

NSF/CASIS Collaboration on Transport Phenomena Research on the International Space Station (ISS) to Benefit Life on Earth

PROGRAM SOLICITATION

NSF 20-501

REPLACES DOCUMENT(S):

NSF 19-525



National Science Foundation

Directorate for Engineering
Division of Chemical, Bioengineering, Environmental and Transport Systems



Center for the Advancement of Science in Space

Submission Window Date(s) (due by 5 p.m. submitter's local time):

December 09, 2019 - March 02, 2020

IMPORTANT INFORMATION AND REVISION NOTES

Appropriateness of Proposals for the NSF-ISS Program:

The NSF-ISS Program is not intended to be used for proposals that are appropriate for existing funding mechanisms or that continue well-established practices.

Prospective proposers must submit a Feasibility Review Form to the Center for the Advancement of Science in Space (CASIS) by January 10, 2020. The form will be evaluated for operational feasibility and terrestrial benefit.

Proposers who have submitted Feasibility Review Forms that pass the initial operational and terrestrial benefit review by CASIS will be invited to submit a full proposal for evaluation by NSF. Documentation from the CASIS team confirming approval to submit a proposal after the operation and terrestrial benefit reviews must be provided as a Single Copy Document in FastLane or Grants.gov when the full proposal is submitted.

CASIS strongly encourages submission of the Feasibility Review Form as early as possible. Potential PIs or teams should consult with the CASIS Operations team (ops@issnationallab.org) for feedback regarding feasibility and compliance with flight requirements and capabilities.

Final Deadline for Submitting the Feasibility Review Form to CASIS: January 10, 2020.

To Submit the Feasibility Review Form, please visit: <http://issnl.us/nsf1>.

CASIS officers will respond to a Feasibility Review Form within three weeks after submission.

Submitted proposals that pass the initial operational and terrestrial benefit review will be eligible for evaluation by NSF.

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 February 25, 2019.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Transport Phenomena Research at the International Space Station to Benefit Life on Earth (NSF-ISS)

Synopsis of Program:

The Division of Chemical, Bioengineering and Environmental Transport (CBET) in the Engineering Directorate of the National Science Foundation (NSF) is partnering with The Center for the Advancement of Science in Space (CASIS) to solicit research projects in the general field of fluid dynamics, particulate and multiphase processes, combustion and fire systems, thermal transport processes, and nanoscale interactions that can utilize the International Space Station (ISS) National Lab to conduct research that will benefit life on Earth. Only U.S. entities including academic investigators, non-profit independent research laboratories and academic-commercial teams are eligible to apply.

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.

- Nora F. Savage, Nanoscale Interactions, telephone: (703) 292-7949, email: nosavage@nsf.gov
- Ronald Joslin, Fluid Dynamics, telephone: (703) 292-7030, email: rjoslin@nsf.gov
- William Olbricht, Particulate and Multiphase Processes, telephone: (703) 292-4842, email: wolbrich@nsf.gov
- Harsha Chelliah, Combustion and Fire Systems, telephone: (703) 292-7062, email: hchellia@nsf.gov
- Ying Sun, Thermal Transport Processes, telephone: (703) 292-7443, email: yisun@nsf.gov
- Shahab Shojaei-Zadeh, Transport Phenomena Cluster, telephone: (703) 292-8045, email: sshojaei@nsf.gov
- Ryan Reeves, Center for the Advancement of Science in Space, telephone: (321) 751-5151, email: rreeves@issnationallab.org

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

- 43.007 --- Center for the Advancement of Science in Space
- 47.041 --- Engineering

Award Information

Anticipated Type of Award: Standard Grant

Estimated Number of Awards: 7

Anticipated Funding Amount: \$3,000,000

NSF Funding (total) available under this solicitation is up to \$3 million to be distributed in FY 2020. Budget requests may be for up to \$400,000 total, direct and indirect costs, and up to four years in duration. The award size and duration should be consistent with the project scope.

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

Funding for ISS Experiments

NSF awards under this solicitation will provide PIs with support to conduct fundamental and translational research, to prepare experiments for execution onboard the ISS, to collaborate with service providers as necessary, to provide preliminary analysis to conduct the experiment, to analyze and interpret data, and to disseminate results broadly. CASIS operations will assist grantees in translating ground-based experiments and technologies into an appropriate ISS certified hardware solution where possible. All costs associated with the translation of the proposed experiments to flight experiments onboard the ISS, including training of ISS crews, transporting the experiment payload and equipment to the ISS, and conducting experiments on the ISS, will be supported by CASIS through their cooperative agreement with NASA. For information regarding available flight hardware for this solicitation, please see: <http://issnl.us/nsf1>.

