Safe Learning-Enabled Systems

PROGRAM SOLICITATION
NSF 23-562

National Science Foundation

Directorate for Computer and Information Science and Engineering
    Division of Information and Intelligent Systems
    Division of Computing and Communication Foundations
    Division of Computer and Network Systems

Open Philanthropy Project LLC

Good Ventures Foundation

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

May 26, 2023

January 16, 2024

IMPORTANT INFORMATION AND REVISION NOTES

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:

Safe Learning-Enabled Systems

Synopsis of Program:

As artificial intelligence (AI) systems rapidly increase in size, acquire new capabilities, and are deployed in high-stakes settings, their safety becomes extremely important. Ensuring system safety requires more than improving accuracy, efficiency, and scalability: it requires ensuring that systems are robust to extreme events, and monitoring them for anomalous and unsafe behavior.

The objective of the Safe Learning-Enabled Systems program, which is a partnership between the National Science Foundation, Open Philanthropy and Good Ventures, is to foster foundational research that leads to the design and implementation of learning-enabled systems in which safety is ensured with high levels of confidence. While traditional machine learning systems are evaluated pointwise with respect to a fixed test set, such static coverage provides only limited assurance when exposed to unprecedented conditions in high-stakes operating environments. Verifying that learning components of such systems achieve safety guarantees for all possible inputs may be difficult, if not impossible. Instead, a system's safety guarantees will often need to be established with respect to systematically generated data from realistic (yet appropriately pessimistic) operating environments. Safety also requires resilience to "unknown unknowns", which necessitates improved methods for monitoring for unexpected environmental hazards or anomalous system behaviors, including during deployment. In some instances, safety may further require new methods for reverse-engineering, inspecting, and interpreting the internal logic of learned models to identify unexpected behavior that could not be found by black-box testing alone, and methods for improving the performance by directly adapting the systems' internal logic. Whatever the setting, any learning-enabled system's end-to-end safety guarantees must be specified clearly and precisely. Any system claiming to satisfy a safety specification must provide rigorous evidence, through analysis corroborated empirically and/or with mathematical proof.

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.

- Jie Yang, Program Director, CISE/IIS, telephone: (703) 292-4768, email: jyang@nsf.gov
- Anindya Banerjee, Program Director, CISE/CCF, telephone: (703) 292-7885, email: abanerje@nsf.gov
- David Corman, Program Director, CISE/CNS, telephone: (703) 292-8754, email: dcorman@nsf.gov
- Pavithra Prabhakar, Program Director, CISE/CCF, telephone: (703) 292-2585, email: pprabhak@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

Estimated Number of Awards: 9

awards per year in FY 2023 and FY 2024, subject to the availability of funds.

Anticipated Funding Amount: $20,000,000

$10,000,000 per year in FY 2023 and FY 2024.

Projects will be funded at two levels:

Foundation Projects -- up to $800,000 total budget with durations up to three years.

Synergy Projects -- $800,001 to $1,500,000 total budget with durations up to four years

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

- 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. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.
- 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.

Who May Serve as PI:

Employees of Open Philanthropy and Good Ventures may not participate in proposals submitted to this initiative, including as unfunded collaborators, via letters of collaboration or support, or via any other means.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

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

An investigator may participate as Principal Investigator (PI), co-Principal Investigator (co-PI), Project Director (PD), Senior Personnel or Consultant in **no more than one (1)** proposal submitted in response to any category of this solicitation per deadline. An investigator cannot be PI, co-PI, or Senior Personnel on **more than two (2) awards** through the life of this program (FY 2023 – FY 2024).

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

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):

  May 26, 2023

  January 16, 2024

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:

Additional reporting requirements apply. Please see the full text of this solicitation for further information.

TABLE OF CONTENTS

I. INTRODUCTION

As artificial intelligence (AI) systems rapidly increase in size, acquire new capabilities, and are deployed in high-stakes settings, their safety becomes extremely important. Ensuring system safety requires more than improving accuracy, efficiency, and scalability: it requires ensuring that systems are robust to extreme events and monitoring them for anomalous and unsafe behavior.

