Ideas Lab: Cross-cutting Initiative in CubeSat Innovations

PROGRAM SOLICITATION
NSF 19-530

National Science Foundation

Directorate for Geosciences
    Division of Atmospheric and Geospace Sciences

Directorate for Engineering
    Division of Electrical, Communications and Cyber Systems
    Engineering Education and Centers

Directorate for Computer & Information Science & Engineering
    Division of Computer and Network Systems

Preliminary Proposal Due Date(s) *(required)* (due by 5 p.m. submitter's local time):

    February 12, 2019

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

    May 30, 2019

IMPORTANT INFORMATION AND REVISION NOTES

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 19-1), which is effective for proposals submitted, or due, on or after January 28, 2019.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

    Ideas Lab: Cross-cutting Initiative in CubeSat Innovations

Synopsis of Program:

CubeSat constellations and swarms have been identified as a new paradigm for space-based measurements to address high-priority science questions in multiple disciplines. However, the full potential of CubeSat constellations and swarms for scientific studies has not yet been realized because of: i) the limitations of some of the existing key CubeSat technology, ii) knowledge gaps in the design and optimization of CubeSat technology for swarms and constellations, and iii) the increasing cost of more sophisticated CubeSat technology. The technology challenges include high bandwidth communications in CubeSat-to-CubeSat and CubeSat-to-ground scenarios, circuits and sensors miniaturization, on-board signal processing, and power generation. The vision of a satellite mission consisting of 10-100 CubeSats will require focused investment and development in a myriad of CubeSat-related technologies to build a cost-effective constellation or swarm of CubeSats. This will require transformative approaches for designing and building CubeSat subsystems and sensors, and innovative production approaches that will reduce the cost of implementing large-scale constellation missions. Spectrum allocations for data transmission and possible electromagnetic interference between or within constellations of CubeSats are issues that also will need to be considered.

This solicitation describes an Ideas Lab focused on CubeSat Innovations to push the envelope of space-based research capabilities by simultaneously developing enabling technologies in several domains, including propulsion systems, sensor design, electronic circuits, antennas, satellite-to-ground and satellite-to-satellite communications and wireless networking, and power management. The vision of this Ideas Lab is to support research and engineering technology development efforts that will lead to new science missions in geospace and atmospheric sciences using self-organizing CubeSat constellations/swarms. The resulting new crosscutting concepts in CubeSat technology are expected to transform and stimulate CubeSat-enabled science and engineering research supported by NSF. The realization of self-organizing CubeSats will also require innovative approaches in educating, training, and developing a cross-disciplinary workforce with the relevant expertise spanning propulsion systems, sensors, circuits, antennas, wireless communications and networking, radio-frequency interference issues, and power management. It is anticipated that these innovations in CubeSat technology and education will enable new mission concepts for Cube-Sat based science investigations.

Transformation in CubeSat technology will also enable science missions that can support the NSF's 10 Big Ideas, such as Navigating the New Arctic by delivering multi-point Earth observations using CubeSat constellations; Windows on the Universe: The Era of Multi-Messenger Astrophysics by developing targeted CubeSat missions to support ground-based facilities, such as the Daniel K. Inouye Solar Telescope or the Global Oscillation Network Group; Harnessing the Data Revolution by supporting the integration of CubeSats into the Internet of Things; NSF INCLUDES by broadening the participation among under-represented groups in STEM research and education; and NSF 2026: Seeding Innovation and Growing Convergent Research at NSF by supporting out-of-the-box innovations necessitated and cultivated by the cross-disciplinary nature of CubeSats.