For other technical and/or operational inquiries, please submit questions to (ops@issnationallab.org).

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.
- For-profit organizations: U.S. commercial organizations, especially small businesses with strong capabilities in scientific or engineering research or education.

Who May Serve as PI:

The PI(s) must be eligible to submit NSF proposals, as described in the PAPPG. Projects can be collaborative and collaborations with industry and relevant costs for their participation are allowed.

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 participate in any capacity (PI, co-PI, Other Senior Personnel, or Consultant) in only one proposal submitted in response to this solicitation. The submitting organization is responsible to ensure that the PI, co-PIs, Other Senior Personnel, and Consultants are participating in only one proposal. This limitation includes proposals submitted by a lead organization and any sub-award submitted as part of a proposal. Violations of this rule will result in return without review of all proposals including the offending individual except for the first such proposal submitted in time-stamped order.

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 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:**

Other budgetary limitations apply. Please see the full text of this solicitation for further information.

C. Due Dates

- **Submission Window Date(s)** (due by 5 p.m. submitter's local time):

December 09, 2019 - March 02, 2020

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:

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

Reporting Requirements:

Standard NSF reporting requirements apply.

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I. INTRODUCTION

The Center for the Advancement of Science in Space (CASIS) is an Internal revenue Code (IRC) Section 501(c)(3) entity responsible for management of the International Space Station (ISS) U.S. National Laboratory under a Cooperative Agreement (NNH11CD70A) with the National Aeronautics and Space Administration (NASA). Per Section 504 of the NASA Authorization Act of 2010, the purpose of CASIS is to maximize the value of the investment the U.S. government made in the ISS National Lab and demonstrate the scientific and technological productivity of the ISS National Lab over the next decade. CASIS seeks to advance scientific research, technology development, and education in conjunction with utilization of the ISS, managing a diverse research, technology, and education portfolio across a broad range of scientific fields.

Because NSF and CASIS have a common interest in research and development in transport, thermal, combustion, nanoscale interactions, and fluid phenomena at microgravity conditions, NSF and CASIS have developed a collaboration to jointly support research that can take advantage of the opportunities afforded by conducting experiments in the ISS.

In 2016, Program Solicitation [NSF 16-518](#) was focused on the fluid dynamics research, in 2017, Program Solicitation [NSF 17-517](#) was focused on combustion and thermal transport processes research, in 2018, Program Solicitation [NSF 18-521](#) was focused on research proposals addressing fluid dynamics and particulate and multiphase processes research, and in 2019, Program Solicitation [NSF 19-525](#) focused on Transport Phenomena research in the microgravity environment. The funded proposals can be found on the website of the programs within the Transport Phenomena Cluster of the Division of Chemical, Bioengineering, Environmental, and Transport Systems. This solicitation is focused on research covered by all the programs within the Transport Phenomena Cluster (Fluid Dynamics, Particulate and Multiphase Processes, Combustion and Fire Systems, and Thermal Transport Processes) and the Nanoscale Interactions program from the Environmental Engineering and Sustainability Cluster.

The purpose of this solicitation is to attract proposals that make use of the ISS National Lab for research projects in the fields related to the Transport Phenomena Cluster and Nanoscale Interactions programs. Responsive proposals will describe using the ISS National Lab for development and testing of fluid dynamics, particulate and multiphase processes, combustion and fire systems, thermal transport processes, and nanoscale interactions that will lead to Earth-based applications and increase the return on the U.S. investment in the ISS National Lab. CASIS goals are to advance science research and technology development, expand human knowledge, inspire and educate the next generation, foster the commercial development of space, and demonstrate scientific capabilities in space for Earth benefit. Fundamental research to study fluid dynamics, particulate and multiphase processes, combustion and fire systems, thermal transport processes, and nanoscale interactions where the results will have direct terrestrial benefit but will involve flight research utilizing the ISS, is solicited.

The collaboration seeks to exploit the complementary missions of (i) research and development for NSF, and (ii) stimulation, development and management of U.S. national uses of the ISS National Lab by U.S. government agencies, academic institutions, and private firms for CASIS. Proposals must seek to exploit the ISS National Lab for fluid dynamics, particulate and multiphase process, combustion and fire systems, thermal transport processes, and nanoscale interactions studies to support applications on Earth. The proposal must include a description of project benefits for life on Earth. Proposals focused on research and technology development supporting only space exploration-related goals do not fall within the scope of the NSF and CASIS mission and will be considered non-responsive to this solicitation. For example, this program does not support research strictly focused on space propulsion.

