

Cyber-Physical Systems (CPS)

PROGRAM SOLICITATION

NSF 20-563

REPLACES DOCUMENT(S):

NSF 19-553



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
Office of Advanced Cyberinfrastructure

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



National Institutes of Health

National Institute of Biomedical Imaging and Bioengineering
National Cancer Institute



National Center for Advancing Translational Sciences
Office of Behavioral and Social Sciences Research



U.S. Dept. of Agriculture



National Institute of Food and Agriculture

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

December 02, 2020

First Wednesday in December, Annually Thereafter

Frontier proposals

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

June 08, 2020 - June 22, 2020

Medium Proposals

IMPORTANT INFORMATION AND REVISION NOTES

Small proposals are not invited in FY 2020. For FY 2021 (beginning Oct. 1, 2020) and beyond, the CPS program anticipates going to a "no-deadline" submission for Small and Medium proposals.

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (*NSF 20-1*), which is effective for proposals submitted, or due, on or after June 1, 2020.

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;
- 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; and
- A **Broader Impacts** section that describes how the research will be disseminated to a broad and diverse audience. This should go beyond traditional academic publications and includes education and outreach from the research team spanning multiple levels of engagement. Broader Impacts encompasses Broadening Participation in Computing (BPC) and Engineering (BPE).

In FY 2020, 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); several National Institutes of Health (NIH) institutes and centers including the National Institute of Biomedical Imaging and Bioengineering (NIBIB), National Cancer Institute (NCI), and National Center for Advancing Translational Sciences (NCATS); 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 \$500,000 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. **Note that Small projects are not accepted under this solicitation.**
- **Medium** projects may request a total budget ranging from \$500,001 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.

- **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 project deadline is different than that for Medium projects.**

Please note, this solicitation includes windows for Medium and Frontier proposals. Small proposals are not invited in FY 2020. For FY 2021 (beginning Oct. 1, 2020) and beyond, the CPS program anticipates going to a "no-deadline" submission for Small and Medium proposals. Specific annual deadlines for Frontier proposals are anticipated to continue as noted in this solicitation.

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, Program Director CISE/CNS, telephone: (703) 292-8754, email: dcorman@nsf.gov
- Sandip Roy, Program Director CISE/CNS, telephone: (703) 292-8950, email: saroy@nsf.gov
- Ralph Wachter, Program Director, CISE/CNS, telephone: (703) 292-8950, email: rwachter@nsf.gov
- Michal Ziv-El, Associate Program Director, telephone: (703) 292-8950, email: mzivel@nsf.gov
- Linda Bushnell, Program Director CISE/CNS, telephone: (703) 292-8950, email: lbushnel@nsf.gov
- Nina Amla, Program Director CISE/CNS, telephone: (703) 292-7991, email: namla@nsf.gov
- Sankar Basu, Program Director CISE/CCF, telephone: (703) 292-7843, email: sabasu@nsf.gov
- Phillip A. Regalia, Program Director, CISE/CCF, telephone: (703) 292-2981, email: pregalia@nsf.gov
- Wendy Nilsen, Program Director, CISE/IIS, telephone: (703) 292-2568, email: wnilsen@nsf.gov
- Sylvia Spengler, Program Director, CISE/IIS, telephone: (703) 292-8930, email: sspengle@nsf.gov
- Jordan Berg, Program Director, ENG/CMMI, telephone: (703) 292-5365, email: jberg@nsf.gov
- Bruce Kramer, Program Director, ENG/CMMI, telephone: (703) 292-5348, email: bkramer@nsf.gov
- Yueyue Fan, Program Director CMMI / ENG, telephone: (703) 292-4453, email: yfan@nsf.gov
- Robert Landers, Program Director, ENG/CMMI, telephone: (703) 292-2652, email: rlanders@nsf.gov
- Radhakisan Baheti, Program Director, ENG/ECCS, telephone: (703) 292-8339, email: rbaheti@nsf.gov
- Anthony Kuh, Program Director, ENG/ECCS, telephone: (703) 292-2210, email: akuh@nsf.gov
- Anil Pahwa, Program Director, ENG/ECCS, telephone: (703) 292-2285, email: apahwa@nsf.gov
- Steven Thomson, National Program Leader, USDA/NIFA, telephone: (202) 603-1053, email: Steven.J.Thomson@nifa.usda.gov
- David Kuehn, Program Manager, DOT/FHWA, telephone: (202) 493-3414, email: david.kuehn@dot.gov
- Christos Papadopoulos, Program Manager, DHS S&T, telephone: (202) 254-2422, email: christos.papadopoulos@hq.dhs.gov
- Christopher Hartshorn, Program Director, NCI/DCTD/CIP/NSDB, telephone: (240) 781-3315, email: hartshorncm@mail.nih.gov
- Danilo Tagle, Associate Director for Special Initiatives, NIH/NCATS, telephone: (301) 594-8064, email: danilo.tagle@nih.gov
- Tiffani Lash, Program Director NIH/NBIB, telephone: (301) 451-4778, email: tiffani.lash@nih.gov
- Dana Wolff-Hughes, Health Scientist Administrator, NIH/OBSSR, telephone: (301) 496-0979, email: dana.wolff@nih.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
- 93.286 --- National Institute of Biomedical Imaging and Bioengineering
- 93.350 --- National Center for Advancing Translational Sciences
- 93.396 --- National Cancer Institute
- 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: 10 to 15

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

Anticipated Funding Amount: \$17,000,000

in FY 2020, 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 labs, professional societies and similar organizations in the U.S. 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

An individual can participate as PI, co-PI, Senior Personnel, or Consultant on no more than two proposals submitted in response to this solicitation.

