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National Robotics Initiative 2.0: Ubiquitous Collaborative Robots (NRI-2.0)

PROGRAM SOLICITATION
NSF 19-536

REPLACES DOCUMENT(S):
NSF 18-518

National Science Foundation

Directorate for Computer & Information Science & Engineering
Division of Information & Intelligent Systems

Directorate for Engineering

Directorate for Education & Human Resources

Directorate for Social, Behavioral & Economic Sciences

U.S. Dept. of Agriculture

National Institute of Food and Agriculture

U.S. Dept. of Energy

U.S. Department of Energy - Office of Environmental Management (EM)

Department of Defense

Defense Advanced Research Projects Agency

Air Force Office of Scientific Research

Office of Naval Research

National Aeronautics and Space Administration

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

February 19, 2019

January 22, 2020

Fourth Wednesday in January, Annually Thereafter

IMPORTANT INFORMATION AND REVISION NOTES

This solicitation is a revision of NSF 18-518, the solicitation for the National Robotics Initiative (NRI-2.0).

The significant changes in the FY 2019 NRI-2.0 solicitation are as follows:

- The deadline has been revised;
- The research thrust of **lowering barriers to entry** has been further described;
- Emphasis has been added that multi-investigator proposals **MUST** include a separate Collaboration Plan, even if the investigators are from the same institution; and
- NASA has been added as a partner organization for Foundational projects only.

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

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

National Robotics Initiative 2.0: Ubiquitous Collaborative Robots (NRI-2.0)

Synopsis of Program:

The NRI-2.0 program builds upon the original National Robotics Initiative (NRI) program to support fundamental research in the United States that will accelerate the development and use of collaborative robots (co-robots) that work beside or cooperatively with people. The focus of the NRI-2.0 program is on **ubiquity**, which in this context means seamless integration of co-robots to assist humans in every aspect of life.

The program supports four main research thrusts that are envisioned to advance the goal of ubiquitous co-robots: **scalability**, **customizability**, **lowering barriers to entry**, and **societal impact**. Topics addressing **scalability** include how robots can collaborate effectively with multiple humans or other robots; how robots can perceive, plan, act, and learn in uncertain, real-world environments, especially in a distributed fashion; and how to facilitate large-scale, safe, robust and reliable operation of robots in complex environments. **Customizability** includes how to enable co-robots to adapt to specific tasks, environments, or people, with minimal modification to hardware and software; how robots can personalize their interactions with people; and how robots can communicate naturally with humans, both verbally and non-verbally. Topics in **lowering barriers to entry** should focus on lowering the barriers for conducting fundamental robotics research and research on integrated robotics application. This may include development of open-source co-robot hardware and software, as well as widely-accessible testbeds. Outreach or using robots in educational programs do not, by themselves, lower the barriers to entry for robotics research. Topics in **societal impact** include fundamental research to establish and infuse robotics into educational curricula, advance the robotics workforce through education pathways, and explore the social, economic, ethical, and legal implications of our future with ubiquitous collaborative robots.

Collaboration between academic, industry, non-profit, and other organizations is encouraged to establish better linkages between fundamental science and engineering and technology development, deployment, and use.

The NRI-2.0 program is supported by multiple agencies of the federal government including the National Science Foundation (NSF), the U.S. Department of Agriculture (USDA), the U.S. Department of Energy (DOE), the National Aeronautics and Space Administration (NASA), and the U.S. Department of Defense (DOD). Questions concerning a particular project's focus, direction and relevance to a participating funding organization should be addressed to that agency's point of contact, listed in section VIII of 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.

For a full listing of agency contacts see Section VIII. of this solicitation.

- David Miller, CISE/IIS, telephone: (703) 292-4914, email: damiller@nsf.gov
- Radhakisan Baheti, ENG/ECCS, telephone: (703) 292-8339, email: rbaheti@nsf.gov
- Jordan Berg, telephone: (703) 292-5365, email: jberg@nsf.gov
- Irina Dolinskaya, ENG/CMMI, telephone: (703) 292-7078, email: idolinsk@nsf.gov
- James Donlon, CISE/IIS, telephone: (703) 292-8074, email: jdonlon@nsf.gov
- Ephraim P. Glinert, CISE/IIS, telephone: (703) 292-8930, email: eglinert@nsf.gov
- David L. Haury, EHR/DRL, telephone: (703) 292-5102, email: dhaury@nsf.gov
- Tatiana Korelsky, CISE/IIS, telephone: (703) 292-8930, email: tkorelsk@nsf.gov
- Bruce Kramer, ENG/CMMI, telephone: (703) 292-5348, email: bkramer@nsf.gov

- Frederick M. Kronz, SBE/OAD, telephone: (703) 292-7283, email: fkronz@nsf.gov
- Dmitry Maslov, CISE/CCF, telephone: (703) 292-8910, email: dmaslov@nsf.gov
- Wendy Nilsen, CISE/IIS, telephone: (703) 292-2568, email: wnilsen@nsf.gov
- Robert Scheidt, ENG/CMMI, telephone: 703-292-2477, email: rscheidt@nsf.gov
- Ralph Wachter, CISE/CNS, telephone: (703) 292-8950, email: rwachter@nsf.gov
- Jie Yang, CISE/IIS, telephone: (703) 292-4768, email: jyang@nsf.gov

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

- 10.310 --- USDA-NIFA Agriculture and Food Research Initiative
- 12.800 --- Air Force Office of Scientific Research
- 43.001 --- National Aeronautics and Space Administration (Science)
- 47.041 --- Engineering
- 47.070 --- Computer and Information Science and Engineering
- 47.075 --- Social Behavioral and Economic Sciences
- 47.076 --- Education and Human Resources
- 81.049 --- Office of Science Financial Assistance Program
- 81.104 --- Environmental Remediation and Waste Processing and Disposal

Award Information

Anticipated Type of Award:

Standard Grant or Continuing Grant or Cooperative Agreement or contract vehicles as determined by the supporting agency

Estimated Number of Awards: 40 to 60

per year, subject to the availability of funds.

Foundational projects will range from $250,000 to $750,000 in total costs for up to three years. Integrative projects will range from $500,000 to $1,500,000 in total costs for up to four years. Please refer to Section III for agency-specific budget criteria.

Anticipated Funding Amount: $25,000,000 to $35,000,000 per year, subject to the 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 investigator may participate as PI, co-PI, or Senior Personnel in **no more than two proposals** submitted in response to this solicitation each year.

In the event that an individual exceeds this limit, 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.**

The above limit applies only to proposals to the NRI-2.0 solicitation, not to the totality of proposals submitted to NSF.

Proposals submitted in response to this solicitation may not duplicate or be substantially similar to other proposals concurrently under consideration by other NSF, DOD, DOE, NASA, or USDA programs. Duplicate or substantially similar proposals will be returned without review, including those substantially similar to previously declined proposals without revisions to address concerns raised by reviewers.

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 NSF, PAPPG guidelines apply.

  For DOD, DOE and NASA, contact the cognizant program officer. See Section VIII for contact information.