II. PROGRAM DESCRIPTION

The unique environment on the ISS National Lab has many benefits and can include high quality and long duration microgravity and extreme conditions including heat and cold cycling, high energy radiation, and vacuum.

Potential research related to fluid dynamics and particulate and multiphase processes may include areas such as (but not limited to):

- Multiphase flow
- Capillary flow
- Separation/Agglomeration
- Sedimentation/Stratification
- Diffusion
- Interfacial behavior
- Surface tension
- Biological and physiological transport

The strong hindrance of processes, such as natural convection and sedimentation, and of those driven or affected by hydrostatic pressure and buoyancy, for instance, can all contribute to the change in the behavior of a substance in space. The effect on these variables allows phenomena of interest to be studied with minimal gravitational interference. Example phenomena related to combustion and fire systems and thermal transport processes may include (but are not limited to):

- Combustion of gas, liquid and solid
- Fire safety
- Low-temperature combustion chemistry
- Convective (forced) flow
- Phase change
- Radiation

Microgravity can influence the crystal growth process and the molecular structure of a material during phase change. Microgravity may also enable the measurement of certain physical/chemical properties, involving multicomponent transport and flame dynamics, which have been shown to be difficult to measure sufficiently well in Earth-based laboratories. The long-term exposure to microgravity is also important in many combustion and thermal transport studies. Longer time scales (e.g., for fully developed flow profiles or weakly-driven flows to occur) are often needed for experimentation, which cannot occur in parabolic flights or drop towers, thus the necessity for the ISS National Lab.

Examples of research related to the Nanoscale Interactions program include 1) investigation of transport, interaction, and impact of nanostructured materials on biological systems in microgravity, and 2) characterization of interfacial interactions and transformation of both simple and complex nanoparticles and/or heterogeneous composites and nanosystems under microgravity conditions.

To receive funding as an NSF-ISS-appropriate project, an ISS-based flight experiment should be proposed. Selected projects must be flight ready within 24 months of the award and final reports must be completed by six months post flight. If flight schedules change, investigators may modify proposed timelines, subject to review and approval by the CASIS Operations team. Prior to submitting a proposal to NSF, the Feasibility Review Form must be approved by CASIS.

This solicitation is not intended to be used for projects that can be accommodated within other NSF funding mechanisms. In addition, this solicitation is not intended to be used for projects that can be conducted in their entirety with ground-based research.

Collaborative proposals may also be submitted. In these cases, if the co-PIs are at different organizations and have complementary skills and facilities, then the use of the separately submitted, collaborative proposal mechanism is allowed. See PAPPG Chapter II.D.3.b for information about submission of a collaborative proposal from multiple organizations.

Prospective proposals will be subject to a review for operational feasibility and terrestrial benefit, both conducted by CASIS. See the CASIS guidelines for further details on these reviews at <http://issnl.us/nsf1>.

The solicitation seeks to increase use of the ISS National Lab for fluid dynamics, particulate and multiphase processes, combustion and fire systems, thermal transport processes, and nanoscale interactions studies to benefit applications or industries on Earth, to promote ISS as well as new and existing facility/technology utilization. Costs such as preparatory work, including but not limited to design of experimental prototypes and numerical simulations, data acquisition, and post-flight data analysis, can be included in the budget. Subject to budgetary and time constraints, CASIS may cover costs of limited modifications to flight hardware, on a case-by-case basis, to meet defined research objectives. Ideal proposals will describe a commercial, civil, or academic project to achieve research or technology development objectives that will directly impact areas including (but not limited to):

- Clean energy
- Carbon emissions and capture
- Manufacturing
- Machinery
- Consumer Products
- Oil & gas
- Electronics
- Medical devices and pharmaceuticals
- Microfluidics and nanofluidics

Prospective proposers should consult with the flight hardware directory at <http://issnl.us/nsf1> for an introduction to the basic capabilities of the ISS payload facilities and instrumentation platforms. NSF will offer grants to research proposals that develop fundamental and translational research and CASIS will assist grantees in translating ground-based experiments and technologies into space-appropriate hardware where possible. An ideal proposal will demonstrate the investigator's knowledge of the significant challenges and importance of the proposed research and how ISS utilization will allow their research goals to be achieved. All proposers should read this online material to clearly understand the hardware platform and capabilities on the ISS.

CASIS also encourages prospective proposers to learn about the availability and capability of flight hardware and integration services by directly communicating with the CASIS Operations team (ops@issnationallab.org). Prospective proposers should read the CASIS guidelines at: <http://issnl.us/nsf1>.