These eligibility constraints will be strictly enforced in order to treat everyone fairly and consistently. In the event that an individual exceeds the two-proposal limit for this solicitation, proposals received within the limit will be accepted based on earliest date and time of proposal submission (i.e., the first two proposals received will be accepted and the remainder will be returned without review). **No exceptions will be made.**

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, NIH, 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 FastLane: *NSF Proposal and Award Policies and Procedures Guide* (PAPPG) guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.
 - Full Proposals submitted via 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 NIH, indirect costs on foreign subawards/subcontracts will be limited to eight percent.

For awards made by NIFA: Previous appropriations have limited indirect costs to 30 percent of the total Federal funds provided (or 42.857

percent of total direct costs) under each award [see, for example, Section 713 of the Consolidated and Further Continuing Appropriations Act, 2018 (Pub. L. 115-141)]. Therefore, when preparing budgets, you should limit your request for the recovery of indirect costs to the lesser of your institution's official negotiated indirect cost rate or the equivalent of 30 percent of total Federal funds awarded. See Part V section 7.9 of the [NIFA Grants.gov Application Guide](#) Application Guide for further indirect cost information.

- **Other Budgetary Limitations:**

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

C. Due Dates

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

December 02, 2020

First Wednesday in December, Annually Thereafter

Frontier proposals

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

June 08, 2020 - June 22, 2020

Medium 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.

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I. INTRODUCTION

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 medical devices, or micro-scale robots. 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 2020, proposals for cyber manufacturing should be submitted to the recently established 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.

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.

In FY 2020, NSF is working closely with multiple agencies across the federal government, including the DHS S&T; DOT FHWA; NIH NIBIB, NCI, and NCATS; 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.

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;
- An **Evaluation/Experimentation Plan** that describes how proposed concepts will be validated and 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 assure effective collaboration; and
- **A Broader Impacts** section that describes the societal impact of the proposed research and how the research will be disseminated to a broad and diverse audience. This should go beyond traditional academic publications and include education and outreach from the research team spanning multiple levels of engagement.

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. For the FY 2020 CPS solicitation, 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 two 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

Medium Projects: Medium projects may be requested with total budgets ranging from \$500,001 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). The underrepresentation of many groups—including women, African Americans, Hispanics, American Indians, Alaska Natives, Native Hawaiians, Native Pacific Islanders, and persons with disabilities—in computing and engineering deprives large segments of the population of the opportunity to be creators of technology and not only consumers. Ending underrepresentation will require a range of measures, including organizational programs and activities as well as culture change 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.**

More information, including examples of BPC/BPE activities and metrics, can be found at: <https://www.nsf.gov/cise/bpc/> and at https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504870&org=EEC&from=home.

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, NIH, 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.

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," "NIH," 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 U.S. Department of Homeland Security Science and Technology Directorate Homeland Security Advanced Research Projects Agency (HSARPA)

Within DHS S&T, HSARPA encourages research and development in cybersecurity to enhance the resilience of critical information infrastructure. HSARPA seeks to develop and transition new technologies, tools, and techniques to secure systems, networks, and infrastructure. Its research interests span a broad range of technology maturity levels ranging from foundational research in cybersecurity technology, to development and transition to practice.

HSARPA 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 automotive/heavy-vehicle, emergency response, and building automation are considered especially relevant for HSARPA. 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. HSARPA 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 HSARPA interests.

More information about relevant DHS S&T cybersecurity technology interests can be found on the following website: <http://www.dhs.gov/science-and-technology/csd-projects>.

[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 and development that provides improved safety and mobility in the development and operation of the highway system. At the same time, CPS for highway transportation must be scalable, reliable, adaptable, and secure while also being cost-effective.

In particular, FHWA is interested in fundamental research that also is aimed towards solving important public needs and can scale across transportation systems and modes, and into other domains. The approaches should consider the open nature of the transportation system, legacy components and processes, and the distributed nature of asset ownership and operations.

The following are examples of how CPS research could respond to public needs across transportation and other domains:

- Traffic management and control systems that improve safety and reliability and enhance social and economic connections within or outside of metropolitan areas;
- Leveraging the differences between machines and people in sensing, analytics, and control to improve system safety, efficiency, and sustainability;
- Increasing safety and convenience for vulnerable travelers through connected and automated systems; and
- Technologies that extend the infrastructure lifecycle and reduce costs through automated maintenance with little or no disruption of service.

These are only illustrative examples of how CPS could result in public benefits for transportation. Investigators are encouraged to consider and propose truly novel solutions to a broad range of public needs that could overlap the examples above or be entirely different.

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.

FHWA encourages leveraging existing tools and infrastructure for connected and automated vehicles and real-world data. With a multimodal approach, the CARMA platform was developed by the Federal Highway Administration (FHWA) to encourage collaboration to improve transportation safety, efficiency and mobility. CARMA focuses on advancing Cooperative Driving Automation (CDA) which enables automated vehicles to communicate between vehicles, infrastructure devices and road users such as pedestrians and cyclists. CARMA provides a series of open-source software (OSS) tools (i.e. CARMA Platform, CARMA Cloud, CARMA Messenger, CARMA 1Tenth, V2XHub, etc.). CARMA open source code is located at <https://github.com/usdot-fhwa-stol> and continually developed by the growing community of users. More information is located at <https://highways.dot.gov/research/research-programs/operations/CARMA> and https://www.its.dot.gov/research_areas/connected_vehicle.htm.

Proposed solutions need to account for a combination of legacy equipment and new systems. Initial deployment of new technologies may begin in specific corridors, but the technologies need to be scalable, reliable, affordable, and adaptable to enable nationwide deployment as well as operation over periods of 30 or more years. While people may update mobile devices every two years, the average age of private motor vehicles is now over 10 years. Roadway signals, infrastructure sensors, truck trailers, and other elements of the highway system have even longer lifecycles before being replaced. This also implies interactions among a mix of human-driven and machine-driven (at various levels of automation) vehicles for many years into the future. Accordingly, new systems need to work with existing equipment while anticipating future technologies.

