Slide 1: National Robotics Initiative 2.0: Ubiquitous Collaborative Robots

Reid Simmons: Good afternoon, and thank you for joining this webinar. I'm Reid Simmons, a program director in the division of Information and Intelligent Systems of CISE and the lead program director for the National Robotics Initiative program.

The National Robotics Initiative began five years ago, and was initially intended as a five year program. Due, in part, to the successful research it has supported in the area of co-robots, the program is being extended. At the same time, the vision and goals of the program are being expanded to include the idea of *ubiquitous collaborative robots*, robots that are available for all, everywhere. This webinar will describe the program, how it differs from previous NRI solicitations, and programmatic details about submitting proposals.

Slide 2: Welcome

Reid Simmons: Let me begin by calling on Jim Kurose, Assistant Director in CISE, and Barry Johnson, Acting Deputy Assistant Director in Engineering, to welcome you and to say a few words about the importance of the National Robotics Initiative and how the NRI 2.0 program fits into the broader picture at NSF.

Jim Kurose: …

Barry Johnson: …

Slide 3: The NRI Team: NSF

Reid Simmons: The National Robotics Initiative is a multi-directorate, multi-agency program. At NSF, the program is supported by four directorates, plus the Office of International Science and Engineering. CISE, the Computer and Information Science and Engineering directorate, is primarily interested in the areas of the program associated with collaboration, human-robot interaction, planning, learning, robot vision, and health and assistive robotics. The Engineering directorate is primarily interested in mechanism design, soft robotics, dynamics and controls, human-robot integration, and manufacturing. SBE, the Social, Behavioral and Economic Sciences directorate, is interested in social, legal, ethical, and economic issues associated with collaborative robots. EHR, the Education and Human Resources directorate, is focused on STEM education and workforce training issues. And, finally, OISE, the Office of International Science and Engineering, coordinates international activities associated with research grants.

The contacts for each of these directorates and offices are listed on this slide.

Slide 4: The NRI Team: Other Partner Agencies

Reid Simmons: In addition, this year three other federal agencies are part of the NRI 2.0 program – the National Institute of Food and Agriculture, at the US Department of Agriculture, the Department of Energy, and the Department of Defense. We will say more about their areas of interest later. Please note that NASA and the National Institutes of Health are *not* participating in the NRI program this year.

Slide 5: Outline

Reid Simmons: The discussion today is intended to introduce you to the NRI 2.0 program, and to help you prepare and submit proposals that are consistent with the goals of the program. We will begin with an overview of the program's vision and goals, and how it differs from the original NRI and other related NSF programs. We then will cover the major research themes that NRI 2.0 is focusing on, including the interests of the participating agencies.

We will then discuss the solicitation in more detail, introducing the two classes of projects supported by the program, their budget ranges, and information about the anticipated number of awards.

Finally, we will present some details that proposers should keep in mind when submitting proposals, and then answer questions. As the operator has indicated, we will take questions by phone after the presentation has been completed.

Slide 6: Vision

Reid Simmons: The vision of the NRI 2.0 program is that robots will become as ubiquitous as computers are today. Nearly 30 years ago, the term "ubiquitous computing" was coined to refer to the concept where computing is made to appear anytime and everywhere. Today, that vision has arrived, where each of us interacts with dozens of computing devices, from laptops, to cell phones, to cars, to microwaves, to ATMs, to toys, and on and on.

Our vision is for a similar future for robotics – that, in the not-so-distant future, robots will be everywhere, assisting each and every one of us with tasks that we can now only just imagine. We envision robots affecting every aspect of society, enriching both our quality of life and our quality of work. Robots will help us at home, in our travels, in our work, and in our recreation. They will learn and adapt to changing situations and our changing preferences. They will help us learn, and help us age gracefully.

Slide 7: Goals

Reid Simmons: To achieve this vision, much fundamental research is needed. The NRI 2.0 program has set out a number of goals that we believe are essential for achieving the vision of ubiquitous collaborative robots. First and foremost, is a focus on collaboration and interaction between multiple robots and multiple humans. While NRI 1.0 focused on a single co-robot interacting with a single human, the vision of ubiquitous robots requires robots that can work in teams with other robots and people. Similarly, the vision requires robots that can physically collaborate with people, such as doing collaborative manipulation. Scalability is needed so that robots can be easily constructed and programmed, using robust hardware and software. Robots also need to be easily customized and personalized, either through design or adaptation, so that the ubiquity of robots does not entail a "one size fits all" solution. And, finally, we must address the societal issues that will arise from this vision of ubiquitous robots, including economic, legal, educational, and workforce issues.