Machine learning is an important area of AI that involves building systems that learn from data or sensor signals without direct instruction. A learning-enabled system is one that has embedded machine learning components. Increasingly, these systems underpin key components of large-scale, safety-critical systems in domains including, for example, healthcare and medicine, criminal justice, autonomous and cyber-physical systems, finance, and high-performance computing applications. Given their deployment in such high-stakes settings, it is imperative that learning-enabled systems be safe: developers must ensure that when deployed, undesirable system behaviors do not arise. Undesirable system behaviors encompass not only overt blunders like prediction errors and system crashes, but also silent failures, like reporting unjustified confidence levels out-of-distribution, and competently achieving unintended objectives.

The objective of the Safe Learning-Enabled Systems program, which builds on the joint goals of the National Science Foundation, Open Philanthropy and Good Ventures, is to foster foundational research that leads to the design and implementation of learning-enabled systems in which safety is ensured with high levels of confidence. While traditional machine learning systems are evaluated pointwise with respect to a fixed test set, such static coverage provides only limited assurance when exposed to unprecedented conditions in high-stakes operating environments. Verifying that learning components of such systems achieve safety guarantees for all possible inputs may be difficult, if not impossible. Instead, a system's safety guarantees will often need to be established with respect to systematically generated data from realistic (yet appropriately pessimistic) operating environments. Safety also requires resilience to "unknown unknowns", which necessitates improved methods for monitoring for unexpected environmental hazards or anomalous system behaviors, including during deployment. In some instances, safety may further require new methods for reverse-engineering, inspecting, and interpreting the internal logic of learned models to identify unexpected behavior that could not be found by black-box testing alone, and methods for improving the performance by directly adapting the systems' internal logic. Whatever the setting, any learning-enabled system's end-to-end safety guarantees must be specified clearly and precisely. Any system claiming to satisfy a safety specification must provide rigorous evidence through analysis corroborated empirically and/or with mathematical proof.

II. PROGRAM DESCRIPTION

The Safe Learning-Enabled Systems program aims to create a community of researchers who collaborate at the intersection of design and implementation of safe learning-enabled systems, and methods for rigorously reasoning (including probabilistically/statistically/logically) about safety amid uncertainty (in data, environment observations, system calibration, etc.). The desired outcome is that future safe learning-enabled systems will be constructed with sound design principles which practitioners can leverage to achieve safety specifications. The program will be considered a success if developers of future learning-enabled systems can (i) informally explain why the systems can be deployed safely in unpredictable environments and (ii) back these informal explanations with rigorous evidence that the system satisfies precise safety specifications.

The program solicits proposals that advance general theories, principles, and methodologies for the design of safe learning-enabled systems, that go beyond specific problem instances, and that are applicable to state-of-the-art learning systems, including considerations for scalability and deployability. The program seeks to support proposals that have the potential to make strong advances in the design and implementation of safe learning-enabled systems as well as advancing methods for reasoning about the safety of those systems when they are deployed in unpredictable environments. An ideal proposal will demonstrate how these two objectives will be achieved, provide evidence that its proposed approach will improve notions of safety, and argue the potential for lasting impact both on rigorous safety evaluation methods and on the design and implementation of safe learning-enabled systems. Proposals that seek to apply existing machine learning methods without incorporating safety characteristics (for example, robustness, tail risks, uncertainty, and the effects of dynamically changing deployment conditions) of the underlying learning-enabled systems are not in scope. Proposals that focus on learning-enabled systems but that do not simultaneously focus on their safety are not in scope. Proposals that increase safety primarily as a downstream effect of improving standard system performance metrics unrelated to safety (e.g., accuracy on standard tasks) are not in scope. Finally, research on securing learning-enabled systems against adversaries is not in scope.