II.D.3 National Institutes of Health

The NIH expects to fund Medium projects. Medium projects must demonstrate innovation at the intersection of multiple disciplines, to accomplish a clear

goal that requires an integrated perspective spanning the disciplines. Funding for Medium projects may be requested of between approximately \$100,001 and \$250,000 per year in direct costs for a period of three to four years. Funding may include applicable indirect costs, with total budgets ranging from \$500,001 to \$1,200,000.

Applications being proposed should be relevant to the missions of the participating NIH institutes and centers:

- **NIBIB:** The mission of the National Institute of Biomedical Imaging and Bioengineering is to improve health by leading the development and accelerating the application of biomedical technologies. NIBIB is committed to integrating the physical and engineering sciences with the life sciences to advance basic research and medical care.
- **NCI:** The National Cancer Institute mission is to conduct and support research that will lead to a future in which we can prevent cancer before it starts, identify cancers that do develop at the earliest stage, eliminate cancers through innovative treatment interventions, and biologically control those cancers that we cannot eliminate so they become manageable, chronic diseases.
- **NCATS:** The National Center for Advancing Translational Sciences strives to develop innovations to reduce, remove, or bypass costly and time-consuming bottlenecks in the translational research pipeline in an effort to speed the delivery of new drugs, diagnostics, and medical devices to patients. NCATS is particularly interested in a comprehensive matrix of human diseases and conditions with known targets and pathways, and all available drugs tested in humans, that can be used for discovery and development of targeted therapeutics— for facilitating the research and development of systems pharmacology aimed at the discovery of multi-targeted drugs and drug combinations.

The NIH encourages CPS research and technology development to enhance health, lengthen life, and reduce illness and disability. Specifically, the participating NIH institutes on this solicitation are interested in targeting this solicitation to support the development of CPS research and technology to facilitate medical treatment during a national crisis (e.g. SARS-CoV-2); achieve functional independence in humans; improve quality of life; assist with behavioral therapy and personalized care; monitor or generate accurate readouts of therapeutic effects of therapies; prevent disease and disability; and promote wellness/health.

Advances in sensors, wearable devices, and patient-facing technologies hold great promise in improving healthcare across the continuum from prevention to survivorship. Little is known, however, about how advances in CPS can integrate these technologies and interfaces to increase patient engagement and activation. In the healthcare setting, CPS systems such as wireless body area networks (WBANs), assistive healthcare systems, and wearable sensors and implantable devices are actively being developed to improve outcomes and quality of life, provide cost-effective healthcare, and potentially speed-up disease diagnosis and prevention. In nonclinical settings, consumer-oriented CPS research can create supportive home environments to accommodate residents' functional deficits while offering insights to patients and caregivers on how best to manage their own care outside of the healthcare setting.

One vision of medical CPS could be the development of personalized patient-care systems which are tightly knit with other non-medical CPS systems. Such a closed-loop environment could enable optimal and timely delivery of healthcare improvements at a significant cost reduction. It is envisioned that such systems will also generate a significant amount of data; technologies for analyzing these data on-the-fly will need to be developed.

Examples of medical CPS research and technology development include, but are not limited to:

- Developing CPS technology that allows first responders and medical practitioners to provide medical care during an outbreak, while protecting them from threats
- Developing CPS technologies to amplify and extend the capabilities of standard-of-care medical devices without significant degradation of their baseline safety and efficacy;
- Developing CPS technologies to manage the workload of medical practitioners and provide decision support during an outbreak or other crisis situation;
- Implementing CPS technology to reduce medical errors in intensive care units (ICUs);
- Developing prototypical closed-loop CPS for medical systems such as artificial organs or continuous monitoring systems;
- Implementing CPS technology for real-time monitoring and analysis of complex biomedical research systems such as microphysiological systems or cancer research models for understanding cancer biology;
- Pursuing approaches to enhance interoperability between various medical devices and/or systems;
- Developing human-system integration (HSI) applications designed to optimize the role of human cognition in relation to CPS support within the context of either clinical or consumer health environments;
- Developing applications to monitor physiologic, motor, and cognitive functioning across environments to inform treatment and facilitate research;
- Developing approaches to understand the behavioral and social aspects of medical CPS implementations;
- Developing real-time patient-specific clinical decision-making approaches;
- Developing real-time data analytic techniques for medical CPS systems, such as machine learning approaches to develop on-the-fly analyses and prediction models;
- Developing CPS applications to improve access, utility, and management of biomedical big data for basic research; and
- Developing hospital-wide applications to decrease fragmentation, improve quality of care, and conserve costs by tracking medical assets and conjoining informatics data flows to enable a "learning healthcare system."

Applicants should describe how the ideas being proposed will address the healthcare needs of the end user (healthy individuals, patient populations with specific targeted diseases, persons with disability, and/or health disparity populations).

II.D.4 U.S. Department of Agriculture National Institute of Food and Agriculture

USDA/NIFA is pursuing an aggressive research agenda to meet the "grand challenges" for agriculture and society. These challenges have a common underlying theme: delivering food, fiber, fuel, and feed within a changing global climate while reducing agriculture's environmental footprint and managing biotic threats to production. NIFA has embarked on a multi-horizon research agenda that is addressing these challenges. Foundational and applied research in CPS are an important element of this agenda.

These CPS efforts address USDA goals indicated at <https://www.usda.gov/sites/default/files/documents/usda-strategic-plan-2018-2022.pdf>, including: protecting agricultural health by preventing and mitigating the spread of agricultural pests and disease (Objective 2.3), enhancing conservation planning with science-based tools and information (Objective 5.1), ensuring lands and watersheds are sustainable, healthy, and productive (Objective 6.2), and mitigation of wildfire risk (Objective 6.3). It is expected that projects will engage academia, industry, stakeholders/users, students, and other organizations to identify critical research needs and to conduct both basic and applied research, while providing training for the next generation of scientists, engineers, and technologists.

