gap between theory and practice. Many practical systems are constructed without clear design principles and often lack basic safety and correctness guarantees. At the same time, many formal methods are based on assumptions that do not correspond to realistic systems or applications. The development of new formal methods, or the adaptation of existing ones to address the variety of practical problems that arise in the design and implementation of complex systems, necessitates partnerships and collaborations that are often not in place. On the other hand, adequate solutions for these practical problems could present new opportunities and challenges for the formal methods communities and spur the development of novel theories and abstractions. This bi-directional fertilization envisioned by the FMitF program can lead to new fields of study on both sides, as well as to cutting-edge theories, tools, and experiments inspired by challenges faced in the field.

By working together, researchers from these different communities will continually inform each other and collaboratively forge new formal methods that are inspired by practical problems, or find novel, unanticipated applications of existing formal methods that can be validated in the field. The long-term vision is that new formal methods realized through protracted exposure to applications will lead to design principles, abstractions, and methodologies for implementing complex systems and applications that are correct by construction.

The FMitF program solicits proposals in three classes:

Track I: Research proposals: FMitF solicits proposals that advance general theories, principles, and methodologies that go beyond specific problem instances. FMitF seeks to support proposals that have the potential to make advances in both formal methods and in the application area to which the formal methods are being deployed. An ideal proposal will integrate both formal methods and field components and argue the potential for lasting impact on both sides. Proposals that make strong advances primarily on one side of this relationship are not in scope. Proposals that seek to apply existing formal methods without theoretical advances that leverage characteristics of the underlying application domain are also not in scope. Research that includes security as part of a more general effort to ensure correctness and reliability is in scope, while efforts that are focused on protecting against specific vulnerabilities or attacks are not in scope. Finally, proposals that only explore theoretical advances without strong connection to the application domain, or those that do not target a realistic problem in the field, are not in scope.

Proposals are expected to clearly address the fundamental contributions to formal methods and the respective field(s) and should (if appropriate) include a plan for developing a proof of concept in the field along with a detailed evaluation plan that discusses the scope of applicability, trade-offs, and limitations. **This discussion should be in a separate section in the Project Description titled "Contributions to Formal Methods and the Field."** Track I proposals must contain a detailed collaboration plan, included as a Supplementary Document, that clearly highlights and justifies the complementary expertise of the PIs in the designated areas and describes the mechanisms for continuous bi-directional collaboration. Projects are limited to $1,000,000 in total budget, with durations of up to four years. The Project Description can be **up to 15 pages**.

Track II: Transition to Practice (TTP) proposals: The objective of this track is to support the ongoing development of extensible and robust formal methods research prototypes/tools to enable usability and accessibility to a larger and more diverse community of users. Track II proposals should support the development, implementation, and deployment of later-stage successful formal methods research and tools into an operational environment in order to bridge the gap between research and practice. A TTP proposal must include a project plan that addresses major tasks and system development milestones, as well as an evaluation plan for the working system. Proposals are expected to identify a target user community or organization that will serve as an early adopter of the technology. Collaborations with industry are strongly encouraged. Projects are limited to $150,000 in total budget, with durations of up to 24 months. The Project Description can be up **to 7 pages**.

Track III: Education proposals: The objective of this track is to support the development and dissemination of education material to increase the accessibility of formal methods. These proposals are expected to develop new course materials in formal methods, either as a standalone course or as part of a course in a field area to which formal methods is applicable. An education proposal must include a project plan that addresses

dissemination efforts and articulates the new communities that will be impacted through the effort. Collaboration with organizations that do not have strong formal methods education in the curriculum are strongly encouraged. Projects are limited to $250,000 in total budget, with durations of up to 36 months. The Project Description can be **up to 7 pages**.

FMitF PI Meeting

The FMitF program is aiming to grow a new research community. In this spirit, the program plans to host a virtual or in-person PI meeting annually, with participation from all funded PIs, along with other representatives from the research community, government, and industry. For each Track I award, at least one collaborating PI focusing on formal methods and at least one PI focusing on the field must attend the PI meeting each year. For Track II and Track III proposals, at least one PI must attend the PI meeting each year.

III. AWARD INFORMATION

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 18

Approximately 9 Track I awards of up to $1,000,000 per award with durations up to 4 years, 7 Track II awards of up to $150,000 per award with durations up to 24 months, and 2 Track III awards of up to $250,000 per award with durations up to 36 months are anticipated, subject to availability of funds and the quality of proposals received.

Anticipated Funding Amount: $10,500,000, subject to availability of funds and quality of proposals received.

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Non-profit, non-academic organizations: Independent museums, observatories, research laboratories, professional societies and similar organizations located in the U.S. that are directly associated with educational or research activities.
- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members.