  For awards made by USDA/NIFA: Section 713 of the Consolidated and Further Continuing Appropriations Act, 2018 (Pub. L. 115-141) limits indirect costs to 30 percent of the total Federal funds provided (or 42.857 percent of total direct costs) under each award. Similar language may be included in the FY 2019 appropriation; 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 for further indirect cost information.

- **Other Budgetary Limitations:**

  Not Applicable

C. Due Dates

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

  February 19, 2019

  January 22, 2020

  Fourth Wednesday in January, Annually Thereafter

Proposal Review Information Criteria

Merit Review Criteria:

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

Award Administration Information

Award Conditions:

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

Reporting Requirements:

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

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I. INTRODUCTION

In the future, robots may become as commonplace as today's automobiles, computers, and cell phones. Robots will be in homes and offices; assisting in hospitals, classrooms, and factories; helping to run farms and mines; and exploring in air, on land, under water, and in space. They will be helping the elderly and people with disabilities in their activities of daily living. They will help in performing mundane or dangerous tasks. They will be among the first responders at natural disasters, rescuing people in need and protecting humans from hazards. Teams of humans and co-robots, large and small, will reliably and efficiently cooperate, enriching the quality of life and work for individuals and society alike.

The NRI-2.0 program seeks research on the fundamental science, technologies, and integrated systems needed to achieve this vision of **ubiquitous collaborative robots**. The NRI-2.0 program builds upon the original NRI program to focus on **ubiquity**: the seamless integration of co-robots into every aspect of human society, and beyond. To achieve this goal, the NRI-2.0 program focuses on research into innovative computational algorithms, designs, modeling, and analytical techniques in four main areas critical to achieving ubiquitous co-robots: **scalability, customizability, lowering barriers to entry,** and **societal impact**.

In terms of this program, **scalability** means how robots can collaborate effectively as their numbers increase dramatically. This includes having robots coordinate with multiple other humans or robots, forming **co-robot teams**. To achieve scalability, co-robots will require fundamental advances in perception, planning, acting, and learning. Such activities may need to be done in a distributed fashion, and may need to leverage other resources, including the cloud, software agents, or other devices, such as cell phones and the Internet of Things. For large co-robot teams, innovative approaches will be needed to manage large-scale physical and digital resources. To facilitate acceptability, robot behavior will need to be transparent, explainable, and legible. It is anticipated that this focus will necessitate new robot designs and new software architectures, especially to facilitate capabilities for inherent safety, safe failure and recovery modes, and self-diagnosis and self-repair.

For the purposes of this program, **customizability** means the ability of robots to easily adapt to new situations and new people. Customizable robots will be able to achieve a wide variety of tasks, in a wide variety of situations, and for a wide diversity of people, with little, or no, change to the underlying hardware and software. They should be able to learn about their tasks, environments, and human preferences, and personalize their interactions accordingly. Co-robots will need effective multi-modal communication, with both novices and experts, using verbal, physical and affective communication channels. They will also need to perceive or infer the behavior and intent of others, plan and learn from both human and robot collaborators, and interact with them physically.

Research addressing **lowering barriers to entry** is aimed at broadening access to co-robots by the larger research community, students, and entrepreneurs. Approaches may include innovative, low-cost, open-source hardware and software, architectures, shareable testbeds, and other resources that can be easily used and augmented. For remote-access testbeds, where the goal is to share robot testbeds with remote users with varying skills, innovative research is needed in immersive, flexible user interfaces; real-time, low-latency performance; safe reachable states; and design trade-offs to meet various constraints.

Finally, research addressing **societal impact** of ubiquitous co-robots will bring to the forefront educational, social, economic, ethical, and legal issues. This program encourages fundamental research to establish and infuse robotics into educational curricula and advance the robotics workforce through education pathways, and to understand the social and economic impacts of robots on our work, our social institutions, and our quality of life. Pertinent research questions may address the social and economic impact of robots on our work, our social institutions, and our quality of life and work. Relevant topics include understanding the complexities of the future co-robot economy; how economic and social inequality will be affected by ubiquitous co-robots; what policies could be instituted to ensure that all stakeholder groups benefit from the presence of co-robots in our everyday lives; and how co-robot algorithms can be developed to ensure that co-robot behavior is consonant with ethical and legal norms, thereby promoting responsible research and innovation.

The NRI-2.0 program seeks to strengthen the robotics research community, fostering innovation and workforce development, accelerating progress, demonstrating novel capabilities, and building ecosystems for innovation. The program seeks to promote research to enable greater adaptability and resilience of robot behaviors, leading to more capable, robust systems. The program also seeks to promote new approaches to the challenges of accountability, interoperability, and trust, which will doubtless be engendered by the vision of ubiquitous co-robots.

The NRI-2.0 program represents a natural evolution in robotics research and the co-robot perspective that is in alignment with the report to the House Robotics Caucus Advisory Committee of the U.S. Congress, "A Roadmap for U.S. Robotics From Internet to Robotics" (http://www.us-robotics.us/reports/CCC%20Report.pdf), first published in 2009 and updated in 2016 (http://jacobsschool.ucsd.edu/contextualrobotics/docs/rm3-final-rs.pdf). Other informative reference reports include the *Office of the Secretary of Defense Unmanned Systems Integrated Roadmap: FY 2013-2038* (http://www.dtic.mil/dtic/tr/fulltext/u2/a592015.pdf) and the *WTEC Panel Report on International Assessment of Research and Development In Robotics* (http://www.wtec.org/robotics/report/screen-robotics-final-report.pdf).

II. PROGRAM DESCRIPTION

Building upon the successes of the National Robotics Initiative (NRI), the goal of the NRI-2.0 program is to support fundamental research that will accelerate the development and use of robots in the United States that work beside or cooperatively with people. Innovative robotics research and applications emphasizing the realization of ubiquitous co-robots is supported by multiple agencies of the federal government including the National Science Foundation (NSF), U.S. Department of Agriculture (USDA), U.S. Department of Energy (DOE), National Aeronautics and Space Administration (NASA), and U.S. Department of Defense (DOD).

The NRI-2.0 program significantly expands the focus of the original NRI program to focus on **ubiquitous co-robots**. This includes themes of:

- **Scalability**: how robots can collaborate effectively with teams of humans or other robots; how they can perceive, plan, act, and learn in uncertain, real-world environments, especially in a distributed fashion; and how they can operate safely, robustly, and reliably in large-scale, complex environments;
- **Customizability**: how robots can adapt to a variety of tasks, environments, and people, with minimal modification to hardware and software; how they can learn to be personalized in their interactions with people; and how they can communicate naturally, both verbally and non-verbally;
- **Lowering barriers to entry**: how the design of the robots' hardware and software can reduce the cost and learning curve related to doing serious robotics research; and how testbeds and other shareable resources can be developed to facilitate robotics research; and
- **Societal impact**: how ubiquitous co-robots affect the social, economic, ethical, legal, and educational aspects of our everyday lives.

