

NSF 25-520: NSF-AFRL REsearch in FLOquet Engineered QuanTum Systems (NSF-AFRL REFLEQTS)

Program Solicitation

Document Information

Document History

- **Posted:** December 6, 2024

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U.S. National Science Foundation

Directorate for Engineering

Division of Electrical, Communications and Cyber Systems



Air Force Research Laboratory

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

March 14, 2025

An Expression of Interest (EOI) must be submitted to nsf-afrl-feqs@nsf.gov by January 24, 2025, prior to the submission of a full proposal.



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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:

NSF-AFRL REsearch in FLoquet Engineered QuanTum Systems (NSF-AFRL REFLEQTS)

Synopsis of Program:

To advance the understanding of novel quantum systems under the influence of time-periodic driving forces, the U.S. National Science Foundation (NSF) and the Air Force Research Laboratory (AFRL) have a mutual interest in exploring innovative concepts on the REsearch in FLoquet Engineered QuanTum Systems (REFLEQTS). For transformational capabilities promised by quantum science to become deployable, new approaches must be developed to create, control, and conserve fragile quantum states on demand.

This topic aligns with the National Quantum Initiative (NQI) as described in the National Science and Technology Council's strategy to extend the research opportunity of Quantum Information Science and Engineering (QISE) by broadening the interagency collaboration and increasing global competitiveness in QISE research outcome that can strengthen National Security.

This solicitation encourages research teams consisting of multiple Principal Investigators (PIs) from multiple institutions to submit proposals on transformative approaches and solutions in materials, devices, theory, and systems to realize the innovative REsearch in FLoquet Engineered QuanTum Systems (REFLEQTS). These systems can be widely applicable, from fundamental science to technology development, for quantum science and engineering including but not limited to quantum sensing,

quantum devices, quantum materials, and quantum systems. Research teams may include, but are not limited to, individuals with expertise in classical and quantum materials, devices, and integrated systems in the areas of photonics, and quantum optics. Teams should emphasize combining these areas to access nonequilibrium states for performance metrics unattainable at equilibrium. The requested funds should support a multidisciplinary team of researchers to provide leadership, innovative research, financial support, and workforce training in the focused research theme of Floquet Engineered Quantum System.

Consistent with the NQI and NSTC Strategic Plan, NSF-AFRL REFLEQTS highlights three sets of goals:

1. Leading an interagency collaboration in quantum science and engineering research to encourage and facilitate a mid-scale research team approach;
2. Integrating theory, experimentation, and data-intensive/-driven approaches to explore the innovative approach for Floquet Engineering application in Quantum Systems;
3. Creating a science and engineering workforce in the area of materials, devices, and systems applicable to the quantum field that is trained for careers in academia or industry.

Broadening Participation In STEM:

NSF recognizes the unique lived experiences of individuals from communities that are underrepresented and/or underserved in science, technology, engineering, and mathematics (STEM) and the barriers to inclusion and access to STEM education and careers. NSF highly encourages the leadership, partnership, and contributions in all NSF opportunities of individuals who are members of such communities supported by NSF. This includes leading and designing STEM research and education proposals for funding; serving as peer reviewers, advisory committee members, and/or committee of visitor members; and serving as NSF leadership, program, and/or administrative staff. NSF also highly encourages demographically diverse institutions of higher education (IHEs) to lead, partner, and contribute to NSF opportunities on behalf of their research and education communities. NSF expects that all individuals, including those who are members of groups that are underrepresented and/or underserved in STEM, are treated equitably and inclusively in the Foundation's proposal and award process.

NSF encourages IHEs that enroll, educate, graduate, and employ individuals who are members of groups underrepresented and/or underserved in STEM education programs and careers to lead, partner, and contribute to NSF opportunities, including leading and designing STEM research and education proposals for funding. Such IHEs include, but may not be limited to, community colleges and two-year institutions, mission-based institutions such as Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), women's colleges, and institutions that primarily serve persons with disabilities, as well as institutions defined by enrollment such as Predominantly Undergraduate Institutions (PUIs), Minority-Serving Institutions (MSIs), and Hispanic Serving Institutions (HSIs).

"Broadening participation in STEM" is the comprehensive phrase used by NSF to refer to the Foundation's goal of increasing the representation and diversity of individuals, organizations, and geographic regions that contribute to STEM teaching, research, and innovation. To broaden participation in STEM, it is necessary to address issues of equity, inclusion, and access in STEM education, training, and careers. Whereas all NSF programs might support broadening participation components, some programs primarily focus on supporting broadening participation research and projects. Examples can be found on the NSF [Broadening Participation in STEM](#) website.

