

NSF 24-581: Cyber-Physical Systems (CPS)

Program Solicitation

Document Information

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National Science Foundation

Directorate for Computer and Information Science and Engineering
Division of Computer and Network Systems
Division of Computing and Communication Foundations
Division of Information and Intelligent Systems
Directorate for Engineering
Division of Civil, Mechanical and Manufacturing Innovation
Division of Electrical, Communications and Cyber Systems



Department of Homeland Security, Science & Technology Directorate



U.S. Department of Transportation, Federal Highway Administration



U.S. Dept. of Agriculture



National Institute of Food and Agriculture

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

August 14, 2024 - September 03, 2024

FRONTIER Proposals

June 01, 2024 - May 31, 2025

June 1 - May 31, Annually Thereafter

SMALL and MEDIUM Proposals. Accepted anytime during the year-long annual submission window.

August 14, 2025 - August 28, 2025

August 14 - August 28, Annually Thereafter

FRONTIER Proposals



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Important Information And Revision Notes

The Cyber Physical Systems program solicitation has been revised and prospective Principal Investigators (PIs) are encouraged to read the solicitation carefully. Among the changes are the following:

- SMALL and MEDIUM CPS proposals are accepted at anytime during the year-long annual submission window. Proposers should choose the annual submission end date listed in the Due Date drop down window in Research.gov to submit to the Small or Medium project class.
 - There remains an annual submission window for FRONTIER proposals
 - The maximum limit for CPS SMALL proposals has been increased from \$500,000 to \$600,000.
 - Content expectations for the Experimentation and Evaluation section of the project description have been clarified.
 - Cyber Physical Systems (CPS) program will only accept medical / health CPS proposals in the SMALL Projects category. Proposals addressing medical / health CPS at the MEDIUM Projects level are instead encouraged to apply to the [Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science \(SCH\) program](#).
 - The Transition to Practice (TTP) option has been eliminated for a proposal submission. Projects may submit TTP supplements for on-going projects.
 - The description for Broadening Participation in Computing has been revised.
 - Added language on other programs including those in Computer and Network Systems Core (Computer Systems Research and Networking Technology and Systems).
 - The National Institutes of Health is no longer participating in this funding opportunity.
 - Added new updated language from the National Institute of Food and Agriculture (NIFA).
 - Added new language and requirements from the Federal Highway Administration (FHWA).
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Any proposal submitted in response to this solicitation should be submitted in accordance with the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) that is in effect for the relevant due date to which the proposal is being submitted. The NSF PAPPG is regularly revised and it is the responsibility of the proposer to ensure that the proposal meets the requirements specified in this solicitation and the applicable version of the PAPPG. Submitting a proposal prior to a specified deadline does not negate this requirement.

Summary Of Program Requirements

General Information

Program Title:

Cyber-Physical Systems (CPS)

Synopsis of Program:

Cyber-physical systems (CPS) are engineered systems that are built from, and depend upon, the seamless integration of computation and physical components. Advances in CPS will enable capability, adaptability, scalability, resiliency, safety, security, and usability that will expand the horizons of these critical systems. CPS technologies are transforming the way people interact with engineered systems, just as the Internet has transformed the way people interact with information. New, smart CPS drive innovation and competition in a range of application domains including agriculture, aeronautics, building design, civil infrastructure, energy, environmental quality, healthcare and personalized medicine, manufacturing, and transportation. CPS are becoming data-rich enabling new and higher degrees of automation and autonomy. Traditional ideas in CPS research are being challenged by new concepts emerging from

artificial intelligence and machine learning. The integration of artificial intelligence with CPS, especially for real-time operation, creates new research opportunities with major societal implications.

While tremendous progress has been made in advancing CPS technologies, the demand for innovation across application domains is driving the need to accelerate fundamental research to keep pace. At the same time, the CPS program seeks to open new vistas for the research community to think beyond the usual cyber-physical paradigms and structures and propose creative ideas to address the myriad challenges of today's systems as well as those of the future that have not yet been designed or fielded.

The CPS program aims to develop the core research needed to engineer these complex CPS, some of which may also require dependable, high-confidence, or provable behaviors. Core research areas of the program include control, data analytics, and machine learning including real-time learning for control, autonomy, design, Internet of Things (IoT), mixed initiatives including human-in- or human-on-the-loop, networking, privacy, real-time systems, safety, security, and verification. By abstracting from the particulars of specific systems and application domains, the CPS program seeks to reveal cross-cutting, fundamental scientific and engineering principles that underpin the integration of cyber and physical elements across all application domains. The program additionally supports the development of methods, tools, and hardware and software components based upon these cross-cutting principles, along with validation of the principles via prototypes and testbeds. This program also fosters a research community that is committed to advancing education and outreach in CPS and accelerating the transition of CPS research into the real world.

All proposals must include the following **as part of the Project Description**:

- A **Research Description** that describes the technical rationale and technical approach of the CPS research, including the challenges that drive the research problem and how the research integrates cyber and physical components. This section must also describe how the research outcomes are translational to other application domains. Specifically, it must include:
 - A subsection titled "**CPS Research Focus**" which describes the cyber-physical system attributes of the challenge problem and clearly identifies the core CPS research areas addressed in which the novel and foundational research contributions are being made. This is intended as not a list of core areas but a focused discussion with content
- An **Evaluation/Experimentation Plan** that describes how proposed concepts will be validated and outlines the metrics for success;
- A **Project Management and Collaboration Plan** that summarizes how the project team is ideally suited to realize the project goals and how the team will ensure effective collaboration;

NSF is working closely with multiple agencies across the federal government, including the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T); the U.S. Department of Transportation (DOT) Federal Highway Administration (FHWA); and the U.S. Department of Agriculture National Institute of Food and Agriculture (USDA NIFA, hereafter referred to as NIFA).

Proposals for three classes of research and education projects—differing in scope and goals—are supported through the CPS program:

- **Small** projects may request a total budget of up to \$600,000 for a period of up to 3 years. They are well suited to emerging new and innovative ideas that may have high impact on the field of CPS. **Small projects** proposals may be submitted at anytime during the year-long annual submission window.
- **Medium** projects may request a total budget ranging from \$600,001 to \$1,200,000 for a period of up to 3 years. They are well suited to multi-disciplinary projects that accomplish clear goals requiring integrated perspectives spanning the disciplines. **Medium Projects** proposals may be submitted at anytime during the year-long annual submission window.

- **Frontier** projects must address clearly identified critical CPS challenges that cannot be achieved by a set of smaller projects. Furthermore, Frontier projects should also look to push the boundaries of CPS well beyond today's systems and capabilities. Funding may be requested for a total of \$1,200,001 to \$7,000,000 for a period of 4 to 5 years. **Note that the Frontier projects have a specific deadline.**

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.

- David Corman, telephone: (703) 292-8754, email: dcorman@nsf.gov
- Vishal Sharma, Program Director, CISE/CNS, telephone: (703) 292-8950, email: vsharma@nsf.gov
- Ralph Wachter, Program Director, CISE/CNS, telephone: (703) 292-8950, email: rwachter@nsf.gov
- Pavithra Prabhakar, Program Director CISE/CCF, telephone: (703) 292-2585, email: pprabhak@nsf.gov
- Phillip A. Regalia, Program Director, CISE/CCF, telephone: (703) 292-2981, email: pregalia@nsf.gov
- Sylvia J. Spengler, telephone: (703) 292-7347, email: sspengle@nsf.gov
- Eyad Abed, Program Director ENG/ECCS, telephone: (703) 292-2303, email: eabed@nsf.gov
- Aranya Chakraborty, Program Director, ENG/ECCS, telephone: (703) 292-8113, email: achakrab@nsf.gov
- Anthony Kuh, Program Director, ENG/ECCS, telephone: (703) 292-4714, email: akuh@nsf.gov
- Bruce Kramer, Program Director, ENG/CMMI, telephone: (703) 292-5348, email: bkramer@nsf.gov
- Alexandra Medina-Borja, Program Director, ENG/CMMI, telephone: (703) 292-7557, email: amedinab@nsf.gov
- Siqian Shen, Program Director, ENG/CMMI, telephone: (703) 292-7048, email: siqshen@nsf.gov
- David Kuehn, Program Manager, DOT/FHWA, telephone: (202) 493-3414, email: david.kuehn@dot.gov
- Steven Thomson, National Program Leader, USDA/NIFA, telephone: (202) 603-1053, email: Steven.J.Thomson@usda.gov
- Benjamin Salazar, Cyber Security Subject Matter Expert, DHS S&T, telephone: (202) 254-5734, email: benjamin.salazar@hq.dhs.gov

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

- 10.310 --- USDA-NIFA Agriculture and Food Research Initiative
- 20.200 --- Highway Research and Development Program
- 47.041 --- Engineering
- 47.070 --- Computer and Information Science and Engineering
- 97.108 --- Department of Homeland Security, Science & Technology Directorate

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant or Cooperative Agreement

Estimated Number of Awards: 20 to 31

Approximately 15 Small projects, 15 Medium projects, and 1 Frontier project subject to receipt of sufficient meritorious proposals and pending availability of funds.

Anticipated Funding Amount: \$30,070,000

in FY 2024, subject to receipt of sufficient meritorious proposals and pending availability of funds.

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

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

Who May Serve as PI:

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: 2

For the CPS program, during any continuous 12-month period, an individual may not participate as PI, co-PI, or Senior/Key Personnel in more than two proposals across all size classes. This limit will be applied beginning with this solicitation and continue to apply to future versions of this solicitation, unless noted otherwise.