For this solicitation, 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. We are 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.

The following two NIFA **goals** have been identified for S&CC in urban and rural settings, respectively:

1. Increased food and nutritional security through the development of high-output and efficient controlled-environment urban agriculture technologies and systems; and
2. More resilient, robust, and reliable agricultural systems leading to more viable and thriving rural communities.

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; and
- New connectivity paradigms and applications for integrated devices, communications, control systems, and databases in dispersed rural settings that enable overlain software to bring quality-of-life improvements to citizens for benefits such as education, health, 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, and control systems) 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.

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

Proposals for Medium or Frontier projects may include a Transition to Practice (TTP) option. Proposed activities under the TTP option **MUST NOT** be described in the Project Description section, and instead **MUST** be described in a Supplementary Document of no more than five pages. The TTP option is meant to leverage proposed research activities and ideas to move results beyond the laboratory. Proposals including this option should clearly describe how the results will be further developed, matured and experimentally deployed in organizations or industries, including in networks and end systems. Any software developed in this program area is required to be released under an open source license listed by the Open Source Initiative (<http://www.opensource.org/>) (this requirement is specific to the TTP option supplement). The TTP funding request may not exceed more than one-third of the base award amount or \$400,000, whichever is less. Note that the budget for the TTP option must be specified separately within the five-page Supplementary Document. The proposal budget should reflect the base project without TTP option. If the TTP option is to be awarded, the proposer will be requested to update the Project Budget and Justification to include TTP costs.

Note: The TTP option is an optional component, above and beyond the requirement for experimentation on an actual CPS for Medium or Frontier projects. We also recognize that TTP option activities may need to overlap with the base project timeline to support the accelerated maturation and TTP goals. This may include early testing of theory, additional robustness in design, and higher fidelity simulation. Proposers should carefully describe in their TTP option description and budget justification the scope of this additional activity, especially if it is anticipated in the early project years.

Proposals submitted with a TTP option will be evaluated with careful attention to the following:

- The expected impact on the deployed environment described in the Supplementary Document;
- The extent to which the value of the proposed CPS research and development is described in the context of a needed capability and potential impact;
- The feasibility, and utility of the capability in its proposed operational role, including potential partnering with industry that will incorporate the TTP

technology;

- A plan that addresses in its goals and milestones the demonstration and evaluation of a working system in the target environment;
- Tangible metrics described to evaluate the success of the capabilities developed, and the steps necessary to take the system from prototype status to production use; and,
- The appropriateness of the budget for the option. The Supplementary Document should explain how the additional budget will be used to execute the option.

If you submit a Transition to Practice (TTP) option, the title should begin with "TTP Option" followed by a colon, then the project class followed by a colon, and then the descriptive title. For example, a CPS Frontier project with the TTP option should have a title of the form CPS: TTP Option: Frontier: [descriptive] Title.

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), and Microsoft Azure. Cloud computing resources described in proposals may be obtained through an external cloud access entity supported by NSF's [Enabling Access to Cloud Computing Resources for CISE Research and Education \(Cloud Access\) Program](#).

Proposers should describe the request in a Supplementary Document no longer than two pages with (a) anticipated annual and total costs for accessing the desired cloud computing resources, based on pricing currently available from the public cloud computing providers; and (b) a technical description of, and justification for, the requested cloud computing resources. The NSF Budget should not include any such costs for accessing public cloud computing resources via CloudBank.org. The total cost of the project, including this cloud computing resource request from CloudBank.org, may not exceed the budget limit described in this solicitation. Proposers 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. Proposers may contact CloudBank.org (see <https://www.cloudbank.org/faq>) for consultation on estimating the budget estimate for using cloud computing resources.

See Section V.A. Proposal Preparation Instructions, Supplementary Documents, for more information.

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: Continuing Grant or Cooperative Agreement or Standard Grant

Estimated Number of Awards: 10 to 15

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

Anticipated Funding Amount: \$17,000,000 in FY 2020, subject to receipt of sufficient meritorious proposals and pending availability of funds.

All awards made under this solicitation by NSF or NIH will be as grants or cooperative agreements as determined by the supporting agency. Note that NCATS will only make cooperative agreements. 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.

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 labs, professional societies and similar organizations in the U.S. 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

An individual can participate as PI, co-PI, Senior Personnel, or Consultant on no more than two proposals submitted in response to this solicitation.

These eligibility constraints will be strictly enforced in order to treat everyone fairly and consistently. In the event that an individual exceeds the two-proposal limit for this solicitation, proposals received within the limit will be accepted based on earliest date and time of proposal submission (i.e., the first two proposals received will be accepted and the remainder will be returned without review). **No exceptions will be made.**

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, NIH, 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 applications from groups eligible to compete as Research in Undergraduate Institutions (RUI; see [NSF 14-579](#)) or Grants Opportunities for Academic Liaison with Industry (GOALI; see [PAPPG, Chapter II.E.4](#)) 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 corporations 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 applicants 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 institutions 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 FastLane, Research.gov, or Grants.gov.

- Full proposals submitted via FastLane: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=papppg. 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. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.
- Full Proposals submitted via 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=papppg. 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 FastLane or Research.gov. PAPPG Chapter II.D.3 provides additional information on collaborative proposals.