To achieve the vision of the NRI-2.0 program, funding will support foundational research in robotics science and technology, including novel approaches, algorithms, designs, representations, and analyses, as well as innovative research in integrated robotic systems. While disciplinary research is important, the NRI-2.0 program also encourages cross-disciplinary projects. Collaboration among academic, industry, government, non-profit, and other organizations is encouraged to establish better linkages between fundamental science and engineering and technology development and use, through partnerships among researchers, applications developers, users and industry. International collaborations that enhance and add significant value to the proposed research and education activities will also be considered. While NRI-2.0 encourages projects that include some aspects of technology development, fundamental research should dominate. Proposers focused on developmental work are encouraged to consider submission to the Small Business Innovative Research (SBIR) or Small Technology Transfer Research (STTR) programs (https://seedfund.nsf.gov).

II.A. Program Scope

All proposals submitted to NRI-2.0 should support the research themes, listed in Section II.A.1, that are the primary foci of the NRI-2.0 program.

Section II.A.2 defines the two classes of proposals – Foundational and Integrative – that will be supported by the program.

Proposals to this solicitation may be selected for funding by any of the sponsoring agencies, although all proposals will go through a uniform review process. Proposals of special relevance to sponsoring agencies listed in this solicitation should address the domain-specific interests listed in Section II.A.3, Sponsoring Agency Mission-Specific Research.

Within NSF, the NRI-2.0 program is administered jointly by the Directorate for Computer and Information Science and Engineering (CISE) and the Directorate for Engineering (ENG). Supporting directorates include the Directorate for Education and Human Resources (EHR) and the Directorate for Social, Behavioral & Economic Sciences (SBE). Within USDA, the program is led by the National Institute of Food and Agriculture (NIFA). Within DOD, the program is led by the Deputy Assistant Secretary of Defense for Research, and is supported by multiple departments and agencies. Within DOE, the program is led by the Assistant Secretary for Environmental Management and is supported by multiple offices and agencies. Contacts for these and related activities at other sponsoring agencies can be found in Section VIII of this solicitation.

Those proposals that are targeting a specific agency sponsorship should indicate so in the last line of the last box of the Project Summary, e.g., "Requested funding agency:" followed by that agency's abbreviated name ("NSF," "USDA," "DOE," "NASA", or "DOD"), but only if they 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 of the joint sponsoring agencies.

II.A.1. Research Themes

This section presents the main research themes that are fundamental for achieving the overall program goals. While this list of themes and sub-themes is not exhaustive, proposers are encouraged to incorporate one or more of the sub themes into their proposals. In all

cases, proposers are reminded that NRI-2.0 proposals **must** show a compelling connection to the overall goal of enabling ubiquitous co-robots.

- *Scalability:*
  - Enable robots to collaborate and coordinate effectively with multiple other agents, either people or robots;
  - Enable robotic systems to reliably perceive, act, plan, and learn, especially in a distributed fashion;
  - Enable shared learning among co-robots and through digital media;
  - Investigate approaches to managing data produced/consumed by robots, especially data shared among agents;
  - Enable transparent, explainable, and legible robot behavior;
  - Investigate designs and controls for facilitating ubiquitous interaction and for making co-robots inherently safe (e.g., soft robots); and
  - Investigate hardware and software approaches to enhance robustness and reliability, and enable robots to fail, recover, and resume safely and gracefully.
- *Customizability:*
  - Investigate approaches for robots achieving a variety of tasks in a variety of situations, with minimal changes to hardware and software;
  - Enable robots to learn efficiently from direct experience with people or other robots, especially to personalize interactions;
  - Enable natural interaction with users, including use of language and non-verbal communication (e.g., gesture, visual, movement, tactile);
  - Enable effective interaction with experts, including through remote operation;
  - Enable robots to reliably recognize and predict the behavior and activities of others;
  - Investigate social intelligence in robots, including use of mental models, perspective taking, and joint attention; and
  - Facilitate physical collaboration, including physical human-robot interaction and augmentation of human capabilities.
- *Lowering Barriers to Entry:*
  - Develop robust, easy-to-use infrastructure for software, hardware, and systems;
  - Investigate composable hardware or software that supports the development of ubiquitous co-robots;
  - Investigate innovative programming languages/paradigms for robots;
  - Develop techniques that would facilitate shareable physical testbeds, especially techniques to make existing testbeds easily available communally (see also Section II.B); and
  - Develop shareable resources, such as software and data.
- *Societal Impact:*
  - Investigate the impact of ubiquitous co-robots on social and economic equality;
  - Investigate possible economic and governance policies;
  - Investigate ethical and legal issues related to ubiquitous co-robots;
  - Investigate issues of trust with respect to ubiquitous co-robots;
  - Investigate issues related to teamwork and integration, partnerships, and worker training for collaboration with robots; and
  - Develop innovative uses for co-robots in education (see also Section II.C).

Note: while security and privacy are also important issues for ubiquitous co-robots, proposals in such areas should be sent to other relevant NSF programs, such as Secure and Trustworthy Cyberspace (SaTC, https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504709).

II.A.2. Classes of Projects

There are two classes of NRI-2.0 projects, with differing requirements and budget ranges. While there will not be a separate competition for the two classes, they will be evaluated using somewhat different criteria.

Foundational (FND) projects focus on fundamental research into technologies that directly support the vision of the NRI-2.0 program. Such projects should lead to transformative approaches that address scientific or technology gaps that currently limit the development, use, or acceptance of co-robots in society. Proposals should clearly explain how the proposed results will further the overall program vision of ubiquitous co-robots. Foundational projects will be in the range of $250,000 to $750,000 in total budget, with durations of up to three years.

Integrative (INT) projects focus on research in the innovative integration of technologies leading to complete co-robotic systems that support the vision of the NRI-2.0 program. Integrative projects must include rigorous evaluation on physical robots, preferably in real-world settings. This evaluation should follow the scientific methodology, including statement of the formal hypotheses, controlled experiments, evaluation metrics, and statistical analyses of the results. Integrative projects should have a longer-term vision, with objectives that could not be attained simply by a collection of smaller projects provided with similar resources. The overall impact to the science of the NRI-2.0 program should be greater than the sum of each individual investigator contributions. Integrative projects should include multiple PIs, preferably from different disciplines. Integrative projects will be in the range of $500,000 to $1,500,000 in total budget, with durations of up to four years.

II.A.3. Sponsoring Agency Mission-Specific Research

NSF will consider for funding proposals addressing any of the research themes described above in Section II.A.1, as well as those described below and in Sections II.B and II.C.