These eligibility constraints will be strictly enforced in order to treat everyone fairly and consistently. Any proposal that exceeds this limit at the time of submission for any PI, co-PI, or Senior/Key Personnel will be returned without review. **No exceptions will be made.** Proposals that are withdrawn prior to commencement of merit review, or those that are returned without review by NSF, will not count against this proposal limit. Proposers are strongly encouraged to verify the dates of prior submissions to the CPS program for all personnel on their teams to avoid their proposals being deemed non-compliant.

Additionally, proposals submitted in response to this solicitation may not duplicate or be substantially similar to other proposals concurrently under consideration by other NSF, DHS, DOT, or NIFA programs. Duplicate or substantially similar proposals will be returned without review, including those substantially similar to previously declined proposals.

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:**

For awards made by NSF, Proposal & Award Policy & Procedures (PAPPG) guidelines apply. Proposals selected for funding by DHS and/or DOT will be awarded by NSF using funds transferred from DHS and/or DOT, respectively, and so they will follow NSF's PAPPG.

For awards made by NIFA: *Indirect Cost (IDC) is not to exceed 30 percent of Total Federal Funds Awarded (TFFA) of the recipient.*

[7 U.S.C. § 3310](#) limits IDC for the overall award to 30 percent of Total Federal Funds Awarded (TFFA) under a research, education, or extension grant. The maximum IDC rate allowed under the award is determined by calculating the amount of IDC using:

1. the sum of an institution's negotiated indirect cost rate and the indirect cost rate charged by sub-awardees, if any; or
2. 30 percent of TFFA.

The maximum allowable IDC rate under the award, including the IDC charged by the sub-awardee(s), if any, is the lesser of the two rates.

If the result of number 1) above is the lesser of the two rates, the grant recipient is allowed to charge the negotiated IDC rate on the prime award and the sub-award(s), if any. Any sub-awards would be subject to the sub-awardee's negotiated IDC rate. The sub-awardee may charge its negotiated IDC rate on its portion of the award, provided the sum of the IDC rate charged under the award by the prime awardee and the sub-awardee(s) does not exceed 30 percent of the TFFA.

If the result of number 2) above is the lesser of the two rates, then the maximum IDC rate allowed for the overall award, including any sub-award(s), is limited to 30 percent of the TFFA. That is, the IDC of the prime awardee plus the sum of the IDC charged by the sub-awardee(s), if any, may not exceed 30 percent of the TFFA.

In the event of an award, the prime awardee is responsible for ensuring the maximum indirect cost allowed for the award is not exceeded when combining IDC for the Federal portion (i.e., prime and sub-awardee(s)) and any applicable cost-sharing (see 7 CFR 3430.52(b)). Amounts exceeding the maximum allowable IDC is considered unallowable. See sections 408 and 410 of 2 CFR 200.

- **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. submitting organization's local time):

August 14, 2024 - September 03, 2024

FRONTIER Proposals

June 01, 2024 - May 31, 2025

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FRONTIER Proposals

Proposal Review Information Criteria

Merit Review Criteria:

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

Award Administration Information

Award Conditions:

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

Reporting Requirements:

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

I. Introduction

Cyber-physical Systems (CPS) are engineered systems that are built from, and depend upon, the seamless integration of computation and physical components. CPS tightly integrate computing devices, actuation and control, networking infrastructure, and sensing of the physical world. The system may include human interaction with or without human aided control. CPS may also include multiple integrated system components operating at wide varieties of spatial and temporal time scales. They can be characterized by architectures that may include distributed or centralized computing, multi-level hierarchical control and coordination of physical and organizational processes.

Advances in CPS should enable capability, adaptability, scalability, resilience, safety, security, and usability far beyond what is available in the simple embedded systems of today. CPS technology will transform the way people interact with engineered systems—just as the Internet has transformed the way people interact with information. CPS are driving innovation and competition in a range of sectors, including agriculture, aeronautics, building design, civil infrastructure, energy, environmental quality, healthcare and personalized medicine, and transportation.

CPS may be very large systems such as airplanes and automobiles. They may be an integration of diverse systems at city-scale or larger such as a transportation management system, a system for controlling urban air transportation, or the smart grid. Alternatively, they may be smaller-scale systems comprising ensembles of components such as sensors and actuators, and processors. The advent of IoT allows CPS components to communicate with other devices through cloud-

based infrastructure, and to interact with (potentially) safety-critical systems, posing new research challenges in safety, security, and dependability.

While tremendous progress has been made in advancing CPS technologies, the demand for innovation across application domains continues to grow and is driving the need to accelerate fundamental research to keep pace. CPS are becoming data-rich enabling new and higher degrees of automation and autonomy. Traditional ideas in CPS research are being challenged by new concepts emerging from artificial intelligence and machine learning. New methods to combine data-driven machine learning and model-based learning for decision and real-time control of cyber-physical systems are encouraged. Similarly, what do high confidence and verification mean in the context of autonomous systems that learn from their experiences? How does one reconcile the concepts of machine learning and data-driven modeling with approaches used in model-based design and formal methods? The CPS program seeks to inspire the research community to explore these and other new vistas. Researchers are encouraged to go beyond the current CPS systems and structures, to propose creative ideas that address these challenges.

Other Funding Opportunities: PIs are encouraged to consider other relevant funding opportunities. In particular, for FY 2024, proposals for cyber manufacturing should be submitted to the NSF cross-directorate [Future Manufacturing \(FM\) program solicitation](#) since the cyber manufacturing theme of the FM solicitation strongly aligns with the CPS research community. FM program directors can be consulted for further clarification.

Proposers should also consider the programs listed at <https://www.nsf.gov/eng/robotics.jsp> for proposals that will enable transformative new functionality or substantially enhance existing functionality to a robot or a class of robots but do not contribute to a broader set of CPS systems beyond robotics. These proposals are not in scope for the CPS program.

In addition, prospective researchers should note the recently published DCL NSF **24-017** (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf24017) which states that the CPS program will only accept CPS medical / health proposals in the **Small Projects** category. Proposals addressing medical / health CPS at the **Medium Projects** level are instead strongly encouraged to be submitted to the [Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science \(SCH\)](#) program.

Also, proposers may wish to consider the CISE core programs which are listed in <https://new.nsf.gov/funding/opportunities/computer-information-science-engineering-core> for proposals that primarily focus on the networking aspects or computer systems aspects of a cyber physical system but do not consider the integrative aspects within an overall CPS research context. The CPS program focus is on those areas of research that tightly integrate computing, networking, control, sensing of the physical world, and the feedback loops that result from that integration.

II. Program Description

The CPS program aims to develop the core research needed to engineer these complex CPS, some of which may also require dependable, high-confidence, or provable behaviors.

Core research areas of the program include control, data analytics, and machine learning including real-time learning for control, autonomy, design, IoT, mixed initiatives including human-in- or human-on-the-loop, networking, privacy, real-time systems, safety, security, and verification. By abstracting from the particulars of specific embodiments and applications, the CPS program seeks to reveal cross-cutting fundamental scientific and engineering principles that underpin the integration of cyber and physical elements across all domains. The program additionally supports the development of methods, tools, and hardware and software components based upon these cross-cutting principles, along with validation of the principles via prototypes and testbeds. This program also fosters a research community that is committed to advancing education and outreach in CPS and to transitioning CPS research into the real world.

To achieve these aims, the program supports:

- Cross-disciplinary, collaborative research that will lead to new fundamental insights;
- Projects that take a coordinated approach, balancing theory with experimentation;

- New perspectives on existing systems yielding breakthroughs as well as revolutionary new system concepts opening up new CPS research horizons;
- Projects that address important basic research needs for synergistic collaboration with mission agencies as described in Section II.D below; and
- Promising innovations that have the potential for accelerated maturation, demonstration, and transition to practice.

The program also supports effective use of testbeds that spur innovations and accelerate research by providing scalable and open environments for experimentation. Researchers should consider using existing testbeds that include virtual simulation environments for early experimentation, higher fidelity hardware-in-the-loop environments, and live platforms. The program strongly encourages proposers to describe how their research may take advantage of such testbeds as a means for experimental validation and maturation in realistic environments. In addition, proposals may explore creation of testbeds for external use. In that case, the testbed concepts must also show their value through integration with research explorations, and the proposal must address how the proposers plan to establish a constituency of users that reaches beyond the developing organization(s). A separate review criterion has been added for proposals whose primary research outcome is creation/construction of a testbed. Simply stating that a testbed will be useful for other researchers does not satisfy this criterion.

NSF is working closely with multiple agencies across the federal government, including DHS S&T; DOT FHWA; and NIFA. Key goals are to identify basic CPS research directions that are common across multiple application domains, including those with high potential for later transition to practice. The proposer may also wish to consider well-justified international collaborations that add significant value and leverage to the proposed research and/or education activities.