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

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

Proposal Titles: 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**. Titles of collaborative proposals should be prepared as above, but should also include "Collaborative Research" followed by a colon at the beginning of the title of the project. For example, the title of each proposal for a collaborative set of proposals for a Medium project would be **Collaborative Research: CPS: Medium: Title**. Proposals that include a Transition to Practice (TTP) option should include "TTP Option" followed by a colon immediately after identifying as CPS. For example, a CPS Frontier project with the TTP option should have a title of the form **CPS: TTP Option: Frontier: Title**. Proposals from PIs in institutions that have RUI (Research in Undergraduate Institutions) eligibility should also include "RUI" followed by a colon before the project title, for example, **CPS: Medium: RUI: Title**. Similarly, GOALI (Grant Opportunities for Academic Liaison with Industry) proposals should include "GOALI" followed by a colon as the last identifier before the project title.

Project Summary:

At the top of the Overview text box, enter the title of the CPS project, the name of the lead PI, and the name of the lead institution. Provide an overview description of the CPS project. This description should explicitly identify the core CPS research areas addressed by the proposal. In separate statements, provide a summary of the intellectual merit of the proposed project in the "intellectual merit" box, and broader impacts in the "broader impacts" box. **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", "NIH", 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, include a prioritized list of keywords extracted from the list below which identify the core CPS Research Area(s) addressed, and the Application Domain(s) that best characterize the project. 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. All proposals must include a prioritized list of 2-4 keywords separated by ",". The keywords must be drawn from the lists below and best characterize the project from the perspectives of the core research area(s) and application domain(s). Proposers must include at least one keyword each from the core research areas and the application domains. 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)

Project Description:

Describe the research and education activities to be undertaken in up to 15 pages for 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.**
- **Evaluation/Experimentation Plan:** This section should describe how the research concepts proposed will be demonstrated and validated. It should present metrics for success. It should identify critical experiments, and describe how the research will be demonstrated, including through simulation, prototyping, and integration with real (including sub-scale) cyber-physical systems. 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 the Supplementary Documents section, upload the following:

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 Personnel, paid/unpaid Consultants or Collaborators, Subawardees, and Postdocs. If the project includes a Transition to Practice (TTP) option, this list must include personnel and institutions involved in the option. 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:

1. Mary Smith; XYZ University; PI
2. John Jones; University of PQR; Senior Personnel
3. Jane Brown; XYZ University; Postdoc
4. Bob Adams; ABC Inc.; Paid Consultant
5. Mary White; WellDone Institution; Unpaid Collaborator

2. *Transition to Practice (TTP) Option Proposals:*

Projects may include a Transition to Practice (TTP) option. Proposals submitted with a TTP option must include a Supplementary Document of up to five pages in order for the option to be considered for funding. This document should describe how successful proposed research results are to be further developed, matured, and experimentally deployed in organizations, networks and end systems. It should also include an option budget that indicates what additional funds would be needed to carry out the TTP option. This budget for the TTP option may not exceed one third of the base project budget or \$400,000 whichever is less. Note no TTP funds should be requested for the first project year.

Note that the budget for the TTP option must be specified separately within the five-page Supplementary Document. The proposal budget should reflect the base project without TTP option. If the TTP option is to be awarded, the proposer will be requested to update the Project Budget and Justification to include TTP costs.

3. *Postdoctoral Researcher Mentoring Plan (if applicable):*

Each proposal that requests funding to support postdoctoral researchers must include, as a Supplementary Document, a description of the mentoring activities that will be provided for such individuals. In no more than one page, the mentoring plan must describe the mentoring that will be provided to all postdoctoral researchers supported by the project, irrespective of whether they reside at the submitting organization, any subawardee organization, or at any organization participating in a simultaneously submitted collaborative project. Please be advised that if required, FastLane will not permit submission of a proposal that is missing a Postdoctoral Researcher Mentoring Plan. See [PAPPG Chapter II.C.2](#) for further information about the implementation of this requirement. **Proposals that include Postdoctoral Mentoring Plans exceeding**

one page in length will not be accepted by FastLane.

4. *Data Management Plan (required):*

Proposals must include a Supplementary Document of no more than two pages labeled "Data Management Plan." This Supplementary Document should describe how the proposal will conform to NSF policy on the dissemination and sharing of research results.

See [PAPPG, Chapter II.C.2j](#) for full policy implementation.

For additional information see <https://www.nsf.gov/bfa/dias/policy/dmp.jsp>.

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 USDA/NIFA: A Data Management Plan (DMP) is required and is to clearly articulate how the project director (PD) and co-PDs plan to manage and disseminate the data generated by the project. The DMP will be considered during the merit review process (see Section VI). The requirements for preparation and inclusion of a DMP in your application is 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 DMPs.

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 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*.

5. *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.

6. *Cloud Computing Resources:*

If requesting cloud computing resources, include a description of your requests (not to exceed 2 pages) that includes: (1) title of the proposal; (2) the total cost of computing resources, with yearly breakdown; (3) which public cloud providers will be used; and (4) a technical description and justification of the request, along with how the cost was estimated.

Single Copy Documents:

Collaborators and Other Affiliations Information: Proposers should follow the guidance specified in [Chapter II.C.1.e](#) of the NSF PAPPG. Grants.gov Users: The COA information must be provided through use of the COA template and uploaded as a PDF attachment.

Note the distinction to the list of Project Personnel and Partner Institutions specified above under Supplementary Documents: 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. The Collaborators and Other Affiliations are entered for each participant within each proposal and, as Single Copy Documents, are available only to NSF staff.

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 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 keywords describing the core CPS Research Area(s) addressed and the Application Domain(s) that characterize the project.
- (RWR) Project Description not to exceed 15 pages for 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.
- Proposed activities under the TTP option **MUST NOT** be described in the Project Description section, and instead **MUST** be described in a Supplementary Document of no more than five pages.
- 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.

There are a number of additional items (such as Data Management Plan, Post Doc Mentoring Plan, Results from Prior NSF Support, etc.) that are

required in all NSF proposals unless otherwise stated. **The proposer is strongly advised to consult the PAPPG for the complete list of requirements.**

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 NIH, indirect costs on foreign subawards/subcontracts will be limited to eight percent.

