Findable Accessible Interoperable Reusable Open Science Research Coordination Networks (FAIROS RCN)

PROGRAM SOLICITATION
NSF 22-553

National Science Foundation

Directorate for Computer and Information Science and Engineering
Office of Advanced Cyberinfrastructure

Directorate for Geosciences

Directorate for Social, Behavioral and Economic Sciences

Directorate for Biological Sciences

Directorate for Mathematical and Physical Sciences

Directorate for Engineering

Directorate for Education and Human Resources

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

April 12, 2022

IMPORTANT INFORMATION AND REVISION NOTES

Important Information

Innovating and migrating proposal preparation and submission capabilities from FastLane to Research.gov is part of the ongoing NSF information technology modernization efforts, as described in Important Notice No. 147 . In support of these efforts, research proposals submitted in response to this program solicitation must be prepared and submitted via Research.gov or via Grants.gov, and may not be prepared or submitted via FastLane.

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 22-1), which is effective for proposals submitted, or due, on or after October 4, 2021.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Findable Accessible Interoperable Reusable Open Science Research Coordination Networks (FAIROS RCN)

Synopsis of Program:

The FAIROS RCN program seeks to create three-year Research Coordination Networks (RCNs) which will foster catalytic improvements in scientific communities focusing on the FAIR (Findability, Accessibility, Interoperability, and Reuse, see Program Description for more information) guiding principles and Open Science best practices (inclusively summarized by the combined phrase FAIROS for purposes of this program). This program will support a broad range of activities by these new RCNs to advance the means by which investigators can share information and ideas, coordinate ongoing or planned research activities, foster synthesis and new collaborations, develop community standards, and in other ways advance science and education through communication and sharing of research products through FAIROS strategies.

FAIROS RCN proposals must select one of two tracks to focus on, either: 1) *Disciplinary Improvements* to targeted scientific communities, or 2) *Cross-Cutting Improvements* that apply to many or most scientific disciplines. In the case of proposals focused on Disciplinary Improvements, it is strongly recommended that prospective PIs contact a program officer from the list of Cognizant Program Officers in the directorate closest to the major disciplinary impact of the proposed work to ascertain that the scientific focus and budget of the proposed work are appropriate for this solicitation. In the case of proposals focused on Cross-Cutting Improvements, it is strongly recommended that prospective PIs contact a program officer from the list of Cognizant Program Officers from the Office of Advanced Cyberinfrastructure. For more on the NSF Public Access Initiative and Office of Integrative Activities, see the Program Description section below.

This program is undertaken in support of the NSF Public Access Initiative as described in the 2015 NSF Public Access Plan entitled "Today's

Data, Tomorrow's Discoveries", an agency-wide response to the need for publicly funded research products to be made publicly accessible. This national priority was first broadly articulated by the Office of Science and Technology Policy in 2013, and is of ongoing importance to NSF as a whole. In addition, this program advances the priorities of NSF's Office of Integrative Activities, which supports work across disciplinary boundaries that: advances research excellence and innovation; develops human and infrastructure capacity critical to the U.S. science and engineering enterprise; and promotes engagement of scientists and engineers at all career stages.

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.

- Martin D. Halbert, CISE/OAC Science Advisor for Public Access, telephone: (703) 292-8516, email: mhalbert@nsf.gov
- Raleigh Martin, GEO/EAR Program Director, telephone: (703) 292-7199, email: ramartin@nsf.gov
- Alan Tomkins, SBE/SES Acting Division Director, telephone: (703) 292-2690, email: ATOMKINS@nsf.gov
- Peter H. McCartney, BIO/DBI Program Director, telephone: (703) 292-8470, email: pmccartn@nsf.gov
- Bogdan Mihaila, CISE/OAC & MPS/PHY Science Advisor, telephone: (703) 292-8235, email: bmihaila@nsf.gov
- Alexis Lewis, ENG/CMMI Deputy Division Director, telephone: (703) 292-2624, email: ALEWIS@nsf.gov
- Lee Zia, EHR/DGE Acting Division Director, telephone: (703) 292-5140, email: lzia@nsf.gov

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

- 47.041 --- Engineering
- 47.049 --- Mathematical and Physical Sciences
- 47.050 --- Geosciences
- 47.070 --- Computer and Information Science and Engineering
- 47.074 --- Biological Sciences
- 47.075 --- Social Behavioral and Economic Sciences
- 47.076 --- Education and Human Resources
- 47.079 --- Office of International Science and Engineering
- 47.083 --- Office of Integrative Activities (OIA)

Award Information

Anticipated Type of Award: Continuing Grant

Estimated Number of Awards: 6 to 7

An expected 6-7 awards of up to $500K per year for three years are planned. However, the number of awards will be based on quality of proposals, availability of funds, and responsiveness to priorities of the participating directorates/divisions.