In addition to the requirements outlined in the PAPPG, all proposals must include the following in the Project Descriptions:

- A **Research Description** that describes the technical rationale and technical approach of the CPS research, including the challenges that drive the research problem and how the research integrates cyber and physical components. This section must also describe how the research outcomes are translational to other application domains. Specifically, it must include:
 - A subsection titled "**CPS Research Focus**" which describes the cyber-physical system attributes of the challenge problem and clearly identifies the core CPS research areas addressed in which the novel and foundational research contributions are being made. This is intended as not a list of core areas but a focused discussion with content
- An **Evaluation/Experimentation Plan** that describes how proposed concepts will be validated and the metrics for success; This section should comprehensively address activities in experimentation including use of full and sub-scale prototypes, and simulation, to demonstrate the research concepts. The section should provide details on specific experiments that will be conducted. This should be considered as an important section whereby the PI demonstrates their insights into the proposed research by clearly describing how the research hypotheses will be confirmed and demonstrated through realistic in-context experiments.
- A **Project Management and Collaboration Plan** that summarizes how the project team is ideally suited to realize the project goals and how the team will assure effective collaboration.

II.A Research Areas and Challenges

This solicitation seeks to address foundational issues that are central across core CPS dimensions including science, engineering, and technology as well as application domains. Research topics that span the lifecycle of CPS are encouraged, including design, synthesis, integration, and real-time operation and performance, including integration with humans. CPS projects are frequently motivated by challenge problems in **application domains**, including but not limited to: aeronautics, agriculture, automotive, manufacturing and transportation systems, energy, and health and wellness, including medical devices. Researchers must focus on one or more core CPS **research area(s)**, including: control, data analytics, and machine learning including real-time learning for control, autonomy, design, IoT, mixed initiatives including

human-in- or on-the loop, networking, privacy, real-time systems, safety, security, and verification. Proposals focused on cyber manufacturing should be submitted to the cyber manufacturing theme of the NSF Future Manufacturing program solicitation which strongly aligns with the CPS research community.


It is essential that proposals not simply describe the development of a CPS, but also emphasize the areas of CPS-focused research contributing to this development in which novel and foundational research contributions are being made. Systems of interest will be at the same time transformative and translational, demonstrating inventive new ideas and multi-disciplinary technical approaches to address societal challenges. Challenge applications can range from highly focused inventions enabled by CPS technology to revolutionary approaches for next-generation infrastructures. The program strongly encourages projects that address concerns shared by other federal agencies such as agriculture, transportation, health, energy, and national security.

II.B Classes of Projects

Proposals for the following three classes of research and education projects, that differ in scope and goals, will be accepted pursuant to this solicitation. The proposer is expected to describe in the Project Description how the project fits within the selected category in terms of its scope and goals

Small Projects: Small projects may be requested with total budgets of up to \$600,000 for periods of up to three years. They are well suited to exploration of emerging and innovative ideas with substantial potential for impact

Medium Projects: Medium projects may be requested with total budgets ranging from \$600,001 to \$1,200,000 for periods of up to three years. They are well suited to multi-disciplinary efforts that accomplish clear goals requiring an integrated perspective spanning the disciplines. Proposals for medium projects are required to clearly describe why the research to be undertaken requires this multi-disciplinary approach. The research plan must include validation of theory through empirical demonstration in a prototype or testbed.

Frontier Projects: Frontier projects may be requested with total budgets ranging from \$1,200,001 to \$7,000,000 for periods of four to five years. The proposal must clearly identify and address critical CPS science, engineering, and/or technological challenges that cannot be achieved by a set of smaller projects. Furthermore, Frontier projects should also look to push the boundaries of CPS well beyond today's systems and capabilities. The goal, scale, and degree of integration of the proposed research must clearly require this major investment. The research plan must include validation of theory through empirical demonstration in a prototype or testbed. There must be a plan for sharing results, including testbeds and artifacts, with the CPS research community, including through the [CPS Virtual Organization \(CPS-VO\)](#) . **Frontier projects are expected to go beyond simply sharing PI meeting artifacts (such as slides) via the CPS-VO, and to have concrete plans for sharing results, testbeds, and/or artifacts.** In addition, Frontier proposals must describe education approaches that prepare students for careers in CPS practice and research, and how these education goals extend beyond the participating organization(s). Frontier projects must include actionable components that seek to increase participation of underrepresented groups in computing. These efforts to broaden participation can be undertaken by an individual PI or in collaboration with others, working within proposing organization(s), professional organizations, and/or community groups. Additional information on broadening participation efforts can be found below.

Mission agency partners for CPS do not typically consider funding Frontier projects. Proposals at the Frontier scale must have a clear NSF target with significant research focus in the CPS core areas and in particular those most directly relevant to CISE.

II.C Broadening Participation in Computing and Engineering

NSF has long been committed to Broadening Participation in Computing (BPC) and Engineering (BPE). This commitment means addressing the underrepresentation of many groups in CISE relative to their participation in post-secondary education (<https://nces.nsf.gov/pubs/nsb20223/data>). Broadening participation will require a range of measures, including institutional programs and activities as well as culture changes across colleges, departments, classes, and research groups.

The CPS program is committed to enhancing the community's awareness of and overcoming barriers to BPC and BPE, and to providing information and resources to PIs so that they can develop interest, skills, and activities in support of BPC/BPE at all levels of the CPS community (K-12, undergraduate, graduate, and postgraduate). Specifically:

- **For Frontier CPS proposals, a meaningful BPC plan is required as a one- to three-page Supplementary Document and will be evaluated during merit review.**
- Each Medium project **must, by the time of award**, have in place an approved BPC/BPE plan. The managing program director will work with each PI team following merit review and prior to making an award to ensure that plans are meaningful and include concrete metrics for success. The CPS program will also provide opportunities for PIs to share BPC/BPE experiences and innovations through program PI meetings. **CISE PIs of Medium proposals are therefore strongly encouraged to consider this eventual requirement as they develop their proposals, and to include one- to three-page descriptions of their planned BPC activities under Supplementary Documents in their submissions.** Feedback will be provided on such plans. Similarly, **ENG PIs are strongly encouraged to include one- to three-page descriptions of their planned BPE activities under Supplementary Documents in their submissions.**
- PIs of Small proposals are **strongly encouraged** to include plans, or begin preparing to include plans, for broadening participation activities in their proposals.

A meaningful BPC / BPE plan can answer positively to the following questions:

Goal and Context: Does the plan describe a goal and the data from your institution(s) or local community that justifies that goal?


Intended population(s): Does the plan identify the characteristics of participants, including school level?

Strategy: Does the plan describe activities that address the stated goal(s) and intended population(s)?

Measurement: Is there a plan to measure the outcome(s) of the activities?

PI Engagement: Is there a clear role for each PI and co-PI? Does the plan describe how the PI is prepared (or will prepare or collaborate) to do the proposed work?

All PIs and co-PIs who are from computing organizations (as described above) are expected to participate in BPC activities in a manner aligned with their personal contexts, interests, and skills. More information regarding the BPC effort can be found at <https://www.nsf.gov/cise/bpc>.

For CISE funded projects, we encourage the use of the resources available at the NSF-funded BPCnet Resource Portal (<https://bpcnet.org> ) . BPCnet provides BPC project and departmental plan templates, suggested activities, and opportunities for consultant services, and publicly available data to support PIs and Departments in creating their BPC Plans. *CISE encourages PIs to leverage departmental plans verified by BPCnet to coordinate efforts within their institution.* BPC plans must include roles for all PIs and co-PIs and be included as a Supplementary Document, following the guidelines as described in the Proposal Preparation Instructions.

II.D Sponsoring Agency Mission-Specific Research

NSF welcomes proposals addressing any of the fundamental CPS research target areas described in Section II.A above. In addition, through this solicitation, multiple federal agencies are interested in addressing CPS basic research needs of relevance to their missions, along with opportunities for accelerated transition to practice. The specific interests of each participating agency are described below. Please note that the mission agencies (DHS, DOT, and NIFA) look to this basic research program for new and creative project ideas that would not be typically submitted to their own agency solicitations.

All proposals, whether targeted for a mission agency or NSF will be reviewed by NSF panels adhering to standard review criteria for intellectual merit and broader impacts, as well as the additional solicitation specific review criteria outlined in this solicitation.

All sponsor-targeted proposals:

Proposals that are targeting a specific agency sponsorship should indicate so just above the keywords in the Project Summary, e.g., "Requested funding agency:" followed by that agency's abbreviated name, i.e., "NSF," "DHS," "DOT," or "NIFA," but only if the proposers have previously communicated with a Program Officer from that agency and received permission or instruction to do so. Those not so designated will be considered for funding by all the joint sponsoring agencies. Also, please note that unless otherwise specified, agencies listed below do not accept Frontier proposals.

II.D.1 Department of Homeland Security (DHS) Science and Technology (S&T) Directorate Technology Centers Division (TCD)

Within DHS S&T, TCD encourages research and development in cybersecurity to enhance the resilience of critical information infrastructure. TCD seeks to develop and transition new technologies, tools, and techniques to secure systems, networks, and infrastructure. Its research interests include foundational research in cybersecurity technologies with applicability in the 3-5 year time horizon.

TCD has particular interests in security technologies relevant to CPS and IoT. The federal Networking and Information Technology Research and Development (NITRD) CPS Senior Steering Group's CPS Vision Statement notes CPS research gaps and identifies drivers and technologies for CPS ^[1]. CPS related to industrial control systems are considered especially relevant for TCD. Relevant technologies include cybersecurity approaches for guarding against malicious attacks on CPS as well as diagnostics and prognostics that aim to identify, predict, and prevent or recover from faults. TCD is interested in CPS technologies that address privacy concerns and manage the use of sensitive information while protecting individual privacy. Validation, verification, and certification that speed up design cycles while ensuring high confidence in system safety and functionality also align well with TCD interests.