Proposals that do not follow the CASIS guidelines will be deemed non-responsive to this solicitation.

III. AWARD INFORMATION

Anticipated Type of Award: Standard Grant

Estimated Number of Awards: 7

Anticipated Funding Amount: Up to \$3,000,000

NSF Funding (total) available under this solicitation is up to \$3 million, to be distributed in FY 2020. Budget requests may be for up to \$400,000 total, including direct and indirect costs, and up to four years in duration. The award size and duration should be consistent with the project scope.

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

Funding for ISS Experiments

NSF awards under this solicitation will provide PIs with support to conduct fundamental and translational research to prepare experiments for execution onboard the ISS, to collaborate with service providers as necessary, to provide preliminary analysis to conduct the experiment, to analyze and interpret data, and to disseminate results broadly. CASIS will assist grantees in translating ground-based experiments and technologies into space-appropriate hardware where possible. Costs associated with the translation of the proposed experiments to flight experiments onboard the ISS, including the training of ISS crews, transporting the experiment payload and equipment to the ISS, and conducting experiments on the ISS, will be supported by CASIS through their cooperative agreement with NASA.

Both organizations will jointly manage the project reviews. All NSF awards will be made via a Standard Grant mechanism. In addition, NSF awardees shall be required to negotiate separate conditions with CASIS for ISS utilization support via a contract mechanism.

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.
- For-profit organizations: U.S. commercial organizations, especially small businesses with strong capabilities in scientific or engineering research or education.

Who May Serve as PI:

The PI(s) must be eligible to submit NSF proposals, as described in the PAPPG. Projects can be collaborative and collaborations with industry and relevant costs for their participation are allowed.

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 participate in any capacity (PI, co-PI, Other Senior Personnel, or Consultant) in only one proposal submitted in response to this solicitation. The submitting organization is responsible to ensure that the PI, co-PIs, Other Senior Personnel, and Consultants are participating in only one proposal. This limitation includes proposals submitted by a lead organization and any sub-award submitted as part of a proposal. Violations of this rule will result in return without review of all proposals including the offending individual except for the first such proposal submitted in time-stamped order.

Additional Eligibility Info:

Grant Opportunities for Academic Liaison with Industry (GOALI) proposals, where academe and industry partner on a research project, are encouraged (see *NSF Proposal & Award Policies & Procedures Guide* (PAPPG Chapter II.E.4): https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.

CASIS strongly encourages all potential proposers to consider industry collaboration.

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 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.

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

- The project title on the proposal Cover Sheet will be preceded by the prefix "ISS:" to distinguish the submission from a regular proposal that would go through a regular review process.
- All investigators who wish to submit a proposal in response to this solicitation must submit a completed CASIS Feasibility Review Form. The CASIS Feasibility Review Form will be available on the CASIS website at: <http://issnl.us/nsf1>.

This CASIS Feasibility Review Form must be completed and submitted via the CASIS website no later than January 10, 2020, to allow time for a response and time to prepare the full proposal.

CASIS officers will respond to a Feasibility Review Form within three weeks after submission.

Documentation from the CASIS team confirming approval to submit a proposal after the operation and terrestrial benefit reviews must be provided as a Single Copy Document in Fastlane or Grants.gov. A proposal submitted without the required authorizations will be returned without review.

- A proposal that passes the operational and terrestrial benefit reviews represents CASIS's preliminary judgment that the project might be appropriate for consideration under this initiative; it is not a commitment to recommend support of a proposal with program funds. For a description about the CASIS operational and terrestrial benefit review criteria, please see <http://issnl.us/nsf1>.
- The proposal must explicitly address how the project will utilize the ISS capabilities and how the research will benefit life on Earth.

NSF awardees under this solicitation will need to execute a User Agreement with CASIS in order to utilize the ISS National Laboratory. A template agreement (<http://issnl.us/nsf1>) has been developed for this program to streamline the processes of forging partnerships between CASIS and awardees.

Additional Instructions for Submission of a GOALI Proposal

When preparing a GOALI proposal, select this program solicitation number and then select "GOALI" as the Type of Proposal. The project title on the proposal Cover Sheet should begin with "ISS: GOALI:". The proposal must be prepared in accordance with the GOALI specific instructions in Chapter II.E.4 of the PAPPG and the additional instructions contained in this solicitation.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Other Budgetary Limitations:

Inclusion of a fee in the proposal budget and/or any subaward budget is unallowable.