All proposals must:

- Discuss the learning-enabled components, and provide reasons why they are appropriate for the system being studied.
- In plain English, state the notion of end-to-end mathematically (i.e., precisely and without ambiguity, and accounting for error bounds) or empirically-based safety.
- Justify why the end-to-end safety properties are critical to the learning-enabled system.
- Identify environmental assumptions under which the safety properties are ensured.
- Provide automated/semi-automated/interactive techniques for establishing the degree to which the safety properties are present in the learning-enabled system.
- Validate that these techniques achieve the mathematically-specified or empirically-based safety guarantees through rigorous (as opposed to ad-hoc) simulation, prototyping, and integration with actual (including sub-scale) learning-enabled systems.

Notions of safety include, but are not limited to, robustness, reliability amid uncertainty, resilience to tail-risks, safe generalization in unseen domains, and reliability under human error. Learning-enabled systems are systems with learning-based components that include, but are not limited to, deployed systems in healthcare and medicine, criminal justice, autonomous and cyber-physical systems, and finance. Learning-enabled systems also include foundational learning-based systems that may be subsequently applied in many downstream domains. Mathematical techniques include, but are not limited to, probabilistic/statistical/logical techniques for reasoning, program analysis, semantics, synthesis, testing, simulation, and verification.

Submitted proposals can be in one of two project classes, defined below:

1. Foundation Projects -- up to $800,000 total budget with durations up to three years (up to 5 awards each deadline).
2. Synergy Projects -- $800,001 to $1,500,000 total budget with durations up to four years (up to 4 awards each deadline).

For Synergy projects, a validation plan must be provided that includes experimentation on an actual learning-enabled system or proposals will be returned without review.

III. AWARD INFORMATION

An estimated 9 awards per year in FY 2023 and FY 2024 are anticipated, subject to availability of funds. $20,000,000 total will be invested in proposals submitted to this solicitation, subject to availability of funds.

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

Proposals may only be submitted by the following:

- 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. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.
- 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.

Who May Serve as PI:

Employees of Open Philanthropy and Good Ventures may not participate in proposals submitted to this initiative, including as unfunded collaborators, via letters of collaboration or support, or via any other means.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

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

An investigator may participate as Principal Investigator (PI), co-Principal Investigator (co-PI), Project Director (PD), Senior Personnel or Consultant in **no more than one (1)** proposal submitted in response to any category of this solicitation per deadline. An investigator cannot be PI, co-PI, or Senior Personnel on **more than two (2) awards** through the life of this program (FY 2023 – FY 2024).

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

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.

Proposal Titles: Proposal titles should begin with the acronym "SLES" followed by a colon and then the title. For example, "SLES: Descriptive Title".

Project Description: Project Descriptions are limited to 15 pages in length.

In addition to the requirements specified in the PAPPG, including the requirement for a separate section labeled "Broader Impacts," the Project Description must include the following separate sections, clearly labeled with the headings used below (i.e., "Components," "Rationale," "Safety Plan" and "Validation"). Proposals lacking one or more of these sections will be returned without review.

Components: The proposal should describe the system components and provide reasons why they are appropriate for the system being studied.

Rationale: A rationale in plain language of a mathematically (i.e., precisely and without ambiguity, and accounting for error bounds) or empirically-based end-to-end safety plan. The proposal should also describe why the end-to-end safety properties are critical to the learning-enabled system.

Safety Plan: Description of the environmental assumptions under which the safety properties are ensured, as well as inclusion of an automated/semi-automated/interactive techniques for establishing the degree to which the safety properties are present in the learning-enabled system.

Validation: A plan to validate these techniques to demonstrate that they can achieve the mathematically or empirically-specified safety guarantees through simulation, prototyping, and integration with actual (including sub-scale) learning-enabled systems. For Synergy projects, the validation plan must include experimentation on an actual learning-enabled system.