More information about DHS S&T TCD can be found on the following website: <https://www.dhs.gov/science-and-technology/Technology-Centers>.

^[1]https://www.nitrd.gov/nitrdgroups/images/6/6a/Cyber_Physical_Systems_%28CPS%29_Vision_Statement.pdf

II.D.2 U.S. Department of Transportation Federal Highway Administration

FHWA has interest in research that provides improved safety and mobility in the development and operation of the highway system. In particular, FHWA is seeking to work with NSF on fundamental CPS advances for important public benefits that can scale across transportation systems and modes, and into other domains.

Public benefits of interest to FHWA and relevant to CPS are applications that increase the safety and mobility of vulnerable road users. Research on cooperation and automation for vehicles is transitioning into pilot deployments with potential benefits from crash avoidance and improved mobility. At the same time, conflicts between vehicles and vulnerable road users are growing. (Information on vulnerable road users is located at <https://highways.dot.gov/safety/hsip/vru-safety-assessment-guidance>.) Applications should focus on fundamental advances that provide CPS solutions for vulnerable road users. In particular, foundational research on CPS could benefit travelers dramatically in higher risk environments, an example being where there is limited separation from higher speed vehicles such as on roadways in rural areas or in underdeveloped areas. Foundational research on CPS also holds potential large benefits for vulnerable road users with physical or cognitive issues that affect their safety and mobility.

Approaches should consider the open nature of the transportation system, legacy components and processes, and the distributed nature of asset ownership and operations. At the same time, CPS for highway transportation must be scalable, reliable, adaptable, and secure while also being cost-effective.

FHWA and other agencies within the U.S. DOT are focused on measuring impacts across programs including the impacts of innovative technologies on how government agencies operate. Accordingly, FHWA encourages CPS research that can quantify how these new technologies meet public needs and can measure the impact of new technology systems on public health, safety, mobility, economic performance, equity, or on the environment.

CPS involves solving complex scientific, engineering, and social or organizational issues and accordingly, require expertise from multiple disciplines.

FHWA encourages leveraging existing tools, test-beds, and real-world data. For example, see <https://www.its.dot.gov/data/> and <https://www.transportation.gov/data/secure> for federal data resources. State DOTs and local agencies also collect data available for research purposes.

For proposals that are directed to FHWA and are selected for funding, FHWA requires a minimum 20 percent funding match for the FHWA portion of funding. The funding match may be in kind based on the value of equipment, materials, data, or labor. Additional information will be provided by FHWA, and the cost match will be reported to and managed by the FHWA.

II.D.3 U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA)

USDA/NIFA is pursuing an aggressive research agenda to meet the "grand challenges" for agriculture and society and has embarked on a multi-horizon research agenda to address these challenges. Foundational and applied research in CPS are important elements of this agenda to ensure that America's agricultural system is equitable, resilient, and prosperous; promote methods to combat climate change, promote climate adaptation, expand opportunities for economic development and quality of life in rural and tribal communities, and provide all Americans safe and nutritious food as outlined in the USDA Strategic Goals [USDA Strategic Plan Fiscal Years 2022-2026](#).

USDA emphasizes automation and associated development of decision tools for plant and animal production and protection; as it applies to fruit, vegetable, and row crop production, as well as precision livestock farming, processing, and aquaculture. Recent foci have centered on development of smart communities, data systems and algorithms for improving access to nutritious food and mitigating the effect of cascading hazards on rural and underserved communities.

For this solicitation, NIFA anticipates a funding amount of \$4,000,000 in FY 2024. NIFA encourages projects that advance science and technology applied to Smart & Connected Communities (both rural and urban) and to real-time agricultural data analytics and control. While other applications of CPS in agriculture might be considered, strong preference will be given to these two topics. Today's traditional CPS notions of control, sensing, and real-time behavior may require new perspectives on modeling, performance prediction, and control to account for the spatial, temporal, and environmental considerations fundamental to agriculture. NIFA is interested in foundational technologies that can be developed and demonstrated in the context of agricultural challenges, and then rapidly converged into capabilities that will transition into practice.

Smart & Connected Communities (S&CC):

The "sharing economy" has explored and built new business models, new marketing opportunities, and new options for consumers. Much of that sharing has been facilitated by location-aware, take-anywhere technology, such as the smart phone. Now, by overlaying that expanded level of human connectivity with networks of connected devices and infrastructure, not just mobile phones, we create new possibilities to enhance the livability and sustainability of communities in both urban and rural settings. While the same basic needs for environmental, social, and economic sustainability exist for both urban and rural communities, solutions to meet those needs can vary quite dramatically.

Reduced population densities, fewer socio-economic resources, and a greater percentage of non-point source pollution means that metrics for rural sustainability will look much different than their urban counterparts. And yet, food security, clean air and water, mobility, quality jobs, disaster preparedness and mitigation, and good healthcare are desirable and important aspects of livability regardless of where one resides.

CPS technology challenges that are directly relevant to NIFA goals for S&CC include:

- Robust and intelligent control systems and sensors to help monitor, optimize, and manage an entire controlled-environment urban agriculture facility including physical environment (lighting, temperature, water, and fertilizers);
- Model-based development and control integrating horticultural knowledge of pests, cultivars tailored to controlled environments, and companion production;
- Integration of renewable energy sources such as solar technology and improved high-efficiency lighting based upon physics and photonics advances;
- Efforts to both mitigate the effects of cascading hazards such as wildfires, high winds, and earthquakes on underserved populations and to provide autonomy for wildfire spread prediction;
- New connectivity paradigms and applications for integrated devices, communications, control systems, and data systems in dispersed rural settings that enable overlain software to bring quality-of-life improvements to citizens for benefits such as education, health, improved access to healthy food choices, economic development, mobility, or environmental quality.

Real-Time Agricultural Data Analytics and Control:

Addressing many of the agricultural grand challenges demands new advances in the integration of CPS (including sensors, communication systems, control systems, and robotics) with real-time information and analytic engines tightly coupled with agriculture and food systems. This integration forms a large-scale CPS that enables data collected throughout the supply chain to be analyzed and used for control and decision-making in other stages of production, processing, distribution, storage, and consumption. Much agricultural data is currently single-use and static. For example, current technology allows for the collection and use of many different types of agricultural data, from soil moisture and chemistry, meteorology and climate, crop and market conditions, and consumer nutrition and preference, to gene sequences and ecological variables. However, these data are often used only at the time and place of collection, and necessarily require a human-in-the-loop. Datasets in many of these fields need to become dynamic (regularly updated, or real-time in some cases) and actively engage in control operations and decision-making in other segments of the supply chain. These datasets are massive and vary in scale and precision, which presents challenges for accessibility, analytics, interoperability, and persistence. Nonetheless, they have potential to significantly impact environmental quality, product traceability, agricultural input use, regional pest management, and system-wide sustainability.

NIFA is interested in new approaches for analytics that can extract actionable information from these datasets and provide real-time control of agricultural CPS. While application of these massive datasets and real-time analytics in controlling CPS may be difficult in many domains, the multiple time scales of agriculture offer an opportunity to reorient our thinking of real-time and may be highly compatible with the processing and data delivery timelines for these massive datasets. Proposals should briefly present metrics and methodology for evaluating the metrics to show the impact of the research. Integrative robotic systems can provide labor-assistive and semi- or fully autonomous support for field and process operations. Applications are encouraged that utilize robotic systems within the CPS framework.

Given the integrative and multi- or trans-disciplinary nature of agricultural sciences, NIFA expects to fund Medium projects. In addition, Frontier projects that demonstrate an agriculture-related critical challenge would also be considered by NIFA, but funding will be limited to the lower end of the Frontier range

II.E Transition to Practice

While the CPS program has eliminated the TTP option at proposal submission, the CPS program encourages those projects that have made and demonstrated significant progress during their initial period of performance to submit high-impact supplement requests for very specific activities that may lead to adoption of the research by clearly identified partners

II.F Cloud Computing Resources

Proposals may request cloud computing resources to use public clouds such as Amazon Web Services (AWS), Google Cloud Platform (GCP), IBM Cloud, and Microsoft Azure. Cloud computing resources described in proposals may be

obtained through an external cloud access entity ([OCI](#)) supported by [CloudBank](#) <https://www.cloudbank.org/>

Proposers should describe this request in a Supplementary Document including: (a) which public cloud providers will be used; (b) anticipated annual and total costs for accessing the desired cloud computing resources, based on pricing currently available from the public cloud computing providers; and (c) a technical description of, and justification for, the requested cloud computing resources. The proposal budget should not include the costs for accessing public cloud computing resources via CloudBank; instead this cost estimate should be discussed in a supplementary document as discussed below. Also, the total cost of the project, including the cloud computing resource request, may not exceed the budget limit described in this solicitation.

For example, a proposal submitted to the Small size class, has a total proposal budget limit of \$600,000. *If a PI wishes to request \$20,000 in cloud computing resources through CloudBank, then his/her proposal should request, as part of the proposal budget, no more than \$580,000. The remaining \$20,000 for cloud computing resources should be specified in the Supplementary Document. If a proposal is a collaborative project with two PIs from two different organizations, then each PI may request cloud computing resources separately through independent Supplementary Documents as long as the total budget (on the budget pages plus in the Supplementary Documents) does not exceed \$600,000.*

If incorporating this request into the proposal, a proposer should include "CloudAccess" (one word without spaces) as a keyword on the Project Summary page, at the end of the Overview section (before the section on Intellectual Merit).