Who May Serve as PI:

By the submission deadline, any PI, co-PI, or other senior project personnel must hold either:

- a tenured or tenure-track position, *or*
- a primary, full-time, paid appointment in a research or teaching position

at a US-based campus of an organization eligible to submit to this solicitation (see above), with exceptions granted for family or medical leave, as determined by the submitting organization. Individuals with *primary* appointments at for-profit non-academic organizations or at overseas branch campuses of U.S. institutions of higher education are not eligible.

A project submitted to Track I must have at least one (co)-PI focusing on formal methods and at least one focusing on another area within computer and information science and engineering.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or co-PI: 3

An investigator may participate as PI, co-PI, or Senior Personnel in at most one proposal in each track per deadline in response to this solicitation.

These eligibility constraints will be strictly enforced in order to treat everyone fairly and consistently. In the event that an individual exceeds this limit, only the first submitted proposal in any category before the deadline will be accepted. **No exceptions will be made**.

Proposals submitted in response to this solicitation may not duplicate or be substantially similar to other proposals concurrently under consideration by NSF.

Additional Eligibility Info:

For US IHE 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

A. Proposal Preparation Instructions

Full Proposal Preparation Instructions: Proposers may opt to submit proposals in response to this Program Solicitation via Research.gov or Grants.gov.

- Full Proposals submitted via Research.gov: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the *NSF Proposal and Award Policies and Procedures Guide* (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg. Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov. The Prepare New Proposal setup will prompt you for the program solicitation number.
- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov*. The complete text of the *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the Download Package button. Paper copies of the Grants.gov Application Guide also may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov.

In determining which method to utilize in the electronic preparation and submission of the proposal, please note the following:

Collaborative Proposals. All collaborative proposals submitted as separate submissions from multiple organizations must be submitted via Research.gov. PAPPG Chapter II.E.3 provides additional information on collaborative proposals.

See PAPPG Chapter II.D.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.

Titles:

Proposal titles must indicate the **FMitF** program, followed by a colon, followed by the track, followed by a colon, and followed by the title of the project. For a collaborative proposal (that is, one submitted as separate submissions from multiple organizations), all participating institutions should use the same title, which should begin with **Collaborative Research** followed by a colon. Thus, a single-institution proposal to Track III would have a title of the form **FMitF: Track III: Title**, and a collaborative proposal to Track I would use the form **Collaborative Research: FMitF : Track I: Title**. Please note that if submitting via Research.gov, the system will automatically insert the prepended title "Collaborative Research" when the collaborative set of proposals is created.

Project Summary:

All Track I proposals must include one or more keywords describing the field area(s) of the proposal on the Project Summary page, at the end of the Overview section (before the section on Intellectual Merit).

Budget:

Each proposal must include the costs of attending a FMitF PI meeting per year as part of the budget of the project. The budget should cover participation by the PIs and/or co-PIs, as described above under "FMitF PI Meeting".

Data Management Plan: In addition to the requirements specified in the PAPPG, the Data Management Plan must address the dissemination of the algorithmic contributions and resulting applications, tools, languages, compilers, libraries, architectures, systems, software, architectures, data, etc. Open-source release of these artifacts is strongly encouraged.

Other Supplementary Documents:

Collaboration Plan: All Track I projects are required to include a Collaboration Plan submitted by the lead institution as a separate Supplementary Document (limited to 3 pages). This plan must describe the distinct expertise provided by the PIs as required above under "Who

May Serve as PI" as well as plans for working together to advance knowledge in both formal methods and at least one field area. Joint supervision of students and postdoctoral researchers is strongly encouraged. The collaboration plan must also describe clear measures of success for both the formal methods and field aspects of the project and a plan for evaluating success. **Projects without this document will be returned without review.**

Letters of Collaboration: Documentation of collaborative arrangements of significance to the proposal through Letters of Collaboration (if applicable) should follow the PAPPG guidelines as below:

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 NSF PAPPG Chapter II.D.2). 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 organizations 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 format provided in the NSF PAPPG Chapter II.D.2.

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.**

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Budget Preparation Instructions:

Budgets for all projects must include funding for travel to attend a FMitF PI Meeting each year of the project. For budget preparation purposes, PIs may assume this meeting will be held in the Washington, DC, area.