To achieve these goals, advances must be made both in foundational technologies and integrated robotic systems. The NRI 2.0 program explicitly supports both types of research.

Slide 8: Relationships to NRI 1.0

Reid Simmons: While the NRI 2.0 program has expanded the focus of the National Robotics Initiative, there is still plenty of overlap between the two. In particular, the focus on collaborative, interactive robots is maintained, although NRI 2.0 extends that to multiple robots collaborating and interacting with multiple humans. The focus on societal impact and education is maintained, although there is an extension to workforce issues. There is less of an emphasis on autonomy, which is now the focus of the new Smart and Autonomous Systems program. The focus on applications in NRI 1.0 has been revamped into a focus on research into integrated systems, and there is less of an emphasis on teaming with industry. Finally, there are several new areas of emphasis, including physical collaboration, scalability, and lowering the barriers to entry.

Slide 9: Relationships to Other Programs

Reid Simmons: There are two other cross-cutting NSF programs that have some overlap in focus with the National Robotics Initiative program. The Cyber-Physical Systems program, CPS for short, is primarily focused on unmanned and robotic systems, collaborative control, mixed initiative systems, design and real time systems verification, and trustworthiness. The Smart and Autonomous Systems program is primarily focused on achieving autonomy, in particular, having self-aware, adaptable systems that exhibit high-level planning and reasoning, and ethical behavior.

Proposers who have questions about where their research best belongs are encouraged to contact program officers for the different programs and discuss the applicability with them prior to submission.

Slide 10: Research Themes

Reid Simmons: To help achieve the vision of the program, the solicitation lists six research themes that are the primary foci of the program. We will talk about each of these themes in turn, but I want to point out that every proposal to the NRI 2.0 program *must* address at least one of those themes. It is allowable for proposals to cover additional themes, as long as primary focus is on one, or more, of these six themes. Proposers, however, are encouraged to focus – trying to address too many themes in one proposal is not advisable.

Slide 11: Research Themes

Reid Simmons: The main foci of the NRI 2.0 program is collaboration and interaction between multiple robots and/or multiple humans. Thus, for instance, single humans coordinating multiple robots, teams of robots assisting teams of people, robot swarms collaborating with one another, are all within scope of the program. Note that while collaboration and interaction often go together, they are, in fact, distinct concepts. For instance, a mixed human/robot team that divides up a building to search is collaborating, but may not be interacting; conversely, a service robot that uses social norms to move through a hallway may be interacting with other pedestrians, but is not collaborating with them.

Issues in collaboration include making and executing collaborative plans, often in a distributed fashion, and informing others of information that is germane to their tasks. Efficient, robust collaboration is a key issue. Issues in interaction include verbal and non-verbal communication; modeling and understanding the behaviors and intentions of others, in order to interact more naturally and effectively; and social intelligence, including the use of mental models to represent and reason about the internal states of others. Also important is issues of trust, specifically, how robots can be designed and behave in ways that increase people's trust in them.

Slide 12: Research Themes

Reid Simmons: The theme of physical embodiment is concerned with designs and materials, such as soft robots, for making co-robots inherently safe. It is also concerned with physical collaboration, including collaborative manipulation and augmentation of human physical capabilities; physical information gathering; and multi-modal communication.

The theme of scalability is concerned with robots that can be easily customized and personalized. The idea is to research approaches to robot hardware and software that will easily adapt to a wide variety of tasks and situations. One way to achieve this is through easily composable hardware and software. As more and more robots collaborate, managing shared data, and creating knowledge from that data, will become increasingly important. And, finally, to achieve widespread use of robots, the robots will have to be extremely robust to both hardware and software failures.

To achieve the level of ubiquity envisioned, many more people will need to be working on robot research and development. To that end, the program encourages efforts to lower the barriers to entry into the field. Ways to achieve that include innovative robot programming paradigms, robust, cost-effective, easy-to-use hardware and software infrastructure, and shareable testbeds. Note that this program is not looking to fund testbed development, per se, but rather fundamental research into ways in which physical testbeds can be shared remotely. In particular, the goal is to enable researchers in one part of the country to access, debug, and test algorithms on remote hardware as if they were there in person. While such remote testbeds have been tried before, the experience is not nearly good enough to enable widespread usage.

Slide 13: Social, Behavioral and Economic Sciences

Reid Simmons: NSF's Directorate for Social, Behavioral, and Economic (SBE) Sciences supports basic research on people and society.

The SBE sciences focus on human behavior and social organizations and how social, economic, political, cultural, technological, and environmental forces affect the lives of people from birth to old age and how people in turn shape those forces.