See Section V.A. Proposal Preparation Instructions, Supplementary Documents, for more information on how to describe the cloud computing resource request as well as the associated budget.

II.G CPS PI Meetings

The CPS program hosts required, two-day PI meetings every year. For all awards, one or more designated CPS project representative(s) (PI/co-PI/senior personnel or NSF-approved replacement) **must attend the entire program on both days of every annual CPS PI meeting** held throughout the duration of a given CPS grant, **including during no-cost extensions. Exceptions due to academic-year teaching constraints will be considered in extreme circumstances.** For collaborative projects, PIs (or a NSF-approved replacement) from each collaborating organization of a given project are expected to participate. Graduate students are also encouraged to attend if space is available. The meeting also includes representatives from the research community, government, and industry.

For the PI meeting, PIs or other project representatives **must** also provide a poster for the poster session and a short video describing their project(s) that will be made available on the [CPS Virtual Organization \(CPS-VO\)](#).

The CPS program sponsors the CPS-VO, a broad community of interest for CPS researchers, developers, and educators. Projects are encouraged to use the CPS-VO to coordinate activities and disseminate artifacts along with research results.

III. Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant or Cooperative Agreement

Estimated Number of Awards: 20 to 31

Subject to receipt of sufficient meritorious proposals and pending availability of funds.

Anticipated Funding Amount: \$30,070,000 in FY 2024, subject to receipt of sufficient meritorious proposals and pending availability of funds.

Projects supported by DHS, and/or DOT will be awarded by NSF using funds transferred from DHS, and/or DOT, respectively.

All awards made under this solicitation by NIFA will be as standard grants. A standard grant is an award instrument by which the agency agrees to support a specified level of effort for a predetermined project period without the announced intention of providing additional support at a future date. NIFA anticipates funding amount of \$4,000,000 in FY2024

Upon conclusion of the review process, meritorious research proposals may be recommended for funding by one of the participating federal agencies, determined at the option of the agencies, not the proposer. Subsequent grant administration procedures will be in accordance with the individual policies of the awarding agency and may require submission of a revised proposal that meets the administrative requirements of the funding agency. (See section VI.B for additional information on agency-specific processes.)

IV. Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

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

Who May Serve as PI:

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: 2

For the CPS program, during any continuous 12-month period, an individual may not participate as PI, co-PI, or Senior/Key Personnel in more than two proposals across all size classes. This limit will be applied beginning with this solicitation and continue to apply to future versions of this solicitation, unless noted otherwise.

These eligibility constraints will be strictly enforced in order to treat everyone fairly and consistently. Any proposal that exceeds this limit at the time of submission for any PI, co-PI, or Senior/Key Personnel will be returned without review. **No exceptions will be made.** Proposals that are withdrawn prior to commencement of merit review, or those that are returned without review by NSF, will not count against this proposal limit. Proposers are strongly encouraged to verify the dates of prior submissions to the CPS program for all personnel on their teams to avoid their proposals being deemed non-compliant.

Additionally, proposals submitted in response to this solicitation may not duplicate or be substantially similar to other proposals concurrently under consideration by other NSF, DHS, DOT, or NIFA programs. Duplicate or substantially similar proposals will be returned without review, including those substantially similar to previously declined proposals.

Additional Eligibility Info:

The CPS program encourages proposals from groups eligible to compete as [Research in Undergraduate Institutions \(RUI\)](#) or Grants Opportunities for Academic Liaison with Industry (GOALI; see [PAPPG, Chapter II.F.5](#)) under the CPS program deadlines.

In addition, the organization limit above does not preclude eligible organizations from submitting proposals that involve participation of for-profit organizations as subawardees, unfunded collaborators, contributors, or GOALI partners.

For proposals that designate NIFA as the requested funding agency, in accordance with the guidelines outlined in the Proposal Preparation Instructions, eligible proposers include: (1) State agricultural experiment stations; (2) Colleges and universities (including junior colleges offering associate degrees or higher); (3) University research foundations; (4) Other research institutions and organizations; (5) Federal agencies; (6) National laboratories; (7) Private organizations or corporations; (8) Individuals who are U.S. citizens, nationals, or permanent residents; and (9) any group consisting of two or more entities identified in (1) through (8).

Eligible organizations do not include foreign and international organizations.

The eligibility criteria for all other proposals, including those targeting a specific agency other than NIFA for sponsorship, are as listed under "Who May Submit Proposals" above. Proposals that do not meet these criteria, and do not explicitly designate NIFA as the requested funding agency in the Project Summary, will be returned without review.

V. Proposal Preparation And Submission Instructions

A. Proposal Preparation Instructions

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

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

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

Collaborative Proposals. All collaborative proposals submitted as separate submissions from multiple organizations must be submitted via Research.gov. PAPPG Chapter II.E.3 provides additional information on collaborative proposals.

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

The following information supplements the guidelines and requirements in the NSF PAPPG and NSF Grants.gov Application Guide:

Proposal Titles: After any PAPPG specific title requirements, if applicable, proposal titles must indicate the CPS program, followed by a colon, then the project class, followed by a colon, then the title of the project. For example, a CPS Frontier proposal title would be **CPS: Frontier: Title**.

Project Summary:

At the beginning of the Overview, enter the title of the CPS project, the name of the lead PI, and the name of the lead organization. Provide an overview description of the CPS project. This description should explicitly identify the core CPS research areas addressed by the proposal. **If submitting a proposal for a specific agency, this must be indicated just above the keywords in the Project Summary, e.g., "Requested funding agency:" followed by that agency's abbreviated name, i.e., "NSF", "DHS", "DOT", or "NIFA".** If no agency is designated, the proposal will be considered for funding by all of the joint sponsoring agencies. If proposers choose to target a specific agency, they must first communicate with a Program Officer from that agency and receive permission or instruction to do so.

At the end of the Project Summary, all proposals must include a **prioritized list of 2-4 keywords maximum** separated by ",". **The keywords must be drawn from the lists below and best characterize the project from the perspectives of the core CPS research area(s) and application domain(s).** CPS proposals are grouped into "review panels" of related proposals for merit review and discussion. Panelists are selected for their expertise in the panel topic area. The suggested topic areas span the core CPS areas of research and application spaces and indicate the areas of panelist expertise that are most important for understanding the innovative aspects of the proposal. In addition, the keyword list should include at least one element that is not "other - please specify". **Proposals that do not include keywords will be returned without review.**

Core Research Areas:

- Autonomy
- Control
- CPS System Architecture
- Data analytics and machine learning including real-time learning for control
- Design of CPS
- Internet of things (IoT)
- Mixed initiatives including human-in- or on-the-loop
- Networking
- Security and privacy
- Real-time systems
- Safety
- Verification.
- Other (Please specify)

Core Application Domains:

- Agriculture
- Civil and Mechanical including infrastructure
- Energy
- Manufacturing
- Medical including Health and Wellness
- Transportation including air and ground
- Other (Please specify)

For example:

- Keywords: Data analytics and machine learning, Energy
- Keywords: Autonomy, Control
- Keywords: Agriculture, Autonomy, Internet of Things (IoT)

Proposers requesting cloud resources through CloudBank.org should include "CloudAccess" (one word without space) at the end of the Overview section (before the section on Intellectual Merit) of the Project Summary page if incorporating this request into the proposal.

Note: The total budget of the project, including any cloud computing resource request from CloudBank.org, may not exceed the budget limits for the respective project classes described in this solicitation. The total cost of the cloud computing resources requested from Cloudbank.org should not be included in the NSF budget, and should be specified only in the associated supplementary document (see below for additional instructions).

Project Description:

Describe the research and education activities to be undertaken in up to 15 pages for Small and Medium proposals and up to 20 pages for Frontier proposals.

Proposals that address a next-generation CPS application in conjunction with research in one or more of the core dimensions of CPS-science, engineering, and technology, should clearly specify the target application in the Project Description.

The Project Description must include the following **subsections** specifically labeled as below. **Proposals that fail to include one or more of these sections will be returned without review (RWR), without exception.**

- **Research Description:** This is the intellectual heart of the Project Description. The Research Description section must describe the technical rationale and technical approach of the CPS research. It should describe the challenges that drive the research problem. It must identify how the research integrates cyber and physical components. It must explain how the proposal goes beyond sensing and how the system "closes the loop." For research focusing on "tools for CPS design or verification", the proposal must show how these tools are applicable to CPS, which have cyber and physical components that "close the loop." This section should describe specific activities for performing the research. It should provide the project research plan including descriptions of major tasks, the primary organization responsible for each task, and the milestones. **The research description must include a Gantt chart which lays out the sequence of major activities and their inter-dependencies.**
 - The **CPS Research Focus** subsection of the Research Description is where the PI **describes how the research is driven by the unique cyber-physical system attributes of the challenge problem and clearly identifies the core CPS research areas addressed (as listed in the Project Summary section above) in which the novel and foundational research contributions are being made. This is not intended to be a list of areas but a focused discussion.**
- **Evaluation/Experimentation Plan:** This section should comprehensively address activities in experimentation including use of full and sub-scale prototypes, and simulation, to demonstrate the research concepts. The section should provide details on specific experiments that will be conducted and describe in detail how the research will be demonstrated, including through simulation, prototyping, and integration with real (including sub-scale) cyber-physical systems. The section should also present metrics for success. This should be considered as an important section whereby the PI demonstrates their insights into the proposed research by clearly describing how the research hypotheses will be confirmed and demonstrated through realistic in-context experiments. For Medium and Frontier projects, the validation plan must include experimentation on an actual cyber-physical system.
- **Project Management and Collaboration Plan:** This section should summarize how the project team is appropriate to realize the project goals and how the team will assure effective collaboration. It should provide a compelling rationale for any multi-institution structure of the project, if appropriate. The plan should identify

organizational responsibilities and how the project will be managed, including approaches for meeting project goals. Specific information should include: 1) the specific roles of the project participants in all involved organizations; 2) information on how the project will be managed across all the investigators, institutions, and/or disciplines; 3) approaches for integration of research components throughout the project and, 4) identification of the specific coordination mechanisms that will enable cross-investigator, cross-institution, and/or cross-discipline scientific integration. In the case of Frontier projects, the plan should also identify a single individual who will be responsible for executing the management and collaboration plan, identify any specific roles for, and the amount of the budget to be allocated for project administration. Frontier projects must also include a kick-off meeting with all participants in coordination with NSF, as well as at least annual in-progress meetings with NSF. For Frontier projects, PIs and all co-PIs must be present in-person for the kick-off meeting. NSF also strongly prefers that PIs and all co-PIs for each Frontier project (including collaborative projects) be present in-person for annual in-progress meetings.