C. Due Dates

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

    February 20, 2024

    Third Tuesday in February, Annually Thereafter

D. Research.gov/Grants.gov Requirements

For Proposals Submitted Via Research.gov:

To prepare and submit a proposal via Research.gov, see detailed technical instructions available at: https://www.research.gov/research-portal/appmanager/base/desktop?_nfpb=true&_pageLabel=research_node_display&_nodePath=/researchGov/Service/Desktop/ProposalPreparationandSubmission.html. For Research.gov user support, call the Research.gov Help Desk at 1-800-381-1532 or e-mail rgov@nsf.gov. The Research.gov Help Desk answers general technical questions related to the use of the Research.gov system. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

Before using Grants.gov for the first time, each organization must register to create an institutional profile. Once registered, the applicant's organization can then apply for any federal grant on the Grants.gov website. Comprehensive information about using Grants.gov is available on the Grants.gov Applicant Resources webpage: https://www.grants.gov/web/grants/applicants.html. In addition, the NSF Grants.gov Application Guide (see link in Section V.A) provides instructions regarding the technical preparation of proposals via Grants.gov. For Grants.gov user support, contact the Grants.gov Contact Center at 1-800-518-4726 or by email: support@grants.gov. The Grants.gov Contact Center answers general technical questions related to the use of Grants.gov. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this solicitation.

Submitting the Proposal: Once all documents have been completed, the Authorized Organizational Representative (AOR) must

submit the application to Grants.gov and verify the desired funding opportunity and agency to which the application is submitted. The AOR must then sign and submit the application to Grants.gov. The completed application will be transferred to Research.gov for further processing.

The NSF Grants.gov Proposal Processing in Research.gov informational page provides submission guidance to applicants and links to helpful resources including the NSF Grants.gov Application Guide, Grants.gov Proposal Processing in Research.gov how-to guide, and Grants.gov Submitted Proposals Frequently Asked Questions. Grants.gov proposals must pass all NSF pre-check and post-check validations in order to be accepted by Research.gov at NSF.

When submitting via Grants.gov, NSF strongly recommends applicants initiate proposal submission at least five business days in advance of a deadline to allow adequate time to address NSF compliance errors and resubmissions by 5:00 p.m. submitting organization's local time on the deadline. Please note that some errors cannot be corrected in Grants.gov. Once a proposal passes pre-checks but fails any post-check, an applicant can only correct and submit the in-progress proposal in Research.gov.

Proposers that submitted via Research.gov may use Research.gov to verify the status of their submission to NSF. For proposers that submitted via Grants.gov, until an application has been received and validated by NSF, the Authorized Organizational Representative may check the status of an application on Grants.gov. After proposers have received an e-mail notification from NSF, Research.gov should be used to check the status of an application.

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

Proposals received by NSF are assigned to the appropriate NSF program for acknowledgement and, if they meet NSF requirements, for review. All proposals are carefully reviewed by a scientist, engineer, or educator serving as an NSF Program Officer, and usually by three to ten other persons outside NSF either as *ad hoc* reviewers, panelists, or both, who are experts in the particular fields represented by the proposal. These reviewers are selected by Program Officers charged with oversight of the review process. Proposers are invited to suggest names of persons they believe are especially well qualified to review the proposal and/or persons they would prefer not review the proposal. These suggestions may serve as one source in the reviewer selection process at the Program Officer's discretion. Submission of such names, however, is optional. Care is taken to ensure that reviewers have no conflicts of interest with the proposal. In addition, Program Officers may obtain comments from site visits before recommending final action on proposals. Senior NSF staff further review recommendations for awards. A flowchart that depicts the entire NSF proposal and award process (and associated timeline) is included in PAPPG Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: https://www.nsf.gov/bfa/dias/policy/merit_review/.

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *Leading the World in Discovery and Innovation, STEM Talent Development and the Delivery of Benefits from Research - NSF Strategic Plan for Fiscal Years (FY) 2022 - 2026*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

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

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

A. Merit Review Principles and Criteria

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

1. Merit Review Principles

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

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

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

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

2. Merit Review Criteria

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

The two merit review criteria are listed below. **Both** criteria are to be given **full consideration** during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (PAPPG Chapter II.D.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.D.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 other underrepresented groups 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

Track I proposals will be evaluated on the basis of the following solicitation-specific review criteria: (1) the extent to which the proposal addresses one or more field areas; (2) the extent to which fundamental contributions to both formal methods and the field area are a likely outcome of this project; and (3) the extent to which the collaboration plan meets the criteria identified in the solicitation.

Track II proposals will be evaluated on the basis of the following solicitation-specific review criteria: (1) the degree to which the project plan addresses system development milestones and an evaluation plan for the working system; (2) the degree to which a target user group or organization who (that) will serve as an early adopter of the technology is identified; and (3) the composition and track record of the proposing team, which should demonstrate not only technical expertise but also skills in systems development.

Track III proposals will be evaluated on the basis of the following solicitation-specific review criteria: (1) the degree to which the project plan describes course material development milestones; (2) the degree to which the dissemination plan targets new communities; and (3) the composition and track record of the proposing team, which should demonstrate not only technical expertise but also education and outreach activities beyond classroom teaching in their own universities.