For awards made by NIFA: Previous appropriations have limited indirect costs to 30 percent of the total Federal funds provided (or 42.857 percent of total direct costs) under each award [see, for example, Section 713 of the Consolidated and Further Continuing Appropriations Act, 2018 (Pub. L. 115-141)]. Therefore, when preparing budgets, you should limit your request for the recovery of indirect costs to the lesser of your institution's official negotiated indirect cost rate or the equivalent of 30 percent of total Federal funds awarded. See Part V section 7.9 of the [NIFA Grants.gov Application Guide](#) Application Guide for further indirect cost information.

Other Budgetary Limitations:

Cost Sharing Requirements for awards made by NIFA:

In accordance with 7 USC 450i(b)(9), if a funded applied **Research 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.

For Equipment Grants: The amount of Federal funds provided may not exceed 50 percent of the cost of the equipment acquired using funds from the grant, or \$50,000, whichever is less. Grantees are required to match 100 percent of Federal funds awarded from non-Federal sources. The Secretary of Agriculture may waive all or part of the matching requirement if all three of the following criteria are met: (1) applicants must be a college, university, or research foundation maintained by a college or university that ranks in the lowest one third of such colleges, universities, and research foundations on the basis of Federal research funds received (see Table 2 following Part VIII for eligibility); (2) if the equipment to be acquired using funds from the grant costs not more than \$25,000; and (3) has multiple uses within a single research project or is usable in more than one research project. If the institution believes it is eligible for the waiver for matching funds, the budget justification must include a letter signed by the institution's AR stating this information. NIFA will consider this justification when ascertaining final matching requirements or in determining if required matching can be waived. NIFA retains the right to make final determinations regarding matching requirements.

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.E 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

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

December 02, 2020

First Wednesday in December, Annually Thereafter

Frontier proposals

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

June 08, 2020 - June 22, 2020

Medium Proposals

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

For Proposals Submitted Via FastLane or Research.gov:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at:

<https://www.fastlane.nsf.gov/a1/newstan.htm>. To prepare and submit a proposal via Research.gov, see detailed technical instructions available at: https://www.research.gov/research-portal/appmanager/base/desktop?_nfpb=true&_pageLabel=research_node_display&_nodePath=/researchGov/Service/Desktop/ProposalPreparationandSubmission.html.

For FastLane or Research.gov user support, call the FastLane and Research.gov Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov or rgov@nsf.gov. The FastLane and Research.gov Help Desk answers general technical questions related to the use of the FastLane and Research.gov systems. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

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

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

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

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

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

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

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *Building the Future: Investing in Discovery and Innovation - NSF Strategic Plan for Fiscal Years (FY) 2018 – 2022*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

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

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

A. Merit Review Principles and Criteria

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

1. Merit Review Principles

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

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

activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus, individual projects should include clearly stated goals, specific descriptions of the activities that the PI intends to do, and a plan in place to document the outputs of those activities.

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

2. Merit Review Criteria

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

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

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

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

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

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

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

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

Additional Solicitation Specific Review Criteria

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

All 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?

Proposals submitted with a Transition to Practice (TTP) option will be evaluated with careful attention to the following:

- The expected impact on the deployed environment described in the Supplementary Document;
- The extent to which the value of the proposed CPS research and development is described in the context of a needed capability and potential impact;
- The feasibility, utility, and interoperability of the capability in its proposed operational role;
- The extent that the plan addresses in its goals and milestones the demonstration and evaluation of a working system in the target environment how the activities will expand the current project's research and development activities; how these activities will address the needed capabilities, potential risks, and lead to potential impact;
- Tangible metrics described to evaluate the success of the capabilities developed, and the steps necessary to take the system from prototype status to production use; and
- The appropriateness of the budget for the option plan. The Supplementary Document should explain how the additional budget will be used to

execute the option plan.

Additional NIH Review Criteria:

The mission of the NIH is to support science in pursuit of knowledge about the biology and behavior of living systems and to apply that knowledge to extend healthy life and reduce the burdens of illness and disability. While many of the NIH and NSF review criteria are based on the same standards of scientific evaluation, some scoring mechanisms and programmatic emphases vary. For example, all proposals under consideration by NIH will be scored by their respective review panels using the NIH 1-9 scoring system, which does not include consideration of broader impacts. Additionally, proposers should pay particular attention to NIH clinical evaluation standards represented by criteria for human protections, inclusion of women, minorities, and children in the study population, and animal subjects' protections, as well as biohazards. In their evaluations of scientific merit, reviewers will be asked to consider the following criteria that are used by NIH:

Overall Impact. Reviewers will provide an overall impact/priority score to reflect their assessment of the likelihood for the project to exert a sustained, powerful influence on the research field(s) involved, in consideration of the following five core review criteria, and additional review criteria (as applicable for the project proposed). Reviewers will consider each of the review criteria below in the determination of scientific merit. An application does not need to be strong in all categories to be judged likely to have major scientific impact. For example, a project that by its nature is not innovative may be essential to advance a field.

Significance. Does the project address an important problem or a critical barrier to progress in the field? If the aims of the project are achieved, how will scientific knowledge, technical capability, and/or clinical practice be improved? How will successful completion of the aims change the concepts, methods, technologies, treatments, services, or preventative interventions that drive this field?

Investigator(s). Are the PD(s)/PI(s), collaborators, and other researchers well suited to the project? If Early Stage Investigators or New Investigators, or in the early stages of independent careers, do they have appropriate experience and training? If established, have they demonstrated an ongoing record of accomplishments that have advanced their field(s)? If the project is collaborative or multi-PD/PI, do the investigators have complementary and integrated expertise; are their leadership approach, governance and organizational structure appropriate for the project?