Supplementary Documents: In addition to the guidance in the PAPPG, upload the following:

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

Provide current, accurate information for all personnel and organizations involved in the project. NSF staff will use this information in the merit review process to manage reviewer selection. The list must include all PIs, co-PIs, Senior Personnel, paid/unpaid Consultants or Collaborators, Subawardees, Postdoctoral Researchers, and project-level advisory committee members. This list should be numbered and include (in this order) Full name, Organization(s), and Role in the project, with each item separated by a semi-colon. Each person listed should start a new numbered line. For example:

Mary Smith; XYZ University; PI

John Jones; University of PQR; Senior Personnel

Jane Brown; XYZ University; Postdoctoral Researcher

Bob Adams; ABC Community College; Paid Consultant

Susan White; DEF Corporation; Unpaid Collaborator

Tim Green; ZZZ University; Subawardee

Data Management Plan (required): See Chapter II.D.2 of the PAPPG for full policy implementation.

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

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

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Budget Preparation Instructions:

Annual Principal Investigator (PI) Meeting: An annual Principal Investigator(s) meeting will be held to discuss scientific and policy issues of interest to awarded PIs and to facilitate communication and collaboration across the community. Students and postdoctoral fellows involved in funded projects will also be encouraged to attend these meetings. PIs should budget for the meetings appropriately.

C. Due Dates

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

    May 26, 2023

    January 16, 2024

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 1-800-673-6188 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.

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

The proposals will also be evaluated based on:

- **Components:** The discussion of the learning-enabled components. The proposal should describe the components and provide reasons why they are appropriate for the system being studied.
- **Rationale:** A rationale in plain language of a mathematically (i.e., precisely and without ambiguity, and accounting for error bounds) or empirically-based end-to-end safety plan. The proposal should also describe why the end-to-end safety properties are critical to the learning-enabled system.
- **Safety Plan:** Description of the environmental assumptions under which the safety properties are ensured, as well as inclusion of an automated/semi-automated/interactive techniques for establishing the degree to which the safety properties are present in the learning-enabled system.
- **Validation:** A plan to validate these techniques to demonstrate that they can achieve the mathematically or empirically-specified safety guarantees through rigorous (as opposed to ad-hoc) simulation, prototyping, and integration with actual (including sub-scale) learning-enabled systems. For Synergy projects, the validation plan must include experimentation on an actual learning-enabled system.

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.

NSF will manage and conduct the peer review process for this solicitation; Open Philanthropy and Good Ventures will only observe the review process and have access to proposal and review information, such as unattributed reviews and panel summaries. NSF will make award decisions.

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 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:

An annual Principal Investigator(s) meeting will be held to discuss scientific and policy issues of interest to awarded PIs and to facilitate communication and collaboration across the community. Students and postdoctoral fellows involved in funded projects will also be encouraged to attend these meetings.

Acknowledgement of Support

Awardees will be required to include appropriate acknowledgment of NSF and partner support in reports and/or publications on work performed under an award. An example of such an acknowledgement would be: "This material is based upon work supported by the National Science Foundation under grant no. (NSF grant number) and is supported in part by funds provided to the National Science Foundation by Open Philanthropy and Good Ventures."

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.

Information from annual and final project reports will be shared with Open Philanthropy and Good Ventures.

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:

- Jie Yang, Program Director, CISE/IIS, telephone: (703) 292-4768, email: jyang@nsf.gov

- Anindya Banerjee, Program Director, CISE/CCF, telephone: (703) 292-7885, email: abanerje@nsf.gov

- David Corman, Program Director, CISE/CNS, telephone: (703) 292-8754, email: dcorman@nsf.gov

- Pavithra Prabhakar, Program Director, CISE/CCF, telephone: (703) 292-2585, email: pprabhak@nsf.gov

For questions related to the use of NSF systems contact, contact:

- NSF Help Desk: 1-800-673-6188
- 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) 292-8143
>
> - **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 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 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

Policies and Important Links | Privacy | FOIA | Help | Contact NSF | Contact Web Master | SiteMap

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

Text Only