The advent of ubiquitous co-robots will introduce new technological forces that will affect the lives of people including new social, economic, ethical, and legal issues.

Fundamental SBE research is needed to address the social and economic impact of robots on our work, our social institutions, and our quality of life and work.

It is also needed to provide understanding for a range of related issues including the complexities of the future co-robot economy; how economic and social inequality will be affected by ubiquitous co-robots; and what societal policies can be instituted to ensure that stakeholder groups can benefit from the presence of co-robots in our everyday lives.

Questions about SBE-related proposals should be addressed to Fred Kronz (fkronz@nsf.gov).

Slide 14: Education and Human Resources

Reid Simmons: The Education and Human Resources, or EHR, directorate supports curricula and education research into the use of collaborative robots in both formal and informal K-16 STEM education. For instance, this includes research into instructional models that integrate co-robotics within STEM courses, and design and rigorous study of robotics competitions to motivate STEM content and careers.

In addition, NRI 2.0 encourages research into learning environments and approaches to advance workforce preparedness in robotics and strategies for broadening participation in robotics-related careers.

Due to limited funds and the multi-agency nature of this solicitation, education-related proposals are discouraged at the higher end of the funding range for the program. Questions about education-related proposals should be addressed to David Haury (dhaury@nsf.gov).

Slide 15: NSF Directorate for Engineering

Reid Simmons: The Engineering Directorate at NSF supports a variety of research themes under the NRI 2.0 program, including those related to control, dynamics, and advanced manufacturing. The Engineering Directorate takes particular interest in the physical embodiment aspects of robotics, and welcomes innovative proposals in this area. In addition, the Engineering Directorate has interests in many of the other NRI 2.0 research themes. Those interested in submitting proposals for consideration by the NSF Engineering Directorate can contact Jordan Berg, Kishan Baheti, or, in the area of Advanced Manufacturing, Bruce Kramer.

Slide 16: National Institute of Food & Agriculture

Steven Thomson: The National Institute of Food & Agriculture has been an NRI participate since the program's genesis in FY 2012. The agency's interests cover food, feed, fiber, and biofuels production, processing, distribution, and consumption from cropland, range, and forest products. NIFA's scope also includes managing air, soil, and water resources and ensuring vital and resilient communities. The two, broad agency priorities remain from prior years, with some tweaks for the NRI 2.0 themes. While these priorities are not exclusionary, they do cover the vast majority of active and important areas in ag robotics R&D.

The Scalable Robotic Technologies priority aims to improve precision agriculture technologies and efficiency in agricultural production. This includes land-based crop production, controlled environment production (e.g., greenhouses, vertical farming), animal production, and natural resource management. There is also a need to improve post-harvest processing and handling of plant and animal products. And, none of these will be possible without improved sensing systems to measure quality attributes or to monitor environmental conditions.

The Configurable Multi-Agent Teams priority seeks R&D advances that will enable robot teams that can operate autonomously or semi-autonomously as part of mixed-agent systems. This includes: high-level planning and control systems architectures; systems for reliable communication, coordination, and unsupervised collaboration; and distributed intelligence combined with fault tolerance and graceful failure modes.

Those proposals that are selected for NIFA funding will be required to resubmit through Grants.gov, using standard forms. Budgets and award amounts may need to be adjusted to accommodate NIFA's Congressionally limited overhead cost rate, which is 30% of the total federal request (42.85% of TDC). Furthermore, NIFA does not fund collaborative projects, so any such proposals will need to be recast with a single, lead institution and collaborators as subcontracts.

For a complete list of all NRI awards made by NIFA during the first five years of the program, please go to the tinyurl.com link provided. Dr. Steve Thomson is now the primary NIFA contact for the NRI.

Slide 17: DOE Interests

Reid Simmons: The Department of Energy's Office of Environmental Management 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). DOE/EM is also 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; or (3) the presence or potential presence of hazards that may result in unacceptable occupational exposure or risk. 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/lab tech, for example, can offer increased ability, efficiency, capability, and safety. Finally, 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 can also be deployed in response to emergencies.

Rod Rimando is the primary DOE contact for the NRI.

Slide 18: DOD Interests

Reid Simmons: The Department of Defense is interested in robotic systems that can increase capabilities and reduce costs and manpower needs. Specifically, the DOD is interested in how team performance and trust can be increased through the use of social interaction and social cues and how physical embodiment of agents affects team performance and human trust in the robotic systems.

Other interests include dynamic modeling of human-robot collaboration and interaction, robotic perception of human intent and other mental states, studying the effectiveness of various models of human-robot interaction, such as delegation and supervisory control, and enabling robots to achieve the tactics and strategies of high-performing teams.