An Ideas Lab is an intensive meeting that brings together multiple diverse perspectives to focus on finding innovative cross-disciplinary solutions to a grand challenge problem. The ultimate aim of this Ideas Lab is to develop cutting edge CubeSat technologies that will enable a constellation/swarm of 10-100 satellites and transform space-based science investigations. The aspiration is that bringing together researchers from diverse scientific and engineering backgrounds will stimulate fresh thinking and innovative approaches that will provide a fertile ground for new and bold ideas on the design and fabrication of CubeSat sensors and circuits, antennas, inter-satellite and satellite-to-ground communications and networking, and innovative CubeSat missions. The goal is to form teams of scientists and engineers, who are experts in their respective domains, to come together and form interdisciplinary teams that will develop innovative and transformative ideas that will eventually be submitted as full proposals to address the challenges of building a CubeSat constellation/swarm of 10-100 CubeSats.

This Ideas Lab is organized by the Division of Atmospheric and Geospace Sciences (AGS) in the Directorate for Geosciences (GEO), the Division of Computer and Network Systems (CNS) in the Directorate for Computer and Information Science and Engineering (CISE), and the Division of Electrical, Communications and Cyber Systems (ECCS) and the Division of Engineering Education and Centers (EEC) in the Directorate for Engineering (ENG).

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.

- Monisha Ghosh, telephone: (703) 292-8746, email: mghosh@nsf.gov
- Jenshan Lin, telephone: (703) 292-8339, email: jenlin@nsf.gov
- Lawrence S. Goldberg, telephone: (703) 292-8339, email: lgoldber@nsf.gov
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Applicable Catalog of Federal Domestic Assistance (CFDA) Number(s):

- 47.041 --- Engineering
- 47.050 --- Geosciences
- 47.070 --- Computer and Information Science and Engineering

Award Information

Anticipated Type of Award: Continuing Grant

Estimated Number of Awards: 1 to 2

A CubeSat Innovation award is expected to be at the level of $750,000 – $1,000,000 per year for up to 4 years. Up to 2 awards are expected depending upon availability of funds and the type, scale, and variety of project ideas developed at the Ideas Lab.

Anticipated Funding Amount: $6,000,000 to $8,000,000

Up to $2,000,000 annually

Eligibility Information

Who May Submit Proposals:

The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG), Chapter I.E.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

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

An individual may serve as PI or Co-PI on only one proposal.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Not required
- **Preliminary Proposals:** Submission of Preliminary Proposals is required. Please see the full text of this solicitation for further information.
- strong>Full Proposals:
    - Full Proposals submitted via FastLane: *NSF Proposal and Award Policies and Procedures Guide* (PAPPG) guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.
    - 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

- **Preliminary Proposal Due Date(s)** *(required)* (due by 5 p.m. submitter's local time):

  February 12, 2019

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

  May 30, 2019

Proposal Review Information Criteria

Merit Review Criteria:

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

Award Administration Information

Award Conditions:

Standard NSF award conditions apply.

Reporting Requirements:

Standard NSF reporting requirements apply.

TABLE OF CONTENTS

I. INTRODUCTION

CubeSats represent a growing trend in pursuing space-based research that spans a multitude of disciplines, including Space Science, Astronomy, Earth Science, Computer Science, and Electrical, Computer, Mechanical and Aerospace Engineering. Over the last decade, advances in sensors, communications, computation, and navigation technologies, along with maturation of other supporting technologies, such as propulsion systems, have enabled CubeSats to address important science and engineering goals with significantly shorter development time and lower cost.

The NSF's CubeSat-based Science Missions for Geospace and Atmospheric Research program, initiated in 2008, supported research efforts to develop innovative and low-cost approaches to space-based measurements of the geospace environment. The program has established beyond a doubt the scientific value of CubeSats by the highly successful implementation of creative and innovative missions that carry out important science experiments while at the same time providing extraordinary educational benefits. The lower cost associated with the development and launch of CubeSats means more of them can be built and flown, allowing for constellations and swarms of CubeSats providing measurements from different viewing locations multiple times a day; this would result in a bounty of data that would be cost-prohibitive with traditional, larger platforms.