Innovation. Does the application challenge and seek to shift current research or clinical practice paradigms by utilizing novel theoretical concepts, approaches or methodologies, instrumentation, or interventions? Are the concepts, approaches or methodologies, instrumentation, or interventions novel to one field of research or novel in a broad sense? Is a refinement, improvement, or new application of theoretical concepts, approaches or methodologies, instrumentation, or interventions proposed?

Approach. Are the overall strategy, methodology, and analyses well-reasoned and appropriate to accomplish the specific aims of the project? Are potential problems, alternative strategies, and benchmarks for success presented? If the project is in the early stages of development, will the strategy establish feasibility and will particularly risky aspects be managed?

If the project involves human subjects and/or NIH-defined clinical research, are the plans to address 1) the protection of human subjects from research risks, and 2) inclusion (or exclusion) of individuals on the basis of sex/gender, race, and ethnicity, as well as the inclusion or exclusion of children, justified in terms of the scientific goals and research strategy proposed?

Environment. Will the scientific environment in which the work will be done contribute to the probability of success? Are the institutional support, equipment and other physical resources available to the investigators adequate for the project proposed? Will the project benefit from unique features of the scientific environment, subject populations, or collaborative arrangements?

Where applicable, the following items will also be considered:

Protections for Human Subjects. For research that involves human subjects but does not involve one of the six categories of research that are exempt under 45 CFR Part 46, the committee will evaluate the justification for involvement of human subjects and the proposed protections from research risk relating to their participation according to the following five review criteria: 1) risk to subjects, 2) adequacy of protection against risks, 3) potential benefits to the subjects and others, 4) importance of the knowledge to be gained, and 5) data and safety monitoring for clinical trials.

For research that involves human subjects and meets the criteria for one or more of the six categories of research that are exempt under 45 CFR Part 46, the committee will evaluate: 1) the justification for the exemption, 2) human subjects involvement and characteristics, and 3) sources of materials. For additional information on review of the Human Subjects section, please refer to the [Human Subjects Protection and Inclusion Guidelines](#).

Inclusion of Women, Minorities, and Children. When the proposed project involves human subjects and/or NIH-defined clinical research, the committee will evaluate the proposed plans for the inclusion (or exclusion) of individuals on the basis of sex/gender, race, and ethnicity, as well as the inclusion (or exclusion) of children to determine if it is justified in terms of the scientific goals and research strategy proposed. For additional information on review of the Inclusion section, please refer to the [Guidelines for the Review of Inclusion in Clinical Research](#).

Vertebrate Animals. The committee will evaluate the involvement of live vertebrate animals as part of the scientific assessment according to the following five points: 1) proposed use of the animals, and species, strains, ages, sex, and numbers to be used; 2) justifications for the use of animals and for the appropriateness of the species and numbers proposed; 3) adequacy of veterinary care; 4) procedures for limiting discomfort, distress, pain and injury to that which is unavoidable in the conduct of scientifically sound research including the use of analgesic, anesthetic, and tranquilizing drugs and/or comfortable restraining devices; and 5) methods of euthanasia and reason for selection if not consistent with the [AVMA Guidelines on Euthanasia](#). For additional information on review of the Vertebrate Animals section, please refer to the [Worksheet for Review of the Vertebrate Animal Section](#).

Biohazards. Reviewers will assess whether materials or procedures proposed are potentially hazardous to research personnel and/or the environment, and if needed, determine whether adequate protection is proposed.

Budget and Period of Support. Reviewers will consider whether the budget and the requested period of support are fully justified and reasonable in relation to the proposed research.

For those proposals that are selected for funding consideration by participating NIH Institutes, the NIH will ask the applicant(s) to resubmit the proposal in an NIH-approved format directly to the Center for Scientific Review (CSR) at the NIH. Each of these NIH applications will be accompanied by a cover letter that associates the application with CPS. Applicants will not be allowed to increase the proposed budget or change the scientific content of the application in the resubmission to the NIH. These NIH applications, along with the summary statements generated based on the review, will be entered into the NIH IMPAC-II system.

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.

Reverse Site Visit may include a combination of NSF, other Government, and/or other external reviewers

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

NIH Process: For those proposals that are selected for potential funding by participating NIH Institutes, the PI will be required to resubmit the proposal in an NIH-approved format directly to the Center for Scientific Review (<http://www.csr.nih.gov>) of the NIH. PIs invited to resubmit to NIH will receive further information on resubmission procedures from NIH. An applicant will not be allowed to increase the proposed budget or change the scientific content of the proposal in the resubmission to the NIH as an NIH application. Indirect costs on any foreign subawards/subcontracts will be limited to eight (8) percent. These NIH applications will be entered into the NIH IMPAC II system. The results of the review will be presented to the involved Institutes' National Advisory Councils for the second level of review. Subsequent to the Council reviews, NIH Institutes will make their funding determinations and selected awards will be made. Subsequent grant administration procedures for NIH awardees, including those related to New and Early Stage Investigators (<http://www.niaid.nih.gov/researchfunding/grant/Pages/aag.aspx>), will be in accordance with the policies of NIH. Applications selected for NIH funding will use the NIH funding mechanisms.

Proposals that are funded by NIH are expected to be renewed as competing continuing applications. PIs should contact their NIH Program Officer for additional information. For information purposes, NIH PIs may wish to consult the NIAID web site, "All about Grants," which provides excellent generic information about all aspects of NIH grantsmanship, including competitive renewals (<http://www.niaid.nih.gov/researchfunding/grant/Pages/aag.aspx>).

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

B. Award Conditions

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

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

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

Special Award Conditions:

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/NIH/USDA-NIFA Cyber-Physical Systems Program."

DHS and DOT Award Administration and Conditions:

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

NIH Award Conditions:

Contact the cognizant NIH organization Program Officer for additional information.