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.

- Seongsin M. Kim, telephone: (703) 292-2967, email: sekim@nsf.gov
- Rosa Lukaszew, telephone: (703) 292-8103, email: rlukasz@nsf.gov
- Dominique M. Dagenais, telephone: (703) 292-2980, email: ddagenai@nsf.gov
- Monica Allen, telephone: (850) 217-7413, email: monica.allen.3@us.af.mil

- Jeffery W. Allen, telephone: (850) 217-3485, email: jeffery.allen.12@us.af.mil

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

- 12.800 --- Air Force Office of Scientific Research
- 47.041 --- Engineering

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 1

1 award up to \$3,000,000 for three years. There will be an option for an extension of the award for a possible additional 2 years.

Anticipated Funding Amount: \$3,000,000

Estimated program budget, number of awards and average award size/duration are subject to the availability of funds.

Eligibility Information

Who May Submit Proposals:

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 sub-awards 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.

Who May Serve as PI:

PIs or co-PIs must hold primary, full-time, paid appointments in research or teaching positions at US-based campuses/offices of IHEs eligible to submit to this solicitation (see above), with exceptions granted for family or medical leave, as determined by the submitting institution.

A minimum of one PI and two co-PIs must participate in each proposal. These participants must represent at least two different institutions. Each PI/co-PI is expected to contribute complementary expertise relevant to the project proposed including expertise in theory and experimentation, fabrication and testing, or other sciences that may be considered where appropriate.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or co-PI: 1

No individual may be a PI, Co-PI, or Senior/Key Personnel on more than one REFLEQTS proposal in the current review cycle. Please be advised that if an individual's name appears in any of the above-mentioned capacities on more than ONE proposal, all submittals after the first proposal (based on time-stamp) 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. submitting organization's local time):

March 14, 2025

An Expression of Interest (EOI) must be submitted to nsf-afri-feqs@nsf.gov by January 24, 2025, prior to the submission of a full proposal.

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.

I. Introduction

The National Quantum Initiative (NQI) Act calls for coordinated efforts to accelerate quantum science and technology research in the United States. The National Science and Technology Council (NSTC) Subcommittee identified a need for deliberate collaborations within multiple funding agencies to combine fundamental and applied research on quantum technologies with new quantum sensing paradigms. Quantum sensors can offer improved accuracy, stability, sensitivity, and precision over traditional technologies. The realization of new quantum sensors is a tangible, near-term objective of the National Quantum Initiative. The NSTC subcommittee recommends four actions that U.S. Departments and Agencies can take to coordinate research and development and facilitate fruitful applications of quantum sensor technologies (<https://www.quantum.gov/strategy/>):

- 1) Agencies leading QIST R&D should accelerate the development of new quantum sensing approaches and prioritize appropriate partnerships with end users to elevate the technology readiness of new quantum sensors.
- 2) Agencies that use sensors should conduct feasibility studies and jointly test quantum prototypes with QIST R&D leaders to identify promising technologies and focus on quantum sensors that address their agency mission.
- 3) Agencies that support engineering R&D should develop broadly applicable components and subsystems, such as compact reliable lasers and integrated optics, to facilitate the development of quantum technologies and promote economies of scale.
- 4) Agencies should streamline technology transfer and acquisition practices to encourage the development and early adoption of quantum sensor technologies.

The modification of quantum systems by time-periodic fields, referred to as ‘Floquet engineering’, has emerged as an exciting new frontier in the fundamental study of light-matter interaction, where time-periodic fields can allow for the dynamic control and creation of new phases of matter not accessible at equilibrium. The remarkable effects of time-periodic forces have been studied in a range of material systems, including topological insulators, van der Waals materials, atomic gasses, and spintronic systems, to name only a representative subset. In each case, the application of time-periodic fields alters the quantum properties of the material, giving rise to the modulation of macroscopically measured optical and/or electronic properties.

The primary objective of NSF-AFRL REFLEQTS is to bring a team of researchers together to conduct groundbreaking and innovative studies in Floquet Engineered Quantum Systems. For transformational capabilities promised by quantum science to become deployable, radically new approaches must be developed to create, control, and conserve fragile states on demand.

REFLEQTS’s research interests focus on engineering novel states of matter with enhanced functionalities in quantum systems, which will include using theoretical studies to define the performance of driven systems, along with developing methods to implement designs and demonstrate new materials, structures, and devices in line with this objective. REFLEQTS requires multiple institutions to participate, a team of interdisciplinary experts, and a clear management plan among the multiple institutions.