A major hindrance in realizing the vision of CubeSat constellations and swarms is the limitation of key enabling technologies including electrical power source and management, low-power electronic circuits, antennas, communications, subsystem miniaturization, on-board interconnects and signal processing. This solicitation seeks projects that will: identify the critical operational and technological gaps in existing CubeSat technologies; formulate innovative cross-disciplinary approaches for addressing the research and technology challenges; and demonstrate the proposed methodology to design and development through new CubeSat missions that achieve significant improvement in performance over current state-of-the-art CubeSat technology. It is expected that successful projects will integrate transformative concepts and techniques from multiple domains, from hardware to software to applications.

It is also expected that successful projects will include innovative approaches for education and training of a diverse workforce with the required cross-disciplinary expertise including propulsion systems, sensors, circuits, antennas, wireless communications and networking, signal processing, and system integration. It is anticipated that these advancements in CubeSat research, technology, and education will transform the design and execution of future CubeSat science missions.

II. PROGRAM DESCRIPTION

The Ideas Lab for CubeSat Innovation is intended to identify critical opportunities for investment that will significantly advance the state-of-the-art of CubeSat engineering and technology to achieve the enhanced operational functionality of constellations or swarms in a cost-effective manner, thereby transforming the scope and execution of CubeSat scientific missions. The goal of this Ideas Lab is to identify, explore, and address the major technology and related barriers to the conception and development of innovative science missions that would benefit from constellations and swarms of CubeSats, and to formulate, design, develop and demonstrate novel, transformative and cost-effective technological solutions to realize these missions. The proposed approaches may be risky, with a significant possibility of failure, but with the potential to rapidly and significantly advance the CubeSat technology and scientific applications and missions.

This activity, particularly the Ideas Lab approach, is designed to foster the development and implementation of creative and innovative project ideas that have the potential to transform research paradigms and/or solve intractable problems. We anticipate that awards made through this solicitation will be high-risk/high-impact, as they represent new and unproven ideas, approaches and/or technologies. Projects that involve the application of novel, collaborative, or interdisciplinary approaches will, therefore, receive priority during the consideration process. Successful proposals developed in the Ideas Lab will be expected to create opportunities to students, through hands-on work on exciting, end-to-end CubeSat projects, for developing the necessary skills and experience needed to succeed in STEM careers. In particular, ideas that demonstrate innovative utilizations of CubeSat development activities to expand participation of underrepresented groups in STEM disciplines are encouraged.

The Ideas Lab

The Ideas Lab is an interactive gathering on a focused problem and typically involves up to 10-30 participants from diverse technical

communities that do not have significant interaction. This Ideas Lab aims to stimulate and facilitate creative thinking and approaches for conceptualizing and formulating promising new techniques and technologies to design, develop and implement a new CubeSat mission that will demonstrate significant advances over state-of-the-art through unprecedented swarm functionality and radically enhanced scope of scientific data gathering, processing, and communication.

Participants will be expected to engage constructively in dialogue with one another, the facilitators, and the Director(s) and mentors to develop collaborative research proposals. Collaboration is an integral aspect of the Ideas Lab.

How will the Ideas Lab Work?

The Ideas Lab is an intensive, interactive and free-thinking environment, where a diverse group of participants from a range of disciplines and backgrounds gets together for five days - away from their daily routines - to immerse themselves in collaborative thinking processes in order to construct innovative solutions and approaches for identifying and tackling challenging problems. The Ideas Lab will run over five days starting mid-morning on Day One and finishing mid-afternoon on Day Five. At the outset, the participants will work collaboratively to identify and define the scope of the research, engineering, and technology challenges relating to the design, development and implementation of novel CubeSat mission capabilities. As the Ideas Lab progresses, participants will dynamically develop and hone novel ideas about how the identified challenges may be addressed, and then use these ideas and approaches to develop research projects, which would contain genuinely innovative and potentially risk-taking investigations. The Ideas Lab will include inputs from a variety of sources and will aim to develop collaborative research projects. Following the Ideas Lab, proposals may be submitted by teams selected to submit a full proposal. Those selected teams will receive further instructions.