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 <http://nifa.usda.gov/responsible->

[and-ethical-conduct-research](#) for more 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 project report, and a project outcomes report for the general public.

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

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

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

DHS and DOT:

Applications 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.

NIH:

Contact the cognizant NIH organization Program Officer for additional information.

USDA/NIFA:

Expected Program Outputs and Reporting Requirements:

The output and reporting requirements are included in the award terms and conditions (see <https://www.nifa.usda.gov/business/awards/awardterms.html> 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 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: <https://nifa.usda.gov/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 <https://nifa.usda.gov/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, Program Director CISE/CNS, telephone: (703) 292-8754, email: dcorman@nsf.gov
- Sandip Roy, Program Director CISE/CNS, telephone: (703) 292-8950, email: saroy@nsf.gov
- Ralph Wachter, Program Director, CISE/CNS, telephone: (703) 292-8950, email: rwachter@nsf.gov
- Michal Ziv-El, Associate Program Director, telephone: (703) 292-8950, email: mzivel@nsf.gov
- Linda Bushnell, Program Director CISE/CNS, telephone: (703) 292-8950, email: lbushnel@nsf.gov
- Nina Amla, Program Director CISE/CNS, telephone: (703) 292-7991, email: namla@nsf.gov
- Sankar Basu, Program Director CISE/CCF, telephone: (703) 292-7843, email: sabasu@nsf.gov
- Phillip A. Regalia, Program Director, CISE/CCF, telephone: (703) 292-2981, email: pregalia@nsf.gov
- Wendy Nilsen, Program Director, CISE/IIS, telephone: (703) 292-2568, email: wnilsen@nsf.gov
- Sylvia Spengler, Program Director, CISE/IIS, telephone: (703) 292-8930, email: sspengle@nsf.gov
- Jordan Berg, Program Director, ENG/CMMI, telephone: (703) 292-5365, email: jberg@nsf.gov
- Bruce Kramer, Program Director, ENG/CMMI, telephone: (703) 292-5348, email: bkramer@nsf.gov

- Yueyue Fan, Program Director CMMI / ENG, telephone: (703) 292-4453, email: yfan@nsf.gov
- Robert Landers, Program Director, ENG/CMMI, telephone: (703) 292-2652, email: rlanders@nsf.gov
- Radhakisan Baheti, Program Director, ENG/ECCS, telephone: (703) 292-8339, email: rbaheti@nsf.gov
- Anthony Kuh, Program Director, ENG/ECCS, telephone: (703) 292-2210, email: akuh@nsf.gov
- Anil Pahwa, Program Director, ENG/ECCS, telephone: (703) 292-2285, email: apahwa@nsf.gov
- Steven Thomson, National Program Leader, USDA/NIFA, telephone: (202) 603-1053, email: Steven.J.Thomson@nifa.usda.gov
- David Kuehn, Program Manager, DOT/FHWA, telephone: (202) 493-3414, email: david.kuehn@dot.gov
- Christos Papadopoulos, Program Manager, DHS S&T, telephone: (202) 254-2422, email: christos.papadopoulos@hq.dhs.gov
- Christopher Hartshorn, Program Director, NCI/DCTD/CIP/NSDB, telephone: (240) 781-3315, email: hartshorncm@mail.nih.gov
- Danilo Tagle, Associate Director for Special Initiatives, NIH/NCATS, telephone: (301) 594-8064, email: danilo.tagle@nih.gov
- Tiffani Lash, Program Director NIH/NBIB, telephone: (301) 451-4778, email: tiffani.lash@nih.gov
- Dana Wolff-Hughes, Health Scientist Administrator, NIH/OBSSR, telephone: (301) 496-0979, email: dana.wolff@nih.gov

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

- FastLane and Research.gov Help Desk: 1-800-673-6188
FastLane Help Desk e-mail: fastlane@nsf.gov
Research.gov Help Desk e-mail: rgov@nsf.gov

For questions relating to Grants.gov contact:

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

IX. OTHER INFORMATION

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

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

U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) Homeland Security Advanced Research Projects Agency (HSARPA):

<http://www.dhs.gov/st-hsarpa>

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

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

National Institutes of Health (NIH):

National Institute of Biomedical Imaging and Bioengineering (NIBIB):

<http://www.nibib.nih.gov>

National Cancer Institute (NCI):

<http://www.cancer.gov/>

National Center for Advancing Translational Sciences (NCATS):

<http://www.ncats.nih.gov/>

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

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

<https://nifa.usda.gov/policy-guide>

ABOUT THE NATIONAL SCIENCE FOUNDATION

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

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

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

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

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

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

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

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

- **Location:** 2415 Eisenhower Avenue, Alexandria, VA 22314
- **For General Information** (NSF Information Center): (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**
 - Send an e-mail to: nsfpubs@nsf.gov
 - or telephone: (703) 292-7827
- **To Locate NSF Employees:** (703) 292-5111

PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See [System of Record Notices](#), NSF-50, "Principal Investigator/Proposal File and Associated Records," and NSF-51, "Reviewer/Proposal File and Associated Records." Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

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

Suzanne H. Plimpton

Reports Clearance Officer
Office of the General Counsel
National Science Foundation
Alexandria, VA 22314

X. APPENDIX

Legislative Authority:

The USDA-NIFA authority for this solicitation is contained in section 2(b) of the Competitive, Special, and Facilities Research Grant Act (7 U.S.C. 450i(b)), of the Agriculture and Food Research Initiative (AFRI). AFRI authorizes the Secretary of Agriculture to award competitive grants for fundamental and applied research, extension, and education to address food and agricultural sciences. AFRI awards are subject to the NIFA regulations found at 7 CFR Part 3430. NIFA's authority to participate in the issuance of a joint RFA is 7 U.S.C. § 3319b.

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