DOD encourages basic research in robotics to support the United States Department of Defense's broad vision for the use of autonomous systems to achieve capability increases and cost savings via increased manpower efficiencies, increased capability, and reduced manpower needs. According to this vision, the value of autonomous and robotics systems is not to replace humans, but to build human-robot teams that complement each other and extend the team's capability to perform a mission. Central to the goal of effective human-robot teaming is the establishment of trust between humans and robots. Research is needed to investigate behaviors, processes and capabilities that support properly calibrated human-robot trust. Examples of research areas on trusted human-robot teaming include the following: (1) investigating socially-designed cues such as humanoid appearance, voice, personality, and other social elements on human trust and overall human-robot team performance; (2) physical "embodiment" features versus non-physical features to determine which have the most influence on human trust and performance; (3) sensing of human intent, cognitive and

affective states, such as workload, stress, fatigue, and fear, since a true robot teammate should know how to help when the humans in the group are falling behind; (4) modeling the processes of high-performing human teams, such as teammate monitoring, backup behavior, joint attention, shared mental models, coordination and negotiation; (5) dynamic modeling of the human-robot partnerships to allow continuous improvement of joint performance in real-world applications; (6) investigations regarding the effectiveness of various models of human-robot interaction, such as delegation and supervisory control; (7) practical methods for robotic systems to sense and measure trust and changes in trust over time; (8) investigations of the impact of culture and cross-cultural interactions on reliance and human-machine cooperation; and (9) investigating methods for safe physical interactions between robots and their collaborators and environment, such as enabling the robots to holistically consider decision-making processes, physical capabilities, and goals to formulate and implement safe failure modes to reduce the probability of harm. Interdisciplinary research and research in collaboration with government labs [e.g., Air Force Research Lab (AFRL), Naval Research Laboratory (NRL), Army Research Laboratory (ARL)] is especially encouraged.

DOE/EM encourages robotics research and technology development for: (1) handling of high-hazard, high-consequence materials and waste; (2) tasks that are dirty, dull, dangerous, and/or difficult to perform; (3) easing the performance of worker/operator tasks that are physically demanding on or stressful to human body or are otherwise ergonomically challenging; (4) performing tasks that are beyond human abilities; (5) improving the ability to respond to and recover from unplanned events or operational emergencies; and (6) improving the safety, quality, efficiency, and productivity of facility operations.

DOE/EM's tasks and environments present unique challenges in the integration of robotics systems. Proposals that demonstrate awareness of these challenges and include plans for integrating and/or demonstrating prototype systems in relevant environments are encouraged. Such proposals typically require close coordination and collaboration with government national laboratories and prime contractors. Robotic solutions that address chemical, biological, radiological, nuclear, explosive, and environmental challenges are sought. Those that address operational upsets, off-normal events, emergencies, and disasters are also sought.

Topics and areas of academic, scientific and engineering pursuit for the application of DOE/EM robotics technologies include but are not limited to:

- *Wearable Robotic Devices for Workers:* DOE/EM seeks wearable, prosthetic-like, exoskeletal, bionic, and other attachable human assistive robotic devices that can serve the workforce by functioning as (1) smart personal protective equipment (PPE) and/or (2) performance augmentation and amplification devices (PAADs).

  Traditional PPE (e.g., hard hats, safety glasses, and steel-toed shoes) is designed to protect workers from external injuries caused by exposure to workplace and environmental hazards. Wearable robotic devices, on the other hand, can protect workers from internal injuries due to, for example, overexertion, bodily reaction, repetitive motion, hyper extensions, over-rotation, excessive and repetitive vibration, and even the latent effects of aging. The integration of sensing devices provides added protection.

  Wearable robotic devices also serve as PAADs. They can enable workers to perform tasks that are physically stressful or demanding, mentally taxing, ergonomically challenging, or even beyond human capability. This allows workers to perform tasks with much greater ease and efficiency as well as with improved safety and quality.

- *Gaining Remote Access:* DOE/EM is pursuing robots that provide remote access to areas and spaces that are inaccessible or prohibit direct entry by workers due to: (1) unsafe, unstable, or unknown physical or structural conditions; (2) configurations that are hard to reach or beyond reach without taking extraordinary mechanical measures; or (3) the presence or potential presence of chemical, biological, radiological, or physical hazards that will or may result in unacceptable occupational exposure or increased health or safety risk. Other workplace conditions that preclude safe worker entry or are otherwise uninhabitable include those that: are oxygen-deprived or have poor air quality; have explosive gases, materials or devices; have extreme temperatures or extreme pressures; have poor or no visibility, no direct line of sight, or are dimly lit; and are submerged or consist of substantially liquid-covered surfaces. Robotic devices help to keep occupational exposures as low as reasonably achievable.
- *Glovebox Operations:* Gloveboxes have widespread use for the handling of radioactive and nuclear materials within an enclosed, hermetically sealed, and controlled environment. Gloveboxes are typically robust, self-standing structures that are not easily moved or adjusted. Their design features create ergonomic challenges for operators of different heights, torso sizes, arm lengths, and hand sizes. Maintenance can become costly as gloves routinely require replacement.

  DOE/EM is pursuing advanced robotic technologies that will address challenges associated with doing work within a glovebox. The integration of robotic arms and hands that can be tele-operated by an operator, for example, can offer increased ability (dexterity, fine motor skills and grip), efficiency (work longer and with more focus), capability (added strength and extended reach), and safety (improved ergonomics).

- *Multi-Use and Multi-User (MU2) Robotic Technologies:* DOE/EM is pursuing dual-purpose robotic technologies that can be used to support normal as well as off-normal operations - that is, MU2 robots that are used to perform routine operations and can also be deployed in response to emergencies. For example, an assistive robot that is used by a health physics technician for performing routine radiological surveys can also be deployed by a first-responder to screen for the presence of airborne radioactivity prior to entering an area.

For many DOE/EM applications, including some of those described above, robotics systems that have some degree of radiation tolerance and/or can be decontaminated are of interest. Proposals that address radiological tasks and/or environments should consider those unique challenges. Proposals that specifically address robotics for radiological and other extreme environments are also of interest.

NASA seeks research and technology development that will significantly increase the performance of robots to collaboratively support deep space human exploration and science missions. NASA's latest Exploration Campaign highlights objectives to establish a long-term presence in the vicinity of and on the Moon, and to invest in technologies needed for the exploration of Mars and other deep-space destinations. NASA environments present unique challenges for human-robot collaboration, including high communication latencies and limited bandwidth between non-collocated robots and humans, operation in reduced (or zero) gravity environments, and operation on other worlds (with associated issues due to radiation, temperature, illumination, dust, etc.).

Proposals should focus on research and technology development that contribute to the seamless integration and operation of non-

collocated human-robot teams. These teams will experience communication latencies from seconds to hours round-trip, with network bandwidths ranging from a few hundred bits per second to a few megabits per second. Additionally, these teams may intermittently be unable to communicate. Robot team members may be located in habitats (both in-orbit and surface), on planetary surfaces, and underground/underwater on icy and ocean worlds. Human team members may be on Earth, or in orbiting habitats.

Research and technology development should focus on being customizable to both the human and robot, preventing single-system or "one-off" solutions. Robotic systems will be of varying archetypes and modalities – it is expected that many of these systems will be mobile and include manipulation capabilities. Some systems may operate with rich data (from sensors, models, etc.), while others may operate with minimal data derived from limited on-board sensors. NASA's current technology roadmap cites critical technologies needed to enable and advance Human-Systems Interaction, which includes human-robot teams (Technology Area 4.4). In addition, some example research and technology areas include, but are not limited to, the following:

- Strategies to decrease data needed between human and robot while not impacting team performance;
- Remote operator interfaces that increase situational awareness and robotic intent understanding, and that optimize operator workload;
- Autonomous performance monitoring; and
- Autonomous command planning and sequencing.