David Han is the primary DOD contact for the NRI.

Slide 19: Project Classes

Reid Simmons: We'll now move on to more programmatic issues. For this program, there are two project classes.

The Foundational class focuses on research into technologies that directly contribute to one of the six themes of the NRI 2.0 program. Proposed projects should lead to transformative approaches that address scientific or technology gaps that currently limit the development, use, or acceptance of ubiquitous co-robots in society.

The Integrative class focuses on research leading to complete co-robotic systems. The focus should be on innovative integration of technologies, in particular, integration that addresses more than one of the NRI 2.0 themes. Integrative projects *must* include evaluation on physical robots, preferably in real-world settings. Moreover, because of the complexity of integration of two or more of the research themes, we encourage proposers to form teams of multiple PIs, from diverse disciplines.

Slide 20: Award Information

Reid Simmons: The anticipated funding for the NRI 2.0 program in fiscal year 2017 is approximately $30-45M, and we expect to fund approximately 40 to 70 projects.

The budget range for Foundational projects is $350K to $750K, in total costs; the budget range for Integrative projects is $500K to $1.5M, in total costs. Note that the maximum allowable budget is smaller than in previous NRI solicitations, which should enable us to make more awards overall.

Also, it is very important to note that in many NSF programs, the ranges of project class budgets are disjoint. NRI 2.0 purposely has overlapping budget ranges to encourage PIs to submit to one class or the other, based primarily on their research objectives alone.

Do not let the budget cap guide your research objectives.

Slide 21: Review Criteria

Reid Simmons: Proposals submitted to the National Science Foundation are evaluated for the Intellectual Merit and Broader Impact.

In addition to the Foundation's review criteria, the NRI 2.0 program will evaluate each submission on well how the proposed research furthers the program's vision of ubiquitous collaborative robots, especially with respect to furthering one, or more, of the six research themes.

For the Integrative projects, the NRI 2.0 program will also evaluate each submission on the innovation in system integration and the evaluation plan for the integrated robotic system, preferably in a real-world setting.

Slide 22: Eligibility Requirements

Reid Simmons: Universities and colleges that are accredited and have a campus in the United States are eligible to submit proposals to the NRI 2.0 competition.

Moreover, non-profit organizations and non-academic organizations, which include research laboratories, museums, observatories, professional societies, and similar organizations within in the United States that are associated with educational and research activities are also eligible to submit proposals to the NRI 2.0 competition.

Do note that at most 2 submissions to the program are allowed in a given year for any PI, co-PI, or Senior Personnel.

Slide 23: Proposal Submission

Reid Simmons: For the fiscal year 2017, NRI 2.0 program has set forth a deadline of February 2, 2017 for proposal submission. This deadline is for both classes of the proposals. We strongly encourage the community to carefully read the solicitation and the Proposal and Award Policies Procedures Guide for a better understanding of the program and proposal preparation.

Do note that the NRI program mandates yearly project representation at the annual PI meeting to be held in the Washington DC area. Consequently, travel to the yearly PI meeting must be accounted for in the submitted project budget.

Slide 24: Supplementary & Single Copy Documents

Reid Simmons: The NRI 2.0 program will require proposers to detail a data management plan.

It is the responsibility of the Lead PI to submit a list of all project personnel and where applicable partner institutions. The list should include PIs and where applicable co-PIs, senior personnel, postdoctoral researchers, consultants, collaborators, sub awardees, and project advisory committee members.

A project with more than one investigator must include a collaboration plan. The length of the plan should correspond with the complexity of project.

If a postdoctoral researcher is involved in the project, then a postdoctoral mentoring plan is mandatory to be included.

It also is mandatory to include a single copy document that lists all of the collaborators of the proposal's PIs, co-PIs, and senior personnel. To assist with generating a single copy document, we encourage the proposers to utilize the Excel template available from the following URL: WWW dot NSF dot GOV forward slash CISE forward slash "C" "O" "L" "L" "A" "B"

Slide 25: Thanks!

Reid Simmons: On behalf of the NSF, NIFA/USDA, DOE, and DOD, we would like to thank all of you for your time and for your interest in the National Robotics Initiative program.

If you would have any questions pertaining to the National Robotics Initiative program, please send them to the following address: “N” “R” “I”@nsf.gov. Email to this address will be available to all the NRI program officers at NSF, and we will forward questions to the contacts at other agencies, as necessary.

The presentation just made, along with a transcript, will be made available in a few days on the NRI program website.

Operator, we are now done with the presentation and ready to take questions.