C. Due Dates

- **Submission Window Date(s)** (due by 5 p.m. submitter's local time):

December 09, 2019 - March 02, 2020

D. FastLane/Research.gov/Grants.gov Requirements

For Proposals Submitted Via FastLane or Research.gov:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: <https://www.fastlane.nsf.gov/a1/newstan.htm>. To prepare and submit a proposal via Research.gov, see detailed technical instructions available at: https://www.research.gov/research-portal/appmanager/base/desktop?_nfpb=true&_pageLabel=research_node_display&_nodePath=/researchGov/Service/Desktop/ProposalPreparationandSubmission.html. For FastLane or Research.gov user support, call the FastLane and Research.gov Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov or rgov@nsf.gov. The FastLane and Research.gov Help Desk answers general technical questions related to the use of the FastLane and Research.gov systems. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

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

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

Proposers that submitted via FastLane or 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 *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

In addition to the standard NSF criteria for evaluating proposals, reviewers will be asked to evaluate the proposal on the following content:

- Proposals should explain clearly the necessity of the ISS National Lab in the proposed project.
- Proposals should list implementation partners or, if partners have not been identified, describe the services needed to complete the proposed research.
- Proposals should specify existing flight hardware to be used in the project and any modifications that are necessary to the hardware to achieve the research objectives. New hardware may also be proposed provided a design has been developed with an appropriate implementation partner.
- Proposals should describe the investigators' capabilities and related experience relevant to the proposed project.

Please note that CASIS will facilitate investigators in identifying service providers, in assessing the feasibility of possible hardware and experiment modifications, and in developing a realistic budget and time frame for the project.

B. Review and Selection Process

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

The review process and panel will be administratively managed by NSF. 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 be completed and submitted by each reviewer. The NSF and CASIS Program Officers will consider the advice of reviewers and will formulate a recommendation to their respective management teams.

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) 292-8134 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.

Special Award Conditions:

Joint NSF/CASIS awardees will be required to include appropriate acknowledgement of NSF and CASIS support in reports and/or publications of work performed under this award. An example of such an acknowledgement is: "This material is based upon work supported by NSF and CASIS under Award No. [Recipient should enter the awarding entities award number(s)]."

Awardees will be required to submit annual and final project reports to NSF and interim progress reports to CASIS to ensure timely execution of the flight experiments.

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 *Award & Administration Guide* (AAG) Chapter II, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

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:

- Nora F. Savage, Nanoscale Interactions, telephone: (703) 292-7949, email: nosavage@nsf.gov

- Ronald Joslin, Fluid Dynamics, telephone: (703) 292-7030, email: rjoslin@nsf.gov
- William Olbricht, Particulate and Multiphase Processes, telephone: (703) 292-4842, email: wolbrich@nsf.gov
- Harsha Chelliah, Combustion and Fire Systems, telephone: (703) 292-7062, email: hchellia@nsf.gov
- Ying Sun, Thermal Transport Processes, telephone: (703) 292-7443, email: yisun@nsf.gov
- Shahab Shojaei-Zadeh, Transport Phenomena Cluster, telephone: (703) 292-8045, email: sshojaei@nsf.gov
- Ryan Reeves, Center for the Advancement of Science in Space, telephone: (321) 751-5151, email: rreeves@issnationallab.org

For questions related to the use of FastLane or Research.gov, contact:

- FastLane and Research.gov Help Desk: 1-800-673-6188
FastLane Help Desk e-mail: fastlane@nsf.gov.
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 Center for the Advancement of Science in Space (CASIS)

The Center for the Advancement of Science in Space (CASIS) is an IRC Section 501(c)(3) entity responsible for management of the International Space Station (ISS) U.S. National Laboratory under a Cooperative Agreement with NASA (NNH11CD70A). Per Section 504 of the NASA Authorization Act of 2010, the purpose of CASIS is to maximize the value of the investment the U.S. government made in the ISS National Lab and demonstrate the scientific and technological productivity of the ISS National Lab over the next decade. CASIS seeks to advance scientific research, technology development, and education in conjunction with utilization of the ISS, managing a diverse research, technology, and education portfolio across a broad range of scientific fields.

CASIS Goals

1. Stimulate, develop, and manage U.S. national uses of the ISS National Lab by U.S. government agencies, academic institutions, and private firms; and
2. Develop tools and techniques to communicate the value of uses of the ISS research platform, and increase the return on the U.S. investment in the ISS National Lab.

The Center for Advancement of Science in Space may be reached at:

6905 N. Wickham Road, Suite 500

Melbourne, FL 32940

Phone: (321) 253-5101

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

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

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

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

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

- **Location:** 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 [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
Office of the General Counsel
National Science Foundation
Alexandria, VA 22314

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