II. Program Description

The overarching goals of NSF-AFRL REFLEQTS are the development of: i) novel and scalable quantum systems, ii) cutting-edge spectro-microscopy techniques, and micro- and nano-photonics, phononic, millimeter/THz frequencies, and electronic structures and mechanisms, iii) enhancing efficiency in generation and detection, and iv) direct read-out of novel states of matter. The proposed research will establish conditions to mitigate the dissipation and decoherence of driven states and to control drive-altered states over extended time periods. Strategies such as using spatially and temporally driving fields and enhanced field confinement may be used to control specific responses and reduce decoherence. This solicitation intends to bridge the fundamental science and technology gap in designing materials and devices with specific functionality aimed at quantum sensing. Note that priority will be given to proposals that combine different modalities with quantum systems for unprecedented performance. Additionally, proposals extending the driven-system platform to periodic drives mediated by collective modes (e.g., acoustic and optical phonons, magnons etc.) are encouraged.

Topics of Interest include, but not limited to:

- Novel and scalable quantum systems that use time-periodic driving forces to deterministically and systematically alter material properties using strong coupling (e.g.: photon-phonon, magnon-photon) under thermodynamic equilibrium with coherent perturbation and the application of these systems to devices/sensors.
- Integration of novel materials such as atomically thin materials, including their twist-controlled (Moiré) heterostructures and artificially engineered structured materials such as meta-atoms novel spintronic materials, into devices and sensing systems in quantum regime.
- Innovative approaches to engineer novel states of matter with enhanced functionalities in quantum systems (e.g. sensitivity, resolution, speed, stability and energy efficiency) towards their application to devices and/or sensors in the quantum regime.
- Cutting-edge spectral-microscopy techniques, micro- and nano-photonic, phononic, millimeter/THz high-frequency electronic systems, and mechanisms for direct read-out of novel Floquet engineered states of matter.

This solicitation will not support quantum computing applications.

III. Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 1 award up to \$3,000,000 for three years. There will be an option for an extension of the award for a possible additional 2 years.

Anticipated Funding Amount: \$3,000,000

Estimated program budget, number of awards and average award size/duration are subject to the availability of funds.

IV. Eligibility Information

Who May Submit Proposals:

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 sub-awards 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.

Who May Serve as PI:

PIs or co-PIs must hold primary, full-time, paid appointments in research or teaching positions at US-based campuses/offices of IHEs eligible to submit to this solicitation (see above), with exceptions granted for family or medical leave, as determined by the submitting institution.

A minimum of one PI and two co-PIs must participate in each proposal. These participants must represent at least two different institutions. Each PI/co-PI is expected to contribute complementary expertise relevant to the project proposed including expertise in theory and experimentation, fabrication and testing, or other sciences that may be considered where appropriate.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or co-PI: 1

No individual may be a PI, Co-PI, or Senior/Key Personnel on more than one REFLEQTS proposal in the current review cycle. Please be advised that if an individual's name appears in any of the above-mentioned capacities on more than ONE proposal, all submittals after the first proposal (based on time-stamp) will be returned without review. No exceptions will be made.

Additional Eligibility Info:

Other Federal agencies and Federally Funded Research and Development Centers (FFRDCs) can be listed as collaborative organizations. However, other Federal agencies and FFRDCs cannot receive any subawards.

For-profit organizations can be listed as collaborative organizations. However, for-profit organizations cannot receive subawards.

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.

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.

Preparation and Submission of an Expression of Interest

Before submitting a full proposal, interested PIs must prepare and submit an Expression of Interest (EOI).

PIs must submit a maximum 3-page Expression of Interest to nsf-afri-feqs@nsf.gov. This 3-page document must include the following information:

Page 1:

- Intended Title of the proposal
- A list of the PI, Co-PIs and Senior/Key Personnel, and their organization affiliations
- Email contact information for the PI and Co-PIs.

The remaining 2 pages should address the following elements:

1. State the relevance to the REFLEQTS research theme, specific research goals, and milestones for advancing the frontiers of quantum information science and engineering.
2. Provide an overview of the proposed major activities in research, education, and workforce development in REFLEQTS.
3. Provide a brief description of collaborative research and education efforts to be cultivated between multiple institutions.

The Expression of Interest must be submitted via email to nsf-afrl-feqs@nsf.gov by **January 24, 2025**.

The submitted Expression of Interest will be shared between NSF and AFRL Program Directors to determine the fulfillment of submission criteria and the relevance of the research topic. If the EOI meets the submission criteria, NSF will invite the teams to submit a full proposal. The full proposal can only be submitted after an invitation is received via email by the REFLEQTS Cognizant Program Officers from NSF.