The nature of the Ideas Lab requires a high degree of trust between participants in order to make the required breakthroughs in scientific thinking. This trust extends to allowing the free and frank exchange of scientific ideas, some being in the very early stages of development. The aim of the Ideas Lab is not to discuss ideas that are already well-developed but not yet published. Rather, the goal is to bring individuals from different disciplines together to interact and engage in free thinking on first principles, to learn from one another and create an integrated vision for future research projects. It is expected that the sharing of these ideas will be encouraged within the Ideas Lab but their confidentiality will be respected outside the Ideas Lab.

The Ideas Lab will be led by Director(s) whose role will be to assist in defining the topics and help facilitate discussions at the event. The Director(s) will be joined by a small number of mentors and a team of professional facilitators. The mentors will be selected by NSF based on their intellectual standing, their impartiality and objectivity, and their broad understanding of, and enthusiasm for, the subject area. The Director(s) and mentors will take full part in the Ideas Lab, but will not be eligible to receive research funding under this collaborative activity. They will, therefore, act as impartial peer reviewers in the process, providing a function analogous to that of an NSF review panel.

The process can be broken down into several stages:

- Defining the scope of the challenges
- Evolving common languages and terminologies amongst people from a diverse range of backgrounds and disciplines
- Sharing perspectives and understanding of the scientific challenges, as well as the diverse expertise brought by the participants to the Ideas Lab
- Taking part in break-out sessions focused on the challenges, using creative thinking techniques
- Capturing the outputs in the form of highly innovative research projects
- Using "real-time" peer review to develop projects at the Ideas Lab

The Ideas Lab will be an intensive event. For the well-being of participants, the venue offers opportunities for relaxation, and the timetable will include networking and other activities as a break from the intensive technical discussions.

Who Should Apply to Participate?

Having the right mix of participants influences the success or failure of such an activity. Applications are encouraged from individuals representing diverse research areas across a range of disciplines. Contributions to this challenge could be made by researchers working in a variety of disciplines or research areas such as space weather, sensors and instrumentations, circuits and antennas, networks and systems, communication systems, wireless networks etc. However, we are not defining the disciplines that should be represented at this Ideas Lab; rather we are asking potential participants to indicate how their expertise can address the challenge of developing and operating the next generation CubeSats that would enable realization of constellations and swarms.

The ability to develop and pursue a new approach will also be crucial. Expertise is required from a very broad range of disciplines, and applicants should not feel limited by conventional perceptions: the Ideas Lab approach is about bringing people together who would not normally interact. We actively encourage people to apply who are experts in their own research areas but have not yet applied it to this challenge.

Location and Date

This Ideas Lab will take place at Airlie in Warrenton, VA, from March 11 to March 15, 2019. Further details of this venue are available at https://www.airlie.com. The environment will encourage free and open-minded thinking, vital for the purposes of this event. Additional information about the venue and meeting logistics will be provided to the selected participants. It should be noted that travel to the Ideas Lab, accommodation, refreshments, breakfast, lunch and dinner costs will be covered by NSF. However, all incidental costs incurred while at the event will be borne by the participant.

Applications for this Activity

In brief, any individual interested in participating in the Ideas Lab should respond to this solicitation by submitting a preliminary proposal application. Participation in the Ideas Lab is by invitation only from the pool of applicants who submitted a preliminary proposal.

Submission of the preliminary proposal will be considered an indication of availability to attend and participate through the full course of the five-day Ideas Lab.

Participants will be selected on the basis of the interests, expertise, and other characteristics described in their submitted preliminary proposals.

Following the Ideas Lab, teams may be selected to submit full proposals to the NSF by the May 30, 2019 deadline. These full proposals must reflect the outline developed at the meeting.

III. AWARD INFORMATION

The total funding available for this Ideas Lab is $6,000,000 to $8,000,000 over 4 years to 1 to 2 selected awards, with up to $2,000,000 in FY 2019, pending availability of funds and compelling proposals.

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG), Chapter I.E.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

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

An individual may serve as PI or Co-PI on only one proposal.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Preliminary Proposals *(required)*: Preliminary proposals are required and must be submitted via the NSF FastLane system, even if full proposals will be submitted via Grants.gov.