- **Broader Impacts:** In addition to the specific information required in the PAPPG, this section should provide plans for integrating research outcomes into education and more broadly advancing CPS education. It should also describe how the research and education outcomes will be disseminated in a manner that enables the CPS research community and others to use the results in ways that go beyond traditional academic publications. For Frontier proposals, the education and outreach discussion should be described within a separate subsection titled Education and Outreach Plan, within Broader Impacts, and must provide significant detail on the planned activities to explain how it will have meaningful impact.

Supplementary Documents:

In addition to the requirements contained in the PAPPG, provide the following as Supplementary Documents.

(1) A list of Project Personnel and Partner Institutions (note: in separately submitted collaborative proposals, only the lead institution should provide this information):

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

- Mei Lin; XYZ University; PI
- Jak Jabes; University of PQR; Senior/Key Personnel
- Jane Brown; XYZ University; Postdoctoral Researcher
- Rakel Ademas; ABC Inc.; Funded Consultant
- Maria Wan; Welldone Institution; Unfunded Collaborator
- Rimon Greene; ZZZ University; Subawardee


Note the distinction between this list and the Collaborators and Other Affiliations (COA) Information document required for all individuals designated as Senior/Key personnel on the proposal. The listing of all project participants is collected by the project lead and entered as a Supplementary Document, which is then automatically included with all proposals in a project. COA Information is included as a Single Copy Document and available only to NSF staff.

(2) Data Management and Sharing Plan

This Supplementary Document should describe how the proposal will conform to NSF policy on the dissemination and sharing of research results.

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

For proposals directed to USDA/NIFA: The Data Management and Sharing Plan must be consistent with requirements specified by NSF as well as the requirements of NIFA as described herein. The plan must clearly articulate how the Project Director / Principal Investigator (PD/PI) and co-PD /PIs plan to manage and disseminate the data generated by the project. The Data Management and Sharing Plan will be considered during the merit review process (see Section VI). The requirements for preparation and inclusion of a NIFA Data Management and Sharing Plan are included on the following web page, <https://nifa.usda.gov/resource/data-management-plan-nifa-funded-research-projects>. Also included on the web page are FAQs and information about accessing examples of NIFA Data Management Plans.

All projects are **strongly** encouraged to share results, including software and other artifacts, with the CPS research community through the [CPS Virtual Organization \(CPS-VO\)](#) . Plans for sharing should be described in the Data Management and Sharing Plan. Frontier proposals are **required** to include a plan for such sharing with the CPS-VO that goes beyond hosting PI meeting information such as *posters and videos to the website*.

(3) Broadening Participation in Computing and Engineering Plans for Frontier, Medium projects:

Each Frontier project **is required** to include as a one- to three-page Supplementary Document a meaningful BPC plan that will be evaluated during merit review.

Each Medium project **must, by the time of award**, have in place an approved BPC / BPE plan. In this ongoing pilot phase, the CPS program will work with each PI team following merit review and prior to making an award to ensure that plans are meaningful and include concrete metrics for success. The CPS program will also provide opportunities for PIs to share BPC / BPE experiences and innovations through program PI meetings. CISE PIs of Medium proposals are therefore strongly encouraged to consider this eventual requirement as they develop their proposals, and to include one- to three-page descriptions of their planned BPC activities under Supplementary Documents in their submissions. Feedback will be provided on such plans. Similarly, ENG PIs are strongly encouraged to include one- to three-page descriptions of their planned BPE activities under Supplementary Documents in their submissions.

(4) Cloud Computing Resources:

- If requesting cloud computing resources, include a description of the request (not to exceed two pages) as a supplementary document that includes: The title of the proposal and the institution name followed by the following information: (a) specific cloud computing providers that will be used; (b) anticipated annual and total costs for accessing the desired cloud computing resources, along with a description of how the cost is estimated; and (c) a technical description of, and justification for, the requested cloud computing resources.
- The NSF Budget should not include any costs for accessing cloud computing resources via CloudBank. The total cost of the project, including this cloud computing resource request, may not exceed the budget limits for the chosen project class, as described in this solicitation (this is applicable only if there's a cap on the budget that can be requested).

Proposal Preparation Checklist:

The following checklist is provided as a reminder of the items that should be included in a proposal submitted to this solicitation. These are a summary of the program specific requirements described above. For the items marked with (RWR), the proposal will be returned without review if the required item is noncompliant at the submission deadline.

For all proposals:

- (RWR) At the end of the Project Summary, include a prioritized list of 2-4 keywords maximum describing the core CPS Research Area(s) addressed and the Application Domain(s) that characterize the project as described in the section.
- (RWR) Project Description not to exceed 15 pages for Small and Medium Proposals, and 20 pages for Frontier Proposals.

- (RWR) Specific labeled sections in the Project Description for "Research Description," "Evaluation/Experimentation Plan," and "Project Management and Collaboration Plan."
- (RWR) A subsection labeled "CPS Research Focus" is required in the "Research Description" section of the Project Description.
- (RWR) A section labeled "Broader Impacts" is required within the Project Description.
- For Frontier proposals, a subsection labeled "Education and Outreach Plan" is required in the Broader Impacts section of the Project Description.
- Proposal titles must indicate the CPS program, followed by a colon, then the project class, followed by a colon, then the title of the project.
- Proposals targeting a specific agency sponsorship should indicate so just above the keywords in the Project Summary, but only if the proposers have previously communicated with a Program Officer from that agency and received permission or instruction to do so.
- Project Personnel and Partner Institutions list as a Supplementary Document must be included.
- (RWR) Frontier projects are required to include one- to three-page plans for Broadening Participation in Computing (BPC) as a Supplementary Document.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Indirect Cost (F&A) Limitations:

For awards made by NSF, Proposal & Award Policy & Procedures (PAPPG) guidelines apply. Proposals selected for funding by DHS and/or DOT will be awarded by NSF using funds transferred from DHS and/or DOT, respectively, and so they will follow NSF's PAPPG.

For awards made by NIFA: *Indirect Cost (IDC) is not to exceed 30 percent of Total Federal Funds Awarded (TFFA) of the recipient.*

[7 U.S.C. § 3310](#) limits IDC for the overall award to 30 percent of Total Federal Funds Awarded (TFFA) under a research, education, or extension grant. The maximum IDC rate allowed under the award is determined by calculating the amount of IDC using:

1. the sum of an institution's negotiated indirect cost rate and the indirect cost rate charged by sub-awardees, if any;
or
2. 30 percent of TFFA.

The maximum allowable IDC rate under the award, including the IDC charged by the sub-awardee(s), if any, is the lesser of the two rates.

If the result of number 1) above is the lesser of the two rates, the grant recipient is allowed to charge the negotiated IDC rate on the prime award and the sub-award(s), if any. Any sub-awards would be subject to the sub-awardee's negotiated IDC rate. The sub-awardee may charge its negotiated IDC rate on its portion of the award, provided the sum of the IDC rate charged under the award by the prime awardee and the sub-awardee(s) does not exceed 30 percent of the TFFA.

If the result of number 2) above is the lesser of the two rates, then the maximum IDC rate allowed for the overall award, including any sub-award(s), is limited to 30 percent of the TFFA. That is, the IDC of the prime awardee plus the sum of the IDC charged by the sub-awardee(s), if any, may not exceed 30 percent of the TFFA.

In the event of an award, the prime awardee is responsible for ensuring the maximum indirect cost allowed for the award is not exceeded when combining IDC for the Federal portion (i.e., prime and sub-awardee(s)) and any applicable cost-

sharing (see 7 CFR 3430.52(b)). Amounts exceeding the maximum allowable IDC is considered unallowable. See sections 408 and 410 of 2 CFR 200.

Other Budgetary Limitations:

Cost Sharing Requirements for awards made with FHWA

For proposals that are selected by FHWA for co-funding with NSF, FHWA requires a minimum 20 percent funding match for the FHWA portion of funding. The funding match may be in kind based on the value of equipment, materials, data, or labor. Additional information will be provided by FHWA to those selected projects, and the match will be reported to and managed by FHWA.