Anticipated Funding Amount: $9,000,000 to $10,500,000

Estimated program budget, number of awards, and average award size/duration are subject to the availability of funds. Each award will be up to $500K per year for three years.

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.
- NSF-funded Federally Funded Research and Development Centers (FFRDCs) should contact the appropriate program before preparing a proposal for submission

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 participate as Principal Investigator, co-Principal Investigator or other Senior Personnel in at most one FAIROS RCN

proposal. Any individual whose biographical sketch is provided as part of the proposal will be considered as Senior Personnel in the proposed activity, with or without financial support from the project. The first submitted proposal (chronological order of submission) in which that individual is participating will be accepted for review, and the remainder will be returned without review. For this purpose, a multi-institution collaborative project is treated as one proposal that is considered submitted when the last component proposal is submitted. Similarly, a person who appears as a PI or Co-PI on one FAIROS RCN proposal may only appear on other FAIROS proposals submitted in response to this solicitation in a non-funded capacity or as a signatory to a letter of collaboration. The reason for the PI limit on FAIROS RCN proposals is to balance the number and quality of the submissions.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

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

B. Budgetary Information

- **Cost Sharing Requirements:**

  Inclusion of voluntary committed cost sharing is prohibited.

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

  Not Applicable

- **Other Budgetary Limitations:**

  Not Applicable

C. Due Dates

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

  April 12, 2022

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria apply.

Award Administration Information

Award Conditions:

Standard NSF award conditions apply.

Reporting Requirements:

Standard NSF reporting requirements apply.

TABLE OF CONTENTS

I. INTRODUCTION

The 2018 National Academies of Sciences, Engineering, and Medicine (NASEM) Report entitled *Open Science by Design: Realizing a Vision for 21st Century Research* began with the observation that: “Openness and sharing of information are fundamental to the progress of science and to the effective functioning of the research enterprise.”

The acronym FAIR stands for Findability, Accessibility, Interoperability, and Reuse of digital assets (for more on the history of the FAIR Guiding Principles, see https://www.go-fair.org/fair-principles/). The FAIR Guiding Principles for scientific data management and stewardship have been widely recognized as important and valuable strategies for improving scientific cyberinfrastructures and practices. These principles have become prominent elements of the larger Open Science movement to make scientific research products publicly accessible, a major national and international priority for the entire research community.

The FAIR and other interrelated Open Science guiding principles (i.e. practices that make scientific results more transparent and accessible) for scientific data management and stewardship establish a conceptual framework for advancing open science through improvements in key aspects of information sharing practices. Improvements in FAIR machine-actionable capabilities for all categories of research products (datasets, publications, code, physical samples, specimen sets, etc.) have now also become broadly accepted as a general means of advancing Open Science more generally. The question now is how to realize the full potential to achieve the ideals of FAIR and other Open Science guiding principles for diverse scientific disciplines and communities?

II. PROGRAM DESCRIPTION

The goal of the FAIROS RCN program is to advance FAIR and Open Science capabilities, both human and technical, by supporting groups of investigators to communicate, innovate, coordinate, and standardize research practices, training, and educational activities across disciplinary, organizational, geographic and international boundaries. All disciplines and all levels of readiness are encouraged to consider applying to this solicitation. The FAIROS RCN program provides opportunities to foster new collaborations, including international partnerships, and address interdisciplinary topics. Innovative ideas for implementing novel networking strategies, collaborative technologies, training, broadening participation, and development of community standards for data and meta- data are especially encouraged. The FAIROS RCN program supports activities to advance the means by which investigators can share information and ideas, coordinate ongoing or planned research activities, foster synthesis and new collaborations, develop community standards, and in other ways advance science and education through communication and sharing of ideas.

FAIROS RCN proposals must select one of two tracks to focus on, either: 1) *Disciplinary Improvements* to targeted scientific communities, or 2) *Cross-Cutting Improvements* that apply to many or most scientific disciplines. In the case of proposals focused on Disciplinary Improvements, it is strongly recommended that prospective PIs contact a program officer from the list of Cognizant Program Officers in the directorate closest to the major disciplinary impact of the proposed work to ascertain that the scientific focus and budget of the proposed work are appropriate for this solicitation. In the case of proposals focused on Cross-Cutting Improvements, it is strongly recommended that prospective PIs contact a program officer from the list of Cognizant Program Officers from the Office of Advanced Cyberinfrastructure.