It is desired that research and technology development include testing to assess human-robot team performance.

NASA's Exploration Campaign is described here: https://www.nasa.gov/feature/nasas-exploration-campaign-back-to-the-moon-and-on-to-mars.

NASA's Technology Roadmaps are available at https://www.nasa.gov/offices/oct/home/roadmaps/index.html.

NASA's Human and Automation/Robotic Integration Risk and Gaps are identified a https://humanresearchroadmap.nasa.gov/risks/risk.aspx?i=163.

NASA's Strategic Plan is available at https://www.nasa.gov/sites/default/files/atoms/files/nasa_2018_strategic_plan.pdf.

USDA/NIFA, consistent with USDA Strategic Goals 2, 5, and 6 (see https://www.usda.gov/sites/default/files/documents/usda-strategic-plan-2018-2022.pdf), encourages robotics research, applications, and education to enhance agricultural production, processing, and distribution systems that benefit consumers and rural communities. These robotics efforts address USDA goals, 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). Projects involving the following topics are particularly desired, although other robotics topics will be considered:

Scalable Robotic Technologies. Examples include the following areas:

- Automated and mechanized intelligent systems that focus on labor-intensive tasks in production and distribution of crops;
- Automated systems for planting, scouting, spraying, culturing, irrigating, and harvesting plant crops (including forests) to decrease costs, improve efficiency, or reduce inputs of water, fertilizer, or chemicals;
- Improved robotics for inspection, monitoring, culturing, sorting, and handling of plants and flowers in controlled environment facilities and nurseries, or for managing or studying (e.g., monitoring, inspecting, sorting, vaccinating, deworming) large numbers of live animals, either domestic or wild;
- Automated systems for inspection, sorting, processing, or handling of animal or plant products (including forest products) in post-harvest, processing, or product distribution environments; and
- Multi-modal and rapid sensing systems for detecting defects, ripeness, physical damage, microbial contamination, size, shape, and other quality attributes of plant or animal products (including forest products), or for monitoring air or water quality.

Configurable Multi-Agent Teams. Examples include the following areas:

- High-level task planning, execution, and control systems for spatially distributed autonomous or semi-autonomous robots that operate in concert with co-workers, either human, robotic, or other devices/systems;
- Innovative use of intelligently-coupled robot drones and unmanned ground vehicles (UGVs) to improve crop and animal management;
- Communication protocols and standards for inter-agent coordination (including natural language) and for unsupervised collaboration; and
- Distributed intelligence, fault tolerance, and "failure with grace" that will allow high-level task completion despite failure of one or more agents (or teams) or temporary loss of human attention.

II.B. Infrastructure and Testbeds

As a way to lower the barrier to entry for robotics researchers and the broader community, this program aims to fund the development of innovative infrastructure projects. As examples, support is available for development of reliable, low-cost, easy-to-use robotic hardware, new paradigms for programming robots (especially teams of co-robots), distributed robot operating systems (especially with connections to the cloud), and design and validation environments for robot hardware and software.

In addition, proposals are encouraged that will develop shareable resources that foster collaborative work environments. Examples include data sets and collections of algorithms of general utility to the community, and approaches to hardware co-robotic testbeds that can be effectively accessed and operated by the community, enabling researchers to perform experiments and collect data remotely. Proposers of such testbeds may want to consider collaborating with a national lab to house and maintain the testbed (see below, for instance), since NSF requires long-term availability and maintainability of any such shareable resource.

To facilitate the advancement of robotics technologies for nuclear applications, DOE/EM is establishing the capability for "radioactive" (rad) testbeds, which are existing DOE/EM nuclear facilities and assets that are utilized as physical platforms for researchers and technologists to demonstrate innovative tooling, treatment technologies, and other technical solutions. These rad testbeds would provide researchers and technologists with unique opportunities to conduct research and technology demonstrations in spaces and areas that (1) have radiation fields; (2) are contaminated with surface and/or fixed radioactivity; (3) are inaccessible, inhabitable, or not

safe for worker entry; and/or (4) are under conditions and configurations of nuclear facilities that are difficult or too expensive to replicate or mock up. Researchers and technologists would also be given the opportunity to use, albeit in small amounts, radioactive wastes and nuclear materials for research and technology demonstrations. DOE/EM encourages the utilization of rad testbeds, particularly when mature technologies originally intended for non-nuclear applications are proposed for nuclear applications.

II.C. Robotic Projects for K-16 Education

To promote further exploration of the linkages of research on ubiquitous collaborative robots to one or more levels of K-16 education, NSF's Directorate for Education and Human Resources will provide funding at the lower end of the Foundational project funding range. Successful projects will advance the vision of ubiquitous co-robots by developing and testing innovative strategies for either: a) engaging students or teachers in the study of robotics in the context of science, technology, engineering, or mathematics (STEM) education; or b) using robotics to enhance teaching and learning in formal or informal STEM education settings. Due to limited funds and the multi-agency nature of this solicitation, **education-focused proposals are discouraged at the higher end of the funding range**.

Example activities are:

- Design of innovative robotic technologies as tools for enhancing STEM learning in formal and informal learning environments;
- Applications that further the development of co-robot systems that support personalized learning;
- Design, implementation, and rigorous study of robotics competitions that impact student engagement, motivation to learn STEM content, and STEM career awareness and interests;
- Research and development of learning experiences and instructional models that integrate co-robotics within STEM courses;
- Development and testing of teacher professional growth opportunities that support increased attention to robotics in school or college settings;
- Research of learning environments and instructional approaches in formal and informal settings to advance workforce preparedness in robotics; and
- Development and testing of education strategies for broadening participation of students from groups underrepresented in education pathways to careers in robotics.

II.D. Principal Investigator Meetings

The NRI-2.0 program anticipates holding annual Principal Investigator (PI) meetings for research investigators, industrial partners, and sponsoring agency representatives. Budgets should account for such trips to the Washington, DC, area for each of the project PIs and other team members as appropriate from all collaborating institutions. These meetings will be highlighted by technology demonstrations and progress reports, and will provide a forum for all to discuss best practices, concerns, and high-risk, high-return ideas and challenges pertinent to the vision of ubiquitous collaborative robots.

III. AWARD INFORMATION

All awards made under this solicitation by NSF, DOD, DOE, NASA, and USDA will be as grants or cooperative agreements or other contract vehicles as determined by the supporting agency. All awards made under this solicitation by USDA/NIFA will be 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.

This solicitation will make awards for two classes of projects. Foundational projects will range from $250,000 to $750,000 **in total costs** for up to three years. Integrative projects will range from $500,000 to $1,500,000 **in total costs** for up to four years. In addition to these **overall** budget ranges, agency requirements and funding mechanisms place limits on **per-year** budget ranges:

- **DOD** will consider projects comprising one or more investigators with budgets ranging from $100,000 to $400,000 **per year in total costs** (direct plus indirect) averaged over the duration of the project, with durations of two to four years. It is expected that the bulk of awards will be made at the lower end of the range.
- **DOE** will consider projects comprising one or more investigators with budgets ranging from approximately $100,000 to $250,000 **per year in total costs** (direct plus indirect) averaged over the duration of the project, with durations of one to three years.
- **NASA** will consider foundational projects with budgets ranging from $85,000 to $150,000 **per year in total costs**(direct plus indirect) averaged over the duration of the project, with durations of up to three years.
- **USDA/NIFA** will consider projects comprising one or more investigators with budgets ranging from $150,000 to $300,000 **per year in total costs** (direct plus indirect) averaged over the duration of the project, with durations of two to four years. Projects exceeding $1,200,000 in total costs may be accepted by USDA/NIFA with prior approval.