Cost Sharing Requirements for awards made by NIFA:

Matching funds requirements may be found at [7 U.S.C. 3157 \(b\)\(9\)](#). If an applied **Research** (see Part VIII, D of this RFA) **or Integrated Project** with an applied research component, is commodity-specific and not of national scope, the grant recipient is required to match the USDA funds awarded on a dollar-for-dollar basis from non-federal sources with cash and/or in-kind contributions.

NIFA may waive the matching funds requirement based on submitted document (see Part IV, C(6) of this RFA), for a grant if we determine that:

- a. The results of the project, while of particular benefit to a specific agricultural commodity, are likely to be applicable to agricultural commodities generally; or
- b. The project involves a minor commodity, the project deals with scientifically important research, and the grant recipient is unable to satisfy the matching funds requirement.

Budget Preparation Instructions:

Budgets for all projects must include funding for one or more designated CPS project representatives (PI/co-PI/senior researcher or NSF-approved replacement) to attend each CPS PI meeting during the proposed lifetime of the award (per Section II.G above). For budget preparation purposes, PIs should assume these meetings will be held in the fall of each year in the Washington, DC, area.

C. Due Dates

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

August 14, 2024 - September 03, 2024

FRONTIER Proposals

June 01, 2024 - May 31, 2025

June 1 - May 31, Annually Thereafter

SMALL and MEDIUM Proposals. Accepted anytime during the year-long annual submission window.

August 14, 2025 - August 28, 2025

August 14 - August 28, Annually Thereafter

FRONTIER Proposals

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/ProposalPreparationanc For Research.gov user support, call the Research.gov Help Desk at 1-800-381-1532 or e-mail rgov@nsf.gov. The Research.gov Help Desk answers general technical questions related to the use of the Research.gov system. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

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

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

The NSF [Grants.gov Proposal Processing in Research.gov informational page](#) provides submission guidance to applicants and links to helpful resources including the NSF [Grants.gov Application Guide](#), [Grants.gov Proposal Processing in Research.gov how-to guide](#), and [Grants.gov Submitted Proposals Frequently Asked Questions](#). Grants.gov proposals must pass all NSF pre-check and post-check validations in order to be accepted by Research.gov at NSF.

When submitting via Grants.gov, NSF strongly recommends applicants initiate proposal submission at least five business days in advance of a deadline to allow adequate time to address NSF compliance errors and resubmissions by 5:00 p.m. submitting organization's local time on the deadline. Please note that some errors cannot be corrected in Grants.gov. Once a proposal passes pre-checks but fails any post-check, an applicant can only correct and submit the in-progress proposal in Research.gov.

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

VI. NSF Proposal Processing And Review Procedures

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

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

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *Leading the World in Discovery and Innovation, STEM Talent Development and the Delivery of Benefits from Research - NSF Strategic Plan for Fiscal Years (FY) 2022 - 2026*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

One of the strategic objectives in support of NSF's mission is to foster integration of research and education through the programs, projects, and activities it supports at academic and research institutions. These institutions must recruit, train, and prepare a diverse STEM workforce to advance the frontiers of science and participate in the U.S. technology-based economy. NSF's contribution to the national innovation ecosystem is to provide cutting-edge research under the guidance of the Nation's most creative scientists and engineers. NSF also supports development of a strong science, technology, engineering, and mathematics (STEM) workforce by investing in building the knowledge that informs improvements in STEM teaching and learning.

NSF's mission calls for the broadening of opportunities and expanding participation of groups, institutions, and geographic regions that are underrepresented in STEM disciplines, which is essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

A. Merit Review Principles and Criteria

The National Science Foundation strives to invest in a robust and diverse portfolio of projects that creates new knowledge and enables breakthroughs in understanding across all areas of science and engineering research and education. To identify which projects to support, NSF relies on a merit review process that incorporates consideration of both the technical aspects of a proposed project and its potential to contribute more broadly to advancing NSF's mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF makes every effort to conduct a fair, competitive, transparent merit review process for the selection of projects.

1. Merit Review Principles

These principles are to be given due diligence by PIs and organizations when preparing proposals and managing projects, by reviewers when reading and evaluating proposals, and by NSF program staff when determining whether or not to recommend proposals for funding and while overseeing awards. Given that NSF is the primary federal agency charged with nurturing and supporting excellence in basic research and education, the following three principles apply:

- All NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.
- NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These "Broader Impacts" may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. The project activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified.
- Meaningful assessment and evaluation of NSF funded projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects. If the size of the activity is limited, evaluation of that activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus,

individual projects should include clearly stated goals, specific descriptions of the activities that the PI intends to do, and a plan in place to document the outputs of those activities.

These three merit review principles provide the basis for the merit review criteria, as well as a context within which the users of the criteria can better understand their intent.

2. Merit Review Criteria

All NSF proposals are evaluated through use of the two National Science Board approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. **Both** criteria are to be given **full consideration** during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (PAPPG Chapter II.D.2.d(i). contains additional information for use by proposers in development of the Project Description section of the proposal). Reviewers are strongly encouraged to review the criteria, including PAPPG Chapter II.D.2.d(i), prior to the review of a proposal.

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

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

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

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

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

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

Additional Solicitation Specific Review Criteria

All proposals will be evaluated on the strength of their Project Management and Collaboration Plan in the Project Description.

All Small, Medium and Frontier proposals **whose primary research outcome is the creation/construction of a testbed will also be evaluated on the strength of their plan to establish a constituency of users that reaches beyond the developing institution(s).**

Frontier proposals will also be evaluated on the strength of their Education and Outreach Plans in the Project Description.

For Frontier proposals, reviewers will also be asked to apply these criteria to the Broadening Participation in Computing (BPC) plan:

- What is the potential for the BPC plan to have a measurable impact on underrepresentation?
- Is the BPC plan well-reasoned, well-organized and based on a sound-rationale?
- Is there a well-defined mechanism for assessing its success?
- Does the PI have adequate resources to carry out these activities?
- How well-qualified is the individual, team or organization to implement the BPC plan?

Additional NIFA Review Criteria:

Adequacy of Facilities. Reviewers will assess the adequacy of the necessary research infrastructure capacity for the performing organization to conduct the proposed work.

Relevance. The extent to which the proposed research meets USDA-NIFA strategic goals and advances the sciences related to agriculture and food systems will be evaluated.

B. Review and Selection Process

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

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

Review and Selection Process:

Proposals submitted in response to this program solicitation will be reviewed by the process below.

A uniform review process will be conducted by NSF for all proposals received responding to this program solicitation. Multiple review panels of experts in the field and additional *ad hoc* reviewers as needed will be assembled. The number and topical clustering of panels will be determined according to the number and topical areas of the proposals received. Staff members from the other supporting agencies will be assigned to work cooperatively with NSF staff on each panel, as appropriate to the category of funding requested. Reviewers will be asked to evaluate proposals using two National Science Board approved merit review criteria and, if applicable, additional program specific criteria. Reviewers will be asked to formulate a recommendation to either support or decline each proposal. A summary rating and accompanying narrative will be completed and submitted by each reviewer. In all cases, reviews are treated as confidential documents. The Program Officer(s) assigned to manage a given proposal's review will consider the advice of reviewers and will formulate a recommendation. Upon conclusion of the review process, meritorious proposals may be recommended for funding by one of the participating agencies, the choice to be determined at the option of the agencies, not the proposer. Subsequent grant administration procedures will be in accordance with the individual policies of the awarding agency.

NSF Process: Those proposals selected for funding by NSF will be handled in accordance with standard NSF procedures. This process begins with NSF drafting and releasing the joint-agency solicitation, which includes program requirements.

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.

DHS and DOT Process: Proposals selected for funding by DHS and/or DOT will be awarded by NSF using funds transferred from DHS and/or DOT, respectively.

NIFA Process: NIFA will make final funding decisions based on the results of the peer review process. Applications selected for funding by NIFA will be forwarded to the NIFA Awards Management Division for award processing in accordance with the NIFA procedures.

VII. Award Administration Information

A. Notification of the Award

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

B. Award Conditions

An NSF award consists of: (1) the award notice, which includes any special provisions applicable to the award and any numbered amendments thereto; (2) the budget, which indicates the amounts, by categories of expense, on which NSF has based its support (or otherwise communicates any specific approvals or disapprovals of proposed expenditures); (3) the proposal referenced in the award notice; (4) the applicable award conditions, such as Grant General Conditions (GC-1)*; or Research Terms and Conditions* and (5) any announcement or other NSF issuance that may be incorporated by reference in the award notice. Cooperative agreements also are administered in accordance with NSF Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATC) and the applicable Programmatic Terms and Conditions. NSF awards are electronically signed by an NSF Grants and Agreements Officer and transmitted electronically to the organization via e-mail.

*These documents may be accessed electronically on NSF's Website at https://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF. Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov.

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

Administrative and National Policy Requirements

Build America, Buy America

As expressed in Executive Order 14005, [Ensuring the Future is Made in All of America by All of America's Workers](#) (86 FR 7475), it is the policy of the executive branch to use terms and conditions of Federal financial assistance awards to maximize, consistent with law, the use of goods, products, and materials produced in, and services offered in, the United States.

Consistent with the requirements of the Build America, Buy America Act (Pub. L. 117-58, Division G, Title IX, Subtitle A, November 15, 2021), no funding made available through this funding opportunity may be obligated for infrastructure projects under an award unless all iron, steel, manufactured products, and construction materials used in the project are produced in the United States. For additional information, visit NSF's [Build America, Buy America](#) webpage.

