Partnerships for Innovation: Building Innovation Capacity (PFI:BIC)

PROGRAM SOLICITATION
NSF 14-610

REPLACES DOCUMENT(S):
NSF 13-587

National Science Foundation

Directorate for Engineering
    Industrial Innovation and Partnerships

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

Letter of Intent Due Date(s) *(required)* (due by 5 p.m. proposer's local time)*:*

December 03, 2014

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

January 28, 2015

IMPORTANT INFORMATION AND REVISION NOTES

Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) supports academe-industry partnerships, which are led by an interdisciplinary academic research team collaborating with at least one industry partner to build technological, human, and service system innovation capacity. This program solicitation is pursuant to program solicitation NSF 13-587, but several important changes have been made. Some of the Important Information and Revision Notes are not new, but they have been clarified or elaborated upon and so warrant inclusion in this section.

Topic: Smart Service Systems—Unrestricted as to domain knowledge and application areas. This topic has been further refined and defined, including a stronger emphasis on service systems in the NSF context, which first and foremost includes the signature characteristic of being ***human-centered*** as well as **smart.** Additionally, the emphasis has been shifted from the goal of ***enabling*** a smart service system to a focus on ***integrating*** a technology or technologies into a specified human-centered smart service system with the potential to achieve transformational change in an existing service system or to spur an entirely new service system. For more information, see the Program Description.

Interdisciplinary as well as cross-organizational research is emphasized. In addition to the discipline or disciplines related to the technology, the disciplines to be included in this project are 1) systems engineering or engineering design, 2) computer science/information technology, and 3) human factors/behavioral science/cognitive engineering. For more information, see the Synopsis.

Types of Partners. Please see the information in the Program Description about the types of partners possible and how they should be described in the proposal.

Human subjects. Because of the importance of the service system as human-centered, research activities that involve "Human Subjects" might be necessary. PIs should be knowledgeable about whether they will need approval for research involving human subjects. See GPG, Chapter II.D.7: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=papp.

Animal studies. In some contexts, animal studies are an important prelude to, and may be needed in addition to, the involvement of human subjects. PIs should be knowledgeable about whether they will need to seek Institutional Animal Care and Use Committee (IACUC) approval. See GPG, Chapter II.D.6: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=papp.

PFI:BIC website information. Proposers should review the more comprehensive information provided on the website (http://www.nsf.gov/eng/iip/pfi/bic.jsp) before submitting a Letter of Intent.

Limit on number of proposals. An academic institution can submit a maximum of two (2) proposals as a lead institution, preferably involving distinct application areas.

Mentoring plan for participating students. A more detailed description of the required mentoring plans has been provided. See the Supplementary Documents section for more information.

Additional merit review criteria have been updated. See the "Other Additional Review Criteria" section for details.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Partnerships for Innovation: Building Innovation Capacity (PFI:BIC)

Synopsis of Program:

The Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) program supports academe-industry partnerships, which are led by an interdisciplinary academic research team with a least one industry partner to build technological, human, and service system innovation capacity. These partnerships focus on the integration of technologies into a specified human-centered smart service system with the potential to achieve transformational change in an existing service system or to spur an entirely new service system. These technologies have been inspired by existing breakthrough discoveries.

Service systems are socio-technical configurations of people, technologies, organizations, and information designed to deliver services that create and deliver value [1]. A **"smart" service system** is a system capable of learning, dynamic adaptation, and decision making based upon data received, transmitted, and/or processed to improve its response to a future situation. The system does so through self-detection, self-diagnosing, self-correcting, self-monitoring, self-organizing, self-replicating, or self-controlled functions. These capabilities are the result of the incorporation of technologies for sensing, actuation, coordination, communication, control, etc. The system may exhibit a sequence of features such as detection, classification, and localization that lead to an outcome occurring within a reasonable time.

PFI:BIC funds research partnerships working on projects that operate in the post-fundamental discovery space but precede being on a clear path to commercialization. These projects require additional effort to integrate the technology into a real service system with human factors considerations, which in turn might spawn additional discoveries inspired by this interaction of humans with the technology.

Partnership activities that drive sustained innovation include the targeted allocation of resources such as capital, time, and facilities; and sharing of knowledge in a cross-organizational and interdisciplinary context. The project must involve research tasks that demonstrate a highly collaborative research plan with participation of the primary industrial partner with the academic researcher during the life of the award.