The number of awards will depend on the quality of proposals received, the availability of funds, considerations for creating a balanced overall program, and the degree to which meaningful collaboration across institutions is realized for Integrative projects. Innovative methods of collaboration across geographic boundaries are encouraged.

Upon conclusion of the NSF review process, meritorious research proposals may be recommended for funding by one of NSF, DOD, DOE, NASA, or USDA/NIFA, 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 V 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 investigator may participate as PI, co-PI, or Senior Personnel in **no more than two proposals-submitted** in response to this solicitation each year.

In the event that an individual exceeds this limit, 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.**

The above limit applies only to proposals to the NRI-2.0 solicitation, not to the totality of proposals submitted to NSF.

Proposals submitted in response to this solicitation may not duplicate or be substantially similar to other proposals concurrently under consideration by other NSF, DOD, DOE, NASA, or USDA programs. Duplicate or substantially similar proposals will be returned without review, including those substantially similar to previously declined proposals without revisions to address concerns raised by reviewers.

Additional Eligibility Info:

For USDA/NIFA: Eligible applicants/Principal Investigators (PIs) for the grant program implemented under this subpart 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 2 or more entities identified in (1) through (8). Eligible institutions do not include foreign and international organizations.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Full 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=pappg. Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.

- Full Proposals submitted via Research.gov: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the NSF Proposal and Award Policies and Procedures Guide (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg. Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 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) 292-7827 or by e-mail from nsfpubs@nsf.gov.

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

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

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

The following information supplements the NSF PAPPG or NSF Grants.gov Application Guide.

Proposal Titles: Proposal titles must indicate the NRI program followed by a colon, then the project class ("FND" or "INT") followed by a colon, then the title of the project. For example, an Integrative proposal would be **NRI: INT: Title**. For collaborative proposals, all participating institutions should use the same title, which should also include the keyword "COLLAB" followed by a colon; for example, **NRI: FND: COLLAB: Title**.

Proposals from institutions that have RUI (Research in Undergraduate Institutions) eligibility should have a proposal title that begins with "NRI: RUI:" followed by either "FND:" or "INT:", then "COLLAB:" (if applicable), followed by the title; for example, **NRI: RUI: FND: COLLAB: Title**.

Project Summary (one page limit): Provides an overview description of the project, including its research and education goals, and the community (or communities) that will be impacted by its results. In separate statements, provide a succinct overview of the project in the "overview" text box, a summary of the intellectual merit in the "intellectual merit" box, and a summary of the broader impacts of the proposed project in the "broader impacts" box. At the top of the "overview" text box, enter the title of the project, the name of the PI, and the lead institution. Those proposals that are targeting a specific agency sponsorship should indicate so in the last line of the "broader impacts" box, e.g., "Requested funding agency:" followed by that agency's abbreviated name ("NSF," "DOD," "DOE," "NASA", or "USDA") but only if they 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 of the joint sponsoring agencies.

To aid in the reviewing process, in the last line of the "overview" box, add the term "Keywords:" followed immediately by one or more of the major research topics: **Scalability**, **Customizability**, **Lowering Barriers**, or **Societal Impact**. The list of keywords may continue, if applicable, with one or more of the following technology terms, in order of relevance: **Control, Design, Dynamics, Human-Robot Interaction, Learning, Locomotion, Manipulation, Mechanisms, Modeling/Representation, Multi-Robot, Natural Language, Perception, Planning, Reasoning, Robustness, Safety, Social Intelligence, Soft Robotics**, and **Trust**. These may be followed, if applicable, by at most one of the following application areas: **Agriculture, Assistive, Construction, Defense, Disaster Recovery, Education, Environmental Monitoring, Field Robotics, Infrastructure, Manufacturing, Medical, Nuclear, Rehabilitation, Shareable Resources, Testbeds, Worker Safety**, and **Workforce Development**.

Project Description: 15-page limit for all proposals. **Project descriptions that do not explicitly address the intellectual merit and broader impacts of the proposed project in separate statements may be returned without review**. The proposal **must** meet all formatting requirements, including font, font size, margin width, and lines per inch, as specified in the PAPPG Chapter II.B.2.

For Integrative (INT) proposals, the Project Description **must** contain a separate section labeled "Evaluation." This section must include a discussion of how the project will be evaluated on a physical robot, including a statement of the formal hypotheses, proposed experiments, evaluation metrics, and statistical analyses to be used. **Proposals without this clearly-identifiable section will be returned without review.**

Supplementary Documents: Supplementary documents are limited to the specific types of documentation listed in the PAPPG, with the following exceptions:

- ***Collaboration Plan.*** **A Collaboration Plan is REQUIRED for projects with more than one investigator, even if the investigators are from the same institution. The Collaboration Plan must be submitted as a Supplementary Document and cannot exceed two pages**. Proposals that require a Collaboration Plan, but do not submit one, will be returned without review. The Collaboration Plan must be labeled "Collaboration Plan" and must provide a thoughtful, strong justification for the team of researchers. The Collaboration Plan must include: 1) the specific roles of the collaborating PIs, co-PIs, other Senior Personnel and paid consultants at all organizations involved; 2) how the project will be managed among participants, especially across institutions and disciplines, with a description of how the researchers will work together collaboratively and effectively; 3) identification of the specific coordination mechanisms that will enable cross-institution and/or cross-discipline scientific integration (e.g., workshops, graduate student exchange, project meetings at conferences, use of videoconferencing and other communication tools, software repositories, etc.); 4) specific references to the budget line items that support these coordination mechanisms; and 5) for Integrative projects, a timeline for the integrative activities.

- ***Documentation of collaborative arrangements of significance to the proposal through letters of collaboration.*** Any substantial collaboration with individuals not included in the budget or not employed by the submitting institution(s) should be described and documented with a letter from each collaborator, which should be provided in the Supplementary Documentation section. **Such letters should simply confirm the commitment to collaborate, as illustrated in the recommended format provided in the PAPPG**. They must explicitly state the nature of the collaboration, appear on the organization's letterhead, and be signed by the appropriate organizational representative. These letters must not otherwise deviate from the restrictions and requirements set forth in PAPPG Chapter II.C.2.j. General letters of support are not allowed by the PAPPG, and must not be included.

- ***Human Subjects Protection.*** Proposals involving human subjects should include a Supplementary Document of no more than two pages in length summarizing potential risks to human subjects; plans for recruitment and informed consent; inclusion of women, minorities, and children; and planned procedures to protect against or minimize potential risks. 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, reviewers will evaluate: 1) the justification for the exemption; 2) human subjects involvement and characteristics; and 3) sources of materials.