Note on Disciplinary Priorities of NSF Directorates: For more details on the priorities of individual NSF Directorates, see the agency Research Areas links provided at https://www.nsf.gov/about/research_areas.jsp and the descriptions in each of the respective programs.

Note on Cross-Cutting Priorities of the NSF Public Access Initiative and Office of Integrative Activities: The Public Access Initiative (PAI) strives to make the outputs of scientific research funded by the National Science Foundation publicly available to the greatest extent and with the fewest constraints possible and consistent with law (for more on PAI, see: https://beta.nsf.gov/public-access). The Office of Integrative Activities (OIA) catalyzes and incubates NSF-wide initiatives; promotes STEM talent; and advances agency policies and research infrastructure (for more on OIA, see: https://www.nsf.gov/od/oia/about.jsp).

This program is undertaken in support of the NSF Public Access Initiative as described in the 2015 NSF Public Access Plan entitled "Today's Data, Tomorrow's Discoveries", an agency-wide response to the need for publicly funded research products to be made publicly accessible. This national priority was first broadly articulated by the Office of Science and Technology Policy in 2013, and is of ongoing importance to NSF as a whole. In addition, this program advances the priorities of NSF’s Office of Integrative Activities, which supports work across disciplinary boundaries that: advances research excellence and innovation; develops human and infrastructure capacity critical to the U.S. science and engineering enterprise; and promotes engagement of scientists and engineers at all career stages.

Proposals must clearly specify in the title of the proposal which option is being proposed by using either “Disciplinary Improvements:” or “Cross-Cutting Improvements:” as the start of the title):

1. **Disciplinary Improvements:** Identify a clearly designated and significant area or closely related areas of science and/or engineering; this should be a disciplinary focus that aligns with preferably one or at most two of the top-level NSF disciplinary research directorates that are clearly specified within the text of the proposal.
2. **Cross-Cutting Improvements:** Identify a functional space which is cross-cutting across multiple areas of science and engineering; this functional space should ideally be relevant to the priorities of both the NSF Office of Integrative Activities and the Public Access Initiative (see notes above). Note

that for purposes of this solicitation, a functional space is a category of essential functions in the life cycle of research activities which is undertaken broadly across disparate areas of science and engineering. Examples of such categories include (but are not limited to) the four core components of the FAIR guiding principles. Other examples may be identified by proposals, but must have similar importance and broad applicability.

Types of Activities to be Undertaken in FAIROS Research Coordination Networks

Activities may include (but are not limited to): convening meetings (virtually and/or in person) of representatives and experts for the purpose of establishing consensus on FAIR/OS related standards and specifications, publishing and disseminating documented standards and specifications after consensus is reached, efforts to better understand how to improve FAIR/OS coordination and capabilities in research communities, and the development and deployment of targeted curricula in FAIR/OS techniques (ideally in ways that will result in a "train-the-trainer" approach to achieve maximal impacts).

The FAIROS RCN solicitation invites proposals which may include (but are not limited to) the following categories and examples of goals to coordinate and improve research efforts in any or all of a variety of ways (where the proposal identifies other goals, it should be made clear how these goals advance FAIROS):

Advancing Quality Control of Metadata for Research Products:

- Improvements to the quality of metadata associated with research products, especially by means of persistent identifiers
- Consensus building activities to establish metadata standards for research products which strike the right balance between robust FAIR principles and reasonable burden on researchers. Proposed activities should clearly indicate how they will represent the perspectives and priorities of stakeholders in the research ecosystem, such as researchers, repository managers, publishers, funding agencies, and metadata specialists
- Foster development of automated tools for data sharing, metadata creation, discovery, identification of interrelationships between research products, etc.
- Address other Persistent Identifier (PID) standards, including how PIDs relate to other aspects, disambiguation of people, organizations, and other research entities

Improving Interoperability and Reproducibility:

- Fostering best practices which increase the likelihood of reproducibility of results
- Developing and fostering acceptance and adoption of machine-actionable standards and systems for interoperability of research products
- Building consensus and adoption of standards for metadata which express interrelationships between research products and entities, especially machine -actionable implementations