Submission of Preliminary Proposals is required for participation in the Ideas Lab. Please note, the preliminary proposal must come from one individual and cannot include co-PIs or collaborators. Participants in the Idea Lab will be selected on the basis of information submitted in the preliminary proposal. Proposers are reminded to identify the program solicitation number (located on the first page of this document) in the first block on the NSF Cover Sheet. Compliance with this requirement is critical to determining the relevant proposal processing guidelines.

As described in the PAPPG Chapter II.E.5, **the Project Description section of the preliminary proposal is limited to two pages** and should conform to the following guidelines:

Page One:

- Please provide a brief summary of your professional background starting with job title and number of years since highest qualification (limit: 200 words)

Please note that if you are selected as a participant, information provided in answer to this question will be made available to the other participants to facilitate networking at the Ideas Lab meeting.

- How do you see your expertise and interests contributing to realizing the goal of the CubeSat Ideas Lab? (limit: 200 words)

Page Two:

Please spend some time considering your answers to the following questions. Your responses (of no more than 100 words each) will help us assess your suitability (unrelated to your research track record) for the innovative and collaborative setting of the Ideas Lab.

- What is your approach to teamwork?
- How would you explain your area of interest to individuals with a different expertise to your own?
- The Ideas Lab is especially suited to individuals who enjoy stepping outside their area of expertise or interest, are positively driven, enjoy creative activity and can think innovatively. The Ideas Lab is an intensive setting requiring you to develop novel approaches with individuals you may not know. How do you consider yourself suited?
- What do you hope to gain from participating in this Ideas Lab, personally and professionally?

Applicants must include a **Biographical Sketch** and a **Current and Pending Support** document (prepared in accordance with standard NSF formatting guidelines).

No appendices or supplementary documents may be submitted.

Submission of the preliminary proposal will be considered an indication of availability to attend and participate through the full course of the five-day residential Ideas Lab workshop. Selected participants will be notified, and logistics arranged for travel to, and participation in, the Ideas Lab. Following the conclusion of the Ideas Lab, NSF program staff will invite the submission of full proposals related to one or more of the ideas developed during the Ideas Lab.

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

- Full proposals submitted via FastLane: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg. Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.

- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov*. The complete text of the *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the Download Package button. Paper copies of the Grants.gov Application Guide also may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

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

Collaborative Proposals. All collaborative proposals submitted as separate submissions from multiple organizations must be submitted via the NSF FastLane system. PAPPG Chapter II.D.3 provides additional information on collaborative proposals.

See PAPPG Chapter II.C.2 for guidance on the required sections of a full research proposal submitted to NSF. Please note that the proposal preparation instructions provided in this program solicitation may deviate from the PAPPG instructions.

Full proposals based on project ideas developed through interactions at the Ideas lab should conform to the project outline developed at the conclusion of the meeting. If substantive changes are contemplated, an NSF Program Director should be contacted for guidance.

All full proposals should include a single copy document that contains a list of collaborators and other affiliations information for the investigators involved in the project. See below for required format.

Single-Copy Documents

Collaborators and Other Affiliations Information:

As detailed in the PAPPG (II.C.1.e), information regarding collaborators and other affiliations must be provided for each individual who has a biographical sketch in this proposal. If you have correctly added biographical sketches for all persons, there should be a separate space within Single Copy Documents to upload each individual's file. The COA information must be provided through use of the COA template.

Cover Sheet:

Proposal titles should begin with the word "CubeSat Ideas Lab:"

Special Information and Supplementary Documentation:

The following special information must be provided as a *Supplementary Document*. This information is not considered part of the 15-page project description limitation but should not exceed a total of 5 pages.