- ***Vertebrate Animals.*** Proposals involving vertebrate animals should include a Supplementary Document of no more than two pages in length. Reviewers 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.

- ***Data Management Plan.*** All proposals **must** include a Supplementary Document of no more than two pages in length labeled "Data Management Plan". This document should describe how the proposal will conform to NSF policy on the dissemination and sharing of research results. See Chapter II.C.2.j of the PAPPG for full policy implementation. For additional information on the Dissemination and Sharing of Research Results, see: https://www.nsf.gov/bfa/dias/policy/dmp.jsp. For specific guidance for Data Management Plans submitted to the Directorate for Computer and Information Science and Engineering (CISE), see: https://www.nsf.gov/cise/cise_dmp.jsp. **Proposals that do not submit a Data Management Plan will be returned without review.**

For USDA/NIFA: Data Management Plan. The required Data Management Plan (DMP) must 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 are included on the following webpage: https://nifa.usda.gov/resource/data-management-plan-nifa-funded-research-projects. Also included on the webpage are FAQs and information about accessing examples of DMPs.

- ***List of Project Personnel and Partner Institutions.*** Provide current, accurate information for all personnel and institutions involved in the project (note: for collaborative proposals, the lead institution should provide this information for all participants). NSF staff will use this information in the merit review process to manage reviewer selection. The list should include all PIs, co-PIs, Senior Personnel, paid/unpaid Consultants or Collaborators, Subawardees, Postdocs, and project-level advisory committee members. 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:
    - Mary Smith; XYZ University; PI
    - John Jones; University of PQR; Senior Personnel
    - Jane Brown; XYZ University; Postdoc
    - ABC Community College; Paid Consultant
    - Susan White; DEF Corporation; Unpaid Collaborator
    - Tim Green; ZZZ University; Subawardee
- ***Postdoctoral Researcher Mentoring Plan (if applicable***). See PAPPG Chapter II.C.2.j for further information about the implementation of this requirement. **Proposals that require a Postdoctoral Researcher Mentoring Plan, but do not submit one, will be returned without review**.

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 bullet 6, above, for 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.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Indirect Cost (F&A) Limitations:

For NSF, PAPPG guidelines apply.

For DOD, DOE and NASA, contact the cognizant program officer. See Section VIII for contact information.

For awards made by USDA/NIFA: Section 713 of the Consolidated and Further Continuing Appropriations Act, 2018 (Pub. L. 115-141) limits indirect costs to 30 percent of the total Federal funds provided (or 42.857 percent of total direct costs) under each award. Similar language may be included in the FY 2019 appropriation; 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 for further indirect cost information.

Budget Preparation Instructions:

Budgets should include travel funds to attend annual NRI Principal Investigator (PI) meetings.

For DOE/EM proposals, budgets should include travel estimates for at least two site visits to DOE/EM field offices and/or DOE national

laboratories each year.

C. Due Dates

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

  February 19, 2019

  January 22, 2020

  Fourth Wednesday in January, Annually Thereafter

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: http://www.grants.gov/web/grants/applicants.html. In addition, the NSF Grants.gov Application Guide (see link in Section V.A) provides instructions regarding the technical preparation of proposals via Grants.gov. For Grants.gov user support, contact the Grants.gov Contact Center at 1-800-518-4726 or by email: support@grants.gov. The Grants.gov Contact Center answers general technical questions related to the use of Grants.gov. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this solicitation.

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

Proposers that submitted via FastLane 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 the PAPPG as 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 *Empowering the Nation Through Discovery and Innovation: NSF Strategic Plan for Fiscal Years (FY) 2011-2016*. 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 core strategies 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 provide abundant opportunities where individuals may

concurrently assume responsibilities as researchers, educators, and students, and where all can engage in joint efforts that infuse education with the excitement of discovery and enrich research through the variety of learning perspectives.

Another core strategy in support of NSF's mission is broadening 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

Programmatic Relevance. All NRI-2.0 proposals must be responsive to the vision of the program. Specifically, proposals must explicitly address the goal of achieving ubiquitous collaborative robots in terms of scalability, customizability, lowering barriers to entry, and/or societal impact.

Integration and Evaluation (for Integrative projects only). Integrative projects focus on research involving complete robotic systems and are typically collaborative and multi-disciplinary. Thus, Integrative projects will also be reviewed on the basis of (1) the innovation in the integration of the system; and (2) the evaluation plan for the robotic system in its intended (preferably real-world) setting. An important criterion for review of the evaluation plan will be its adherence to the scientific methodology, including statement of formal hypotheses, controlled experiments, evaluation metrics, and statistical analyses of results.

Subsequent to the uniform review process, a process of selection by the supporting agencies will be conducted. When considering their funding choices appropriate to the interests and goals described in the solicitation, each agency may apply and prioritize the additional review criteria below to highlight the specific objectives of their programs and activities.

Additional DOD Review Criteria

There are no additional review criteria for DOD.

Additional DOE Review Criteria

Programmatic Relevance. Reviewers will assess relevancy to the DOE nuclear cleanup mission. DOE/EM is engaged in protecting the environment and the health and safety of local constituents by cleaning up the environmental legacy of the Cold War. To achieve this in the safest, fastest and most economical manner, DOE/EM has established a goal to accelerate cleanup of the nuclear weapons manufacturing and testing sites. This acceleration will necessitate the identification, evaluation, development, demonstration and implementation of innovative, transformational technologies and approaches that can improve on the current baseline of activities. It will also require human capital development programs to assure a sufficient supply of trained environmental professionals over the entire period of performance of DOE/EM activities.

Radioactive and/or Hazardous Waste. When radioactive testbeds are utilized, reviewers will assess whether materials or procedures will potentially generate orphan waste (i.e., no known disposition path) or other radioactive and/or hazardous waste streams, and if needed, determine whether treatment, storage and/or disposal is beyond current DOE facility capabilities.

Occupational Exposure to Ionizing Radiation. When radioactive testbeds are utilized, reviewers will assess whether the work will require monitoring for occupational exposure to ionizing radiation.

Additional NASA Review Criteria

Programmatic Relevance. Reviewers will assess relevancy to future NASA space exploration missions, as stated in NASA's Exploration Campaign objectives (https://www.nasa.gov/feature/nasas-exploration-campaign-back-to-the-moon-and-on-to-mars). The proposed research should demonstrate an understanding of the unique environment of human-robot teams functioning in this space.

Additional USDA/NIFA Review Criteria

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

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

B. Review and Selection Process

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

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 the 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. Those not so designated will be considered for funding by all of the joint sponsoring agencies. 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.

In all cases, 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 and 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.

USDA/NIFA Process: USDA/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 USDA/NIFA Awards Management Division for award processing in accordance with the USDA/NIFA procedures. NIFA reserves the right to negotiate with the PD/PI and/or with the submitting organization or institution regarding project revisions (e.g., reductions in the scope of work, funding level, period, or method of support) prior to recommending any AFRI project for funding.