Special Award Conditions:

For all awards, one or more designated CPS project representatives (PI/co-PI/senior researcher or NSF-approved replacement) must attend annual CPS PI meetings and participate in collaborative activities with the CPS-VO throughout the duration of the grant.

Attribution of support in publications must acknowledge the joint program, as well as the funding organization and award number, by including the phrase, "as part of the NSF/DHS/DOT/USDA-NIFA Cyber-Physical Systems Program."

DHS Award Administration and Conditions:

Proposals selected for funding by DHS will be awarded by NSF using funds transferred from DHS, and will thus follow NSF's award conditions described above.

DOT Award Administration and Conditions:

Proposals selected for funding by DOT will be awarded by NSF using funds transferred from DOT, and will thus follow NSF's award conditions described above.

Independent of the NSF award, DOT/FHWA requires a minimum 20 percent funding match for the FHWA portion of funding. Additional information will be provided by FHWA to those selected projects, and the match will be reported to and managed by FHWA. This requirement will not be included as a condition of the NSF award.

NIFA Award Administration and Conditions:

Within the limit of funds available for such purpose, the NIFA awarding official shall make grants to those responsible, eligible applicants whose applications are judged most meritorious under the procedures set forth in this solicitation. The date specified by the NIFA awarding official as the effective date of the grant shall be no later than September 30 of the federal fiscal year in which the project is approved for support and funds are appropriated for such purpose, unless otherwise permitted by law. The project need not be initiated on the grant effective date, but as soon thereafter as practical so that project goals may be attained within the funded project period. All funds granted by NIFA under this solicitation may be used only for the purpose for which they are granted in accordance with the approved application and budget, regulations, terms and conditions of the award, applicable federal cost principles, USDA assistance regulations, and NIFA General Awards Administration Provisions at 7 CFR part 3430, subparts A through E.

Changes in Project Plans:

- a. The permissible changes by the grantee, PD(s), or other key project personnel in the approved project grant shall be limited to changes in methodology, techniques, or other similar aspects of the project to expedite achievement of the project's approved goals. If the grantee or the PD(s) is (are) uncertain as to whether a change complies with this provision, the question must be referred to the Authorized Departmental Officer (ADO) for a final determination. The ADO is the signatory of the award document, not the program contact.

- b. Changes in approved goals or objectives shall be requested by the grantee and approved in writing by the ADO prior to effecting such changes. In no event shall requests for such changes be approved which are outside the scope of the original approved project.
- c. Changes in approved project leadership or the replacement or reassignment of other key project personnel shall be requested by the grantee and approved in writing by the ADO prior to effecting such changes.
- d. Transfers of actual performance of the substantive programmatic work in whole or in part and provisions for payment of funds, whether or not Federal funds are involved, shall be requested by the grantee and approved in writing by the ADO prior to effecting such transfers, unless prescribed otherwise in the terms and conditions of the grant.
- e. Changes in Project Period: The project period may be extended by NIFA without additional financial support, for such additional period(s) as the ADO determines may be necessary to complete or fulfill the purposes of an approved project, but in no case shall the total project period exceed five years. Any extension of time shall be conditioned upon prior request by the grantee and approval in writing by the ADO, unless prescribed otherwise in the terms and conditions of a grant.
- f. Changes in Approved Budget: Changes in an approved budget must be requested by the grantee and approved in writing by the ADO prior to instituting such changes if the revision will involve transfers or expenditures of amounts requiring prior approval as set forth in the applicable Federal cost principles, Departmental regulations, or grant award.

Responsible and Ethical Conduct of Research:

In accordance with sections 2, 3, and 8 of 2 CFR Part 422, institutions that conduct USDA-funded extramural research must foster an atmosphere conducive to research integrity, bear primary responsibility for prevention and detection of research misconduct, and maintain and effectively communicate and train their staff regarding policies and procedures. In the event that an application to NIFA results in an award, the Authorized Representative (AR) assures, through acceptance of the award, that the institution will comply with the above requirements. Award recipients shall, upon request, make available to NIFA the policies, procedures, and documentation to support the conduct of the training. See [Responsible and Ethical Conduct of Research](#) for further information.

C. Reporting Requirements

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

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

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

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

DHS and DOT:

Proposals selected for funding by DHS, and/or DOT will be awarded by NSF using funds transferred from DHS, and/or DOT, respectively, and will thus follow NSF's award conditions described above.

USDA/NIFA:

Expected Program Outputs and Reporting Requirements:

The output and reporting requirements are included in the award terms and conditions (see [NIFA/USDA Terms-and-Conditions](#) for information about NIFA award terms). If there are any program or award-specific award terms, those, if any, will be identified in the award.

Other USDA/NIFA Requirements: Several federal statutes and regulations apply to grant applications considered for review and to project grants awarded under this program. These may include, but are not limited to, the ones listed on the NIFA web page: [NIFA/USDA Government Regulations and Guidelines](#)

The NIFA Federal Assistance Policy Guide—a compendium of basic NIFA policies and procedures that apply to all NIFA awards, unless there are statutory, regulatory, or award-specific requirements to the contrary—is available at [NIFA Policy Guide](#).

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:

- David Corman, telephone: (703) 292-8754, email: dcorman@nsf.gov
- Vishal Sharma, Program Director, CISE/CNS, telephone: (703) 292-8950, email: vsharma@nsf.gov
- Ralph Wachter, Program Director, CISE/CNS, telephone: (703) 292-8950, email: rwachter@nsf.gov
- Pavithra Prabhakar, Program Director CISE/CCF, telephone: (703) 292-2585, email: pprabhak@nsf.gov
- Phillip A. Regalia, Program Director, CISE/CCF, telephone: (703) 292-2981, email: pregalia@nsf.gov
- Sylvia J. Spengler, telephone: (703) 292-7347, email: sspengle@nsf.gov
- Eyad Abed, Program Director ENG/ECCS, telephone: (703) 292-2303, email: eabed@nsf.gov
- Aranya Chakraborty, Program Director, ENG/ECCS, telephone: (703) 292-8113, email: achakrab@nsf.gov
- Anthony Kuh, Program Director, ENG/ECCS, telephone: (703) 292-4714, email: akuh@nsf.gov
- Bruce Kramer, Program Director, ENG/CMMI, telephone: (703) 292-5348, email: bkramer@nsf.gov
- Alexandra Medina-Borja, Program Director, ENG/CMMI, telephone: (703) 292-7557, email: amedinab@nsf.gov
- Siqian Shen, Program Director, ENG/CMMI, telephone: (703) 292-7048, email: siqshen@nsf.gov
- David Kuehn, Program Manager, DOT/FHWA, telephone: (202) 493-3414, email: david.kuehn@dot.gov

- Steven Thomson, National Program Leader, USDA/NIFA, telephone: (202) 603-1053, email: Steven.J.Thomson@usda.gov
- Benjamin Salazar, Cyber Security Subject Matter Expert, DHS S&T, telephone: (202) 254-5734, email: benjamin.salazar@hq.dhs.gov

For questions related to the use of NSF systems contact:

- NSF Help Desk: 1-800-381-1532
- Research.gov Help Desk e-mail: rgov@nsf.gov

For questions relating to Grants.gov contact:

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

IX. Other Information

The NSF website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this website by potential proposers is strongly encouraged. In addition, "NSF Update" is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF [Grants Conferences](#). Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. "NSF Update" also is available on [NSF's website](#).

Grants.gov provides an additional electronic capability to search for Federal government-wide grant opportunities. NSF funding opportunities may be accessed via this mechanism. Further information on Grants.gov may be obtained at <https://www.grants.gov>.

U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T)

<https://www.dhs.gov/science-and-technology>

U.S. Department of Transportation (DOT) Federal Highway Administration (FHWA):

<http://www.fhwa.dot.gov/>

U.S. Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA):

<http://www.nifa.usda.gov/>

[NIFA Policy Guide](#)

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The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861-75). The Act states the purpose of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering."

NSF funds research and education in most fields of science and engineering. It does this through grants and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the US. The Foundation accounts for about one-fourth of Federal support to academic institutions for basic research.

NSF receives approximately 55,000 proposals each year for research, education and training projects, of which approximately 11,000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships. The agency operates no laboratories itself but does support National Research Centers, user facilities, certain oceanographic vessels and Arctic and Antarctic research stations. The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

Facilitation Awards for Scientists and Engineers with Disabilities (FASED) provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See the *NSF Proposal & Award Policies & Procedures Guide* Chapter II.F.7 for instructions regarding preparation of these types of proposals.

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

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

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

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

- **Location:** 2415 Eisenhower Avenue, Alexandria, VA 22314
- **For General Information** (NSF Information Center): (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**
 - Send an e-mail to: nsfpubs@nsf.gov
 - or telephone: (703) 292-8134
- **To Locate NSF Employees:** (703) 292-5111

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The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by proposers will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/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 proposers or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See [System of Record Notices, NSF-50](#), "Principal Investigator/Proposal File and Associated Records," and [NSF-51](#), "Reviewer/Proposal File and

Associated Records." Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

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

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

X. Appendix

Legislative Authority:

Section 2(b) of the Competitive, Special, and Facilities Research Grant Act (hereafter referred to as the Act) ([7 U.S.C. 3157](#)), as amended, authorizes the Secretary of Agriculture to establish the Agriculture and Food Research Initiative (AFRI); a new competitive grant program to provide funding for fundamental and applied research, extension, and education to address food and agricultural sciences. AFRI is subject to the provision found at 7 CFR Part 3430.

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