1. A detailed management plan including a description of the risk reduction approach being adopted.
2. A detailed project schedule.
3. A satellite and subsystem environmental testing plan that conforms to the CubeSat standard and a plan for how to meet additional testing requirements that may be issued by the launch provider.
4. A description of reviews planned during development and testing.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

C. Due Dates

- **Preliminary Proposal Due Date(s)** *(required)* (due by 5 p.m. submitter's local time):

    February 12, 2019

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

    May 30, 2019

(due by 5 p.m. submitter's local time)

D. FastLane/Grants.gov Requirements

For Proposals Submitted Via FastLane:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: https://www.fastlane.nsf.gov/a1/newstan.htm. For FastLane user support, call the FastLane Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov. The FastLane Help Desk answers general technical questions related to the use of the FastLane system. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

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

Submitting the Proposal: Once all documents have been completed, the Authorized Organizational Representative (AOR) must submit the application to Grants.gov and verify the desired funding opportunity and agency to which the application is submitted. The AOR must then sign and submit the application to Grants.gov. The completed application will be transferred to the NSF FastLane system for further processing.

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

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

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 *Building the Future: Investing in Discovery and Innovation - NSF Strategic Plan for Fiscal Years (FY) 2018 – 2022*. 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.C.2.d(i). contains additional information for use by proposers in development of the Project Description section of the proposal). Reviewers are strongly encouraged to review the criteria, including PAPPG Chapter II.C.2.d(i), prior to the review of a proposal.

When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- **Intellectual Merit:** The Intellectual Merit criterion encompasses the potential to advance knowledge; and
- **Broader Impacts:** The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to
   a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
   b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?
3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

Broader impacts may be accomplished through the research itself, through the activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. NSF values the advancement of scientific knowledge and activities that contribute to achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

Proposers are reminded that reviewers will also be asked to review the Data Management Plan and the Postdoctoral Researcher Mentoring Plan, as appropriate.

Additional Solicitation Specific Review Criteria

Full proposals derived from the Ideas Lab will be evaluated to determine whether the scientific themes/objectives in the proposal are congruent with the ideas presented at the Ideas Lab, and whether any significant changes in project scope or resources from those presented at the Ideas Lab have been justified.

Full proposals submitted in response to this program solicitation will be reviewed internally by the cognizant NSF Program Officers, the Ideas Lab mentors, and other external reviewers, as appropriate.

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by Ad hoc Review and/or Panel Review, Internal NSF Review, or Ideas Lab Mentors.

The Ideas Lab review and selection process is outlined in the PAPPG Chapter II.E.5.

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

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF strives to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. Large or particularly complex proposals or proposals from new awardees may require additional review and processing time. The time interval begins on the deadline or target date, or receipt date, whichever is later. The interval ends when the Division Director acts upon the Program Officer's recommendation.

After programmatic approval has been obtained, the proposals recommended for funding will be forwarded to the Division of Grants and Agreements for review of business, financial, and policy implications. After an administrative review has occurred, Grants and Agreements Officers perform the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments, obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

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

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

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

B. Award Conditions

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) 292-7827 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.

C. Reporting Requirements

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

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

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

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

VIII. AGENCY CONTACTS

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

General inquiries regarding this program should be made to:

- Monisha Ghosh, telephone: (703) 292-8746, email: mghosh@nsf.gov
- Jenshan Lin, telephone: (703) 292-8339, email: jenlin@nsf.gov
- Lawrence S. Goldberg, telephone: (703) 292-8339, email: lgoldber@nsf.gov
- Mary F. Poats, telephone: (703) 292-5357, email: mpoats@nsf.gov
- Julie Martin, telephone: (703) -292-8657, email: julmarti@nsf.gov
- Lisa Winter, telephone: (703) -292-8519, email: lwinter@nsf.gov

For questions related to the use of FastLane, contact:

- FastLane Help Desk, telephone: 1-800-673-6188; e-mail: fastlane@nsf.gov.

For questions relating to Grants.gov contact:

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

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 http://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.E.6 for instructions regarding preparation of these types of proposals.

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

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

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

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

- **Location:** 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) 292-7827
- **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 Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004), and NSF-51, "Reviewer/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004). Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

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

Suzanne H. Plimpton
Reports Clearance Officer
Office of the General Counsel
National Science Foundation
Alexandria, VA 22314

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