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

DOE Process: DOE/EM will make final funding decisions based on the results of the peer review process. Applications selected for funding by DOE/EM will be forwarded to the EM Consolidated Business Center for award processing in accordance with the DOE/EM procedures.

NASA Process: NASA will make final funding decisions based on the results of the peer review process; the selection official may take portfolio balance and other program-related factors into account when selecting proposals for award.

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

Notification of the award will be made through use of standard processes of the relevant funding agencies. Organizations whose proposals are declined will be advised as promptly as possible by the cognizant NSF Program administering the program. (See Section VI.B. for additional information on the review process.)

B. Award Conditions

NSF:

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

*These documents may be accessed electronically on NSF's Website at https://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF. Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

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

Special Award Conditions:

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 Joint National Robotics Initiative program."

The final version of any accepted software and robotics operating systems sharing plans will become a condition of the award grant, contract or agreement. The effectiveness of software and robotics operating system sharing may be evaluated as part of the administrative review of each award.

DOD, DOE, and NASA:

Contact the cognizant organization program officer for additional information.

USDA/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

- 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 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.
- 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.
- 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.
- 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.
- 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.
- 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 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 https://nifa.usda.gov/responsible-and-ethical-conduct-research for further information.

C. Reporting Requirements

NSF:

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

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

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

More comprehensive information on NSF Reporting Requirements and other important information on the administration of NSF awards is contained in the NSF *Award & Administration Guide* (AAG) Chapter II, available electronically on the NSF Website at

https://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

Additional data may be required for NSF sponsored Cooperative Agreements.

DOD and DOE:

Contact the cognizant organization program officer for additional information.

NASA:

The reporting requirements will be consistent with 2 CFR 1800.902, "Technical Publications and Reports," and Exhibit E - Required Publications and Reports of the NASA *Grant and Cooperative Agreement Manual*. Grants and cooperative agreements typically require annual and final technical reports, financial reports, and final patent reports. The following additional requirements will be incorporated into the NASA NRI-2.0 awards:

- Progress Reports due every 90 days;
- Continuation Review Package/Presentation: For awards greater than one year, an annual continuation package and virtual presentation will also be required; and
- Annual Technical Seminar: The PI shall present a technical seminar at a minimum of one NASA center annually.

USDA/NIFA:

Expected Program Outputs and Reporting Requirements

The output and reporting requirements are included in the award terms and conditions (see http://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 USDA/NIFA Requirements: Several federal statutes and regulations apply to grant applications considered for review and to project grants awarded under this program. These may include, but are not limited to, the ones listed on the NIFA web page: https://www.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 http://www.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 Miller, CISE/IIS, telephone: (703) 292-4914, email: damiller@nsf.gov
- Radhakisan Baheti, ENG/ECCS, telephone: (703) 292-8339, email: rbaheti@nsf.gov
- Jordan Berg, telephone: (703) 292-5365, email: jberg@nsf.gov
- Irina Dolinskaya, ENG/CMMI, telephone: (703) 292-7078, email: idolinsk@nsf.gov
- James Donlon, CISE/IIS, telephone: (703) 292-8074, email: jdonlon@nsf.gov
- Ephraim P. Glinert, CISE/IIS, telephone: (703) 292-8930, email: eglinert@nsf.gov
- David L. Haury, EHR/DRL, telephone: (703) 292-5102, email: dhaury@nsf.gov
- Tatiana Korelsky, CISE/IIS, telephone: (703) 292-8930, email: tkorelsk@nsf.gov
- Bruce Kramer, ENG/CMMI, telephone: (703) 292-5348, email: bkramer@nsf.gov
- Frederick M. Kronz, SBE/OAD, telephone: (703) 292-7283, email: fkronz@nsf.gov
- Dmitry Maslov, CISE/CCF, telephone: (703) 292-8910, email: dmaslov@nsf.gov
- Wendy Nilsen, CISE/IIS, telephone: (703) 292-2568, email: wnilsen@nsf.gov
- Robert Scheidt, ENG/CMMI, telephone: 703-292-2477, email: rscheidt@nsf.gov
- Ralph Wachter, CISE/CNS, telephone: (703) 292-8950, email: rwachter@nsf.gov
- Jie Yang, CISE/IIS, telephone: (703) 292-4768, email: jyang@nsf.gov

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

- FastLane and Research.gov Help Desk: 1-800-673-6188

  FastLane Help Desk e-mail: fastlane@nsf.gov.

  Research.gov Help Desk e-mail: rgov@nsf.gov

For questions relating to Grants.gov contact:

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

Department of Defense

Marc Steinberg

Program Manager
Office of Naval Research
875 N. Randolph Street, ONR, Department: Code 35
Arlington, VA 22203
Email: marc.steinberg.ctr@navy.mil

Department of Energy, Office of Environmental Management

Rodrigo V. Rimando, Jr.
U.S. Department of Energy, Headquarters
1000 Independence Ave, SW
Washington, DC 20585
Email: rodrigo.rimando@em.doe.gov
Telephone: (240) 676-6470

National Aeronautics and Space Administration

Dr. Kimberly Hambuchen
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United States Department of Agriculture

Dr. Steven Thomson
National Institute of Food and Agriculture
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Washington DC 20024
Email: steven.j.thomson@nifa.usda.gov
Telephone: (202) 401-6301

IX. OTHER INFORMATION

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

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

NATIONAL SCIENCE FOUNDATION
https://www.nsf.gov

DEPARTMENT OF DEFENSE
http://www.acq.osd.mil/rd/

DEPARTMENT OF ENERGY
OFFICE OF ENVIRONMENTAL MANAGEMENT
https://www.energy.gov/em/office-environmental-management

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
http://www.nasa.gov

UNITED STATES DEPARTMENT OF AGRICULTURE
NATIONAL INSTITUTE OF FOOD AND AGRICULTURE
http://www.nifa.usda.gov

PUBLIC BRIEFINGS

One or more collaborative webinar briefings with question and answer functionality may be held prior to the submission deadline date. Schedules will be posted on the sponsor announcement web sites.

ABOUT THE NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as

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

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

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

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

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

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

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

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

- **Location:** 2415 Eisenhower Avenue, Alexandria, VA 22314
- **For General Information** (NSF Information Center)**:** (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**

  Send an e-mail to: nsfpubs@nsf.gov

  or telephone: (703) 292-7827
- **To Locate NSF Employees:** (703) 292-5111

PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004), and NSF-51, "Reviewer/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004). Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

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

Suzanne H. Plimpton
Reports Clearance Officer
Office of the General Counsel
National Science Foundation

Alexandria, VA 22314

X. APPENDIX

Legislative Authority:

The USDA authority for this solicitation is contained in Section 7406 of the Food, Conservation, and Energy Act of 2008 (FCEA) (Pub. L. 110-246) which amends section 2(b) of the Competitive, Special, and Facilities Research Grant Act (7 U.S.C. 3157) to authorize the Secretary of Agriculture to establish the Agriculture and Food Research Initiative (AFRI); a new competitive grant program to provide funding for fundamental and applied research, extension, and education to address food and agricultural sciences. AFRI is subject to the provision found at 7 CFR Part 3430.