Advancing Stewardship Practices for Research Products:

- Establishing data stewardship competency centers
- Foster development of incentives and best practices to improve data & metadata quality control
- Foster incentivization systems for: recognition of citation of data sets, tracking re-use of research products, encouraging the production of data sets as a primary class of research output, and/or developing rating and ranking systems for repositories
- Consensus building activities for best practices and standards in repository services

Data Science and Curation Training and Preparation for Improving FAIROS Capabilities:

- Creating training programs and open curricular resources for data science and curation at either or both the graduate and undergraduate levels
- Fostering adoption of better data science and curation practices, especially in related groups of disciplinary research communities

Equity and Democratization of Access to Data:

- Fostering equity by design, with attention given to: the beginning of research careers, understanding how differential access to research data impacts marginalized groups, and consideration of strategies by which to provide marginalized groups with a greater voice in governance and oversight efforts for advancing FAIROS
- Implementing the CARE Principles for Indigenous Data Governance: Collective Benefit, Authority to Control, Responsibility, Ethics
- Strategies for increasing the FAIROS capabilities of Historically Black Colleges and Universities (HBCU) and Minority Serving Institutions (MSI)

Improving Reproducibility of Scientific Results:

- Development of strategies to improve reproducibility (the functional capability to recreate results using the original dataset used in a given scientific inquiry as originally reported), and especially the more specific and testable capability of computational reproducibility (entailing the range of measures needed for an independent and neutral party to functionally recreate the computational steps which led to a particular result using exactly the same original dataset used in the original experiment).
- Improving the understanding of replicability, the capability for independent and neutral parties to recreate the results of an original experiment to a reasonable degree of accuracy (if not the exact results) using a different dataset, comprised of relevant data gathered separately from the process whereby the original researchers gathered the data they used.
- Exploring the factors that lead to generalizability (the ability of research results to be applied in other contexts), especially in terms of specific practical approaches to utilizing the FAIR guiding principles to advance generalizability.

Metrics and Assessment Mechanisms:

- Developing and testing mechanisms to assess the value of open science practices, especially quantitative measures of the worth of openness, and which provide standardized metrics for gauging how often available datasets are downloaded and how they are (re)used
- Piloting systems for testing assessment mechanisms as described above
- Analytics of what is coming out of various efforts, coordination and alignment of definitions and metrics

Sustainability of Infrastructure which Supports FAIR Principles and Open Science:

- Exploring strategies for applying records management life cycle models to research data management planning
- Assessing different cost models and frameworks for data management
- Analyzing tradeoffs in funding investments (at both federal, state, and local levels) for long term cyberinfrastructures to sustain access to data versus funding new research activities?

Additional Considerations in Developing RCN proposals:

Standard NSF review criteria of Intellectual Merit and Broader Impacts will be considered in the context of FAIROS RCN priorities, and all proposals must clearly address the standard review criteria with reference to the FAIR guiding principles and Open Science best practices.
Proposals should address the following two issues:

- Describe how the proposed Research Coordination Network will address recognized FAIR and OS coordination needs and advance research capabilities in coherent, aligned, and compelling ways within either: a) a clearly designated and significant areas of science and/or engineering, i.e. a disciplinary focus that aligns with the top level NSF disciplinary research directorates, or b) a functional space which is clearly cross-cutting across multiple areas of science and engineering. For purposes of this solicitation, a functional space is a category of essential functions in the life cycle of research activities which is undertaken broadly across disparate areas of science and engineering. Examples of such categories include (but are not limited to) the four core components of the FAIR guiding principles. Other examples may be identified by proposals, but must have similar importance and broad applicability.
- Describe how the proposal will concretely improve coordination and advancing research capabilities through FAIR principles and Open Science best practices in the specified area or areas of science and/or engineering. The proposed activities of the RCN must present compelling approaches to accomplishing the proposed goals. Articulate how the proposed goals align with the priorities of relevant NSF disciplinary research directorates, or alternatively, all areas of scientific inquiry in cross-cutting ways that respective disciplinary communities would acknowledge as important.

III. AWARD INFORMATION

Anticipated Type of Award: Continuing Grant

Estimated Number of Awards: 6 to 7

An expected 6-7 awards of up to $500K per year for three years are planned. However, the number of awards will be based on quality of proposals, availability of funds, and responsiveness to priorities of the participating directorates/divisions.