B. Review and Selection Process

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

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

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF strives to be able to tell proposers whether their proposals have been declined or recommended for funding within six months. Large or particularly complex proposals or proposals from new recipients 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 or the Division of Acquisition and Cooperative Support for review of business, financial, and policy implications. After an administrative review has occurred, Grants and Agreements Officers perform the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments, obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

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

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

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

B. Award Conditions

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

*These documents may be accessed electronically on NSF's Website at https://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF. Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov.

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

Administrative and National Policy Requirements

Build America, Buy America

As expressed in Executive Order 14005, Ensuring the Future is Made in All of America by All of America's Workers (86 FR 7475), it is the policy of the executive branch to use terms and conditions of Federal financial assistance awards to maximize, consistent with law, the use of goods, products, and materials produced in, and services offered in, the United States.

Consistent with the requirements of the Build America, Buy America Act (Pub. L. 117-58, Division G, Title IX, Subtitle A, November 15, 2021), no funding made available through this funding opportunity may be obligated for an award unless all iron, steel, manufactured products, and construction materials used in the project are produced in the United States. For additional information, visit NSF's Build America, Buy America webpage.

Special Award Conditions:

The FMitF program is aiming to grow a new research community. In this spirit, the program plans to host a virtual or in-person PI meeting annually, with participation from all funded PIs, along with other representatives from the research community, government, and industry. For each Track I award, at least one collaborating PI focusing on formal methods and at least one PI focusing on the field must attend the PI meeting each year. For Track II and **Track III** proposals, at least one PI must attend the PI meeting each year.

C. Reporting Requirements

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

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

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

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

VIII. AGENCY CONTACTS

Please note that the program contact information is current at the time of publishing. See program website for any updates to the points of contact.

General inquiries regarding this program should be made to:

- Pavithra Prabhakar, Program Director, CISE/CCF, telephone: (703) 292-8910, email: pprabhak@nsf.gov
- Alhussein A. Abouzeid, Program Director, CISE/CNS, telephone: (703) 292-8950, email: aabouzei@nsf.gov
- Anindya Banerjee, Program Director, CISE/CCF, telephone: (703) 292-7885, email: abanerje@nsf.gov
- Damian Dechev, Program Director, CISE/CCF, telephone: (703) 292-8910, email: ddechev@nsf.gov
- Sorin Draghici, Program Director, CISE/IIS, telephone: (703) 292-2232, email: sdraghic@nsf.gov
- Jason O. Hallstrom, Program Director, CISE/CNS, telephone: (703) 292-8950, email: jhallstr@nsf.gov
- Thomas Martin, Program Director, CISE/IIS, telephone: 703-292-2170, email: tmartin@nsf.gov
- Daniela Oliveira, Program Director, CISE/CNS, telephone: (703) 292-4352, email: doliveir@nsf.gov

For questions related to the use of NSF systems contact:

- NSF Help Desk: 1-800-381-1532
- Research.gov Help Desk e-mail: rgov@nsf.gov

For questions relating to Grants.gov contact:

- Grants.gov Contact Center: If the Authorized Organizational Representatives (AOR) has not received a confirmation message from Grants.gov within 48 hours of submission of application, please contact via telephone: 1-800-518-4726; e-mail: support@grants.gov.

IX. OTHER INFORMATION

The NSF website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this website by potential proposers is strongly encouraged. In addition, "NSF Update" is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF Grants Conferences. Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. "NSF Update" also is available on NSF's website.

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 https://www.grants.gov.

ABOUT THE NATIONAL SCIENCE FOUNDATION

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

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

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

Facilitation Awards for Scientists and Engineers with Disabilities (FASED) provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See the *NSF Proposal & Award Policies & Procedures Guide* Chapter II.F.7 for instructions regarding preparation of these types of proposals.

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

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

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

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

- **Location:**   2415 Eisenhower Avenue, Alexandria, VA 22314

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

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

- **To Order Publications or Forms:**

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

or telephone:	(703) 292-8134
● **To Locate NSF Employees:**	(703) 292-5111

PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by proposers 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 proposers 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 System of Record Notices, NSF-50, "Principal Investigator/Proposal File and Associated Records," and NSF-51, "Reviewer/Proposal File and Associated Records." 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
Policy Office, Division of Institution and Award Support
Office of Budget, Finance, and Award Management
National Science Foundation
Alexandria, VA 22314

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National Science Foundation, 2415 Eisenhower Avenue, Alexandria, Virginia 22314, USA
Tel: (703) 292-5111, FIRS: (800) 877-8339 | TDD: (703) 292-5090 or (800) 281-8749

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