Full Proposal Preparation Instructions

The following instructions supplement the guidance in the PAPPG and NSF Grants.gov Application Guide:

All proposals with collaborators from one or more institutions must be submitted as a single proposal with subaward(s) administered by the submitting organization. The type of collaborative proposals by a simultaneous submission from multiple organizations with each organization requesting a separate award will not be accepted.

Senior/Key Personnel: NSF policy allows proposers to identify a PI and a maximum of four co-PIs on a proposal. A minimum of three PI/Co-PIs must be identified for REFLEQTS proposals.

Title of Proposed Project: The title for the proposed project must begin with "NSF-AFRL REFLEQTS:". The title must state clearly and succinctly the major theme(s) of the project.

Additional Budget Preparation Instructions:

In addition to the normal budget preparation requirements, Proposed budgets must include funds for travel by at least one PI or co-PI to attend the annual program review at NSF or AFRL in the Washington, DC, or Eglin AFB, FL area.

Note, for projects that are awarded, there may be an additional option for a possible 2-year extension to the original project. If this option arises, those supplement requests will also be securely shared with AFRL at that time. However, no information on a possible extension is required at the submission deadline.

Additional Supplementary documents must include the following Special Information:

1. Copy of the Invitation email to submit.

2. Research Integration Plan. A Research Integration Plan is required for all projects. The Research Integration Plan may not exceed two pages. Proposals that fail to submit a Research Integration Plan will be returned without review. The Research Integration Plan must be labeled "Research Integration Plan" and should include the following:

- i) Provide a list of the PI, co-PIs, and Senior/Key Personnel, with a description of the expertise each person brings to the project and how this expertise will be applied to achieve convergent research.
- ii). Identify the key disciplines involved in achieving the objectives of the proposed research and justify why the proposed research team is necessary for the creation of new knowledge and discovering solutions as proposed.
- iii) Management Plan: Outline the management plan to integrate these disciplines, including responsibilities, means of communication, management of personnel within the project team, management of intellectual property resulting from the project, project assessment, risk mitigation measures, and timeline of activities. The management plan should also describe how students will be engaged in and trained through REFLEQTS.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

C. Due Dates

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

March 14, 2025

An Expression of Interest (EOI) must be submitted to nsf-afri-feqs@nsf.gov by January 24, 2025, prior to the submission of a full proposal.

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/ProposalPreparationan 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/applicants>. 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 and Sharing Plan and the Mentoring Plan, as appropriate.

Additional Solicitation Specific Review Criteria

Reviewers will be asked to comment on:

- The degree to which the Research Integration Plan and Project Description demonstrates the commitment of the participating investigators to work synergistically to accomplish the project objectives including engaging and training students in collaborative and convergent research.
- The degree to which the Research Integration Plan demonstrates that the participating investigators have the necessary expertise covering related research fields sufficient to accomplish the project objectives.
- The extent to which the project scope justifies the requested budget and proposed research activities are suitable as integrated activities.

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by

Ad hoc Review and/or Panel Review, or Review.

Technical review by ad hoc, review panel or combination of both will be coordinated by the REFLEQTS Cognizant Program Officers from NSF and AFRL with input from other NSF Program Directors. Cognizant AFRL staff will attend the review panel as observers and will have access to proposal materials.

Reviewers shall be informed that their unattributed reviews and panel summaries may be shared with AFRL.

After scientific, technical, and programmatic review and consideration of appropriate factors, NSF and AFRL will discuss funding decisions based on reviews and discussions/rankings from the panels. NSF will receive input from AFRL, but NSF will retain the sole responsibility for the final funding and award recommendation.

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)*; 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 infrastructure projects under 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:

All awards will include the special award condition that the PI will attend an annual program review.

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 annual project report, and a project outcomes report for the general public.

Failure to provide the required annual or final annual 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 annual 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.

All submitted annual or final annual project reports will be shared with REFLEQTS cognizant Program Officers once those reports are approved by NSF.

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:

- Seongsin M. Kim, telephone: (703) 292-2967, email: sekim@nsf.gov
- Rosa Lukaszew, telephone: (703) 292-8103, email: rlukasz@nsf.gov
- Dominique M. Dagenais, telephone: (703) 292-2980, email: ddagenai@nsf.gov
- Monica Allen, telephone: (850) 217-7413, email: monica.allen.3@us.af.mil
- Jeffery W. Allen, telephone: (850) 217-3485, email: jeffery.allen.12@us.af.mil

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** (NSF Information Center): (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**
Send an e-mail to: nsfpubs@nsf.gov
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/recipients 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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