Anticipated Funding Amount: $9,000,000 to $10,500,000

Estimated program budget, number of awards, and average award size/duration are subject to the availability of funds. Each award will be up to $500K per year for three years.

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.
- NSF-funded Federally Funded Research and Development Centers (FFRDCs) should contact the appropriate program before preparing a proposal for submission

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 participate as Principal Investigator, co-Principal Investigator or other Senior Personnel in at most one FAIROS RCN proposal. Any individual whose biographical sketch is provided as part of the proposal will be considered as Senior Personnel in the proposed activity, with or without financial support from the project. The first submitted proposal (chronological order of submission) in which that individual is participating will be accepted for review, and the remainder will be returned without review. For this purpose, a multi-institution collaborative project is treated as one proposal that is considered submitted when the last component proposal is submitted. Similarly, a person who appears as a PI or Co-PI on one FAIROS RCN proposal may only appear on other FAIROS proposals submitted in response to this solicitation in a non-funded capacity or as a signatory to a letter of collaboration. The reason for the PI limit on FAIROS RCN proposals is to balance the number and quality of the submissions.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

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

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

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

Collaborative Proposals. All collaborative proposals submitted as separate submissions from multiple organizations must be submitted via Research.gov. PAPPG Chapter II.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.

The following provides additional guidance beyond that contained in the PAPPG or NSF Grants.gov Application Guide.

Project Title: The title must begin with either “Disciplinary Improvements:” or “Cross-Cutting Improvements:” to make clear which track the proposal addresses.

Project Summary (1-page limit):

The project Summary includes an overview description of the RCN, the approaches to FAIR guiding principles and Open Science being proposed, proposed outcomes, and the research communities that will be beneficially impacted. The statement on intellectual merit should describe the potential of the proposed RCN to advance knowledge. The statement on broader impacts should describe the potential of the proposed activity to benefit society and contribute to the achievement of specific, desired societal outcomes.

Project Description (15-page limit):

The Project Description should define a plan that will lead to RCN activities within the three-year timeframe of the project that will foster transformative and robust improvements based on FAIR guiding principles and Open Science practices for specified areas of science and/or engineering. Disciplinary Improvements proposals should clearly specify the relevant NSF disciplinary research directorates within the Project Description.

It is expected that each RCN will involve investigators with a variety of backgrounds that will bring synergistic strengths to the RCN. The inclusion of new researchers, post-docs, graduate students, and undergraduates is strongly encouraged. Proposals should clearly articulate well-developed mechanisms that will maintain openness, ensure access, and actively promote participation by interested parties. NSF funding predominantly supports U.S. participants. Any proposed international collaboration should articulate how it strengthens the project's activities. Participants from institutions outside the U.S. are encouraged to seek support from their respective funding organizations. NSF funds may not be used to support the expenses of international scientists and students at their home institutions.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

C. Due Dates

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

  April 12, 2022

D. Research.gov/Grants.gov Requirements

For Proposals Submitted Via Research.gov:

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

For Proposals Submitted Via Grants.gov:

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

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

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

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

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

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

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *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 other underrepresented groups in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

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

B. Review and Selection Process

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

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

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF strives to be able to tell 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.

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:

- Martin D. Halbert, CISE/OAC Science Advisor for Public Access, telephone: (703) 292-8516, email: mhalbert@nsf.gov
- Raleigh Martin, GEO/EAR Program Director, telephone: (703) 292-7199, email: ramartin@nsf.gov
- Alan Tomkins, SBE/SES Acting Division Director, telephone: (703) 292-2690, email: ATOMKINS@nsf.gov
- Peter H. McCartney, BIO/DBI Program Director, telephone: (703) 292-8470, email: pmccartn@nsf.gov
- Bogdan Mihaila, CISE/OAC & MPS/PHY Science Advisor, telephone: (703) 292-8235, email: bmihaila@nsf.gov
- Alexis Lewis, ENG/CMMI Deputy Division Director, telephone: (703) 292-2624, email: ALEWIS@nsf.gov
- Lee Zia, EHR/DGE Acting Division Director, telephone: (703) 292-5140, email: lzia@nsf.gov

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

PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended.

The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See System of Record Notices, NSF-50, "Principal Investigator/Proposal File and Associated Records," and NSF-51, "Reviewer/Proposal File and Associated Records." Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

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

Suzanne H. Plimpton
Reports Clearance Officer
Policy Office, Division of Institution and Award Support
Office of Budget, Finance, and Award Management
National Science Foundation
Alexandria, VA 22314