Cultivating smart service systems requires not only the participation of the scientific discipline or disciplines related to the technology, but also of a range of other disciplines needed to achieve successful integration into a smart service system. The resulting system requires an understanding of human interaction with technology and a human-centered design to assure the desirability and the effectiveness of the proposed service system. Thus, in addition to the discipline related to the technology, the disciplines to be included in this project are 1) systems engineering or engineering design, 2) computer science/information technology, and 3) human factors/behavioral science/cognitive engineering. *Some teams not experienced with service engineering might benefit from consulting with an individual with expertise in service operations or service systems.* NSF recognizes that the labels for the aforementioned disciplines may vary in different institutions and organizations, so what is important here is to demonstrate the equivalence of the representation of these disciplines. **The proposer will be asked to show how the disciplines will be integrated in the context of the project as part of the research plan in the Project Description.**

Examples [2] of technology applied to service systems include smart healthcare, smart cities, on-demand transportation, precision agriculture, smart infrastructure, and other technologies enabling self-service and customized service solutions.

WEBINARS: Webinars will be held to answer questions about the solicitation. Register on the PFI:BIC website where details will be posted (http://www.nsf.gov/eng/iip/pfi/bic.jsp). Potential proposers and their partners are encouraged to attend. Also, Vice Presidents for Research and academic personnel concerned with the review of their respective institution's selection of candidates for submission, individuals from Sponsored Research Offices, and those focused on the identification and understanding of limited application submissions are encouraged to attend.

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[1] Spohrer J., Maglio P. P., Bailey J., Gruhl D. (2007). Steps towards a science of service systems. Computer 40(1):71-77. doi:10.1109/MC.2007.33.

[2] Note that examples have been provided in this solicitation to offer a sense of the variety of possibilities across types of service systems and the forefront technologies that would allow them to achieve their apex of effectiveness and efficiency, but by no means are they intended to represent program emphases or priorities.

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.

- Sara B. Nerlove, ENG/IIP/PFI:BIC, Program Director, telephone: (703) 292-7077, email: snerlove@nsf.gov

- Alexandra Medina-Borja, ENG/OAD, telephone: (703) 292-7557, email: amedinab@nsf.gov

- Chris Paredis, ENG/CMMI, telephone: (703) 292-2241, email: cparedis@nsf.gov

- Leon Esterowitz, ENG/CBET, telephone: (703) 292-7942, email: lesterow@nsf.gov

- Gurdip Singh, CISE, telephone: (703) 292-8950, email: gsingh@nsf.gov

- Alexander Leonessa, ENG/CBET, telephone: (703) 292-2678, email: aleoness@nsf.gov

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

- 47.041 --- Engineering
- 47.070 --- Computer and Information Science and Engineering

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 10

Anticipated Funding Amount: $10,000,000

- Anticipated Funding Amount is subject to the availability of funds and the quality of proposals received.

- Awards may be up to $1,000,000 with an award duration of three (3) years.

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

- U.S. universities and two-and four-year colleges (including community and technical colleges) accredited in, and having a campus located in the U.S., acting on behalf of their faculty members. Such organizations also are referred to as academic institutions. The lead (submitting) organization must be an academic institution.

  Separately submitted collaborative proposals from different organizations requesting an individual award are not permitted.

Who May Serve as PI:

The PI cannot concurrently be a PI on more than one active PFI:BIC award.

A PI who is named in a proposal in response to this program solicitation **may not be named in a proposal for funding consideration in the same fiscal year** to the Partnerships for Innovation: Accelerating Innovation Research (PFI:AIR) program.

Limit on Number of Proposals per Organization: 2

Academic institutions are limited to participation on two (2) proposals as a lead institution preferably involving distinct application areas. A lead academic institution that has submitted a proposal has the option to participate as a subawardee on any other proposal submitted under this solicitation. Lead academic institutions that have submitted a proposal may also provide consultants to other proposals submitted under this solicitation.

Limit on Number of Proposals per PI or Co-PI: 1

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Submission of Letters of Intent is required. Please see the full text of this solicitation for further information.

- **Preliminary Proposal Submission:** Not required

- **Full Proposals:**
  - Full Proposals submitted via FastLane: NSF Proposal and Award Policies and Procedures Guide, Part I: Grant Proposal Guide (GPG) Guidelines apply. The complete text of the GPG is available electronically on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg.
  - 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: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide)

B. Budgetary Information

- **Cost Sharing Requirements:** Inclusion of voluntary committed cost sharing is prohibited.

- **Indirect Cost (F&A) Limitations:** Not Applicable

- **Other Budgetary Limitations:** Other budgetary limitations apply. Please see the full text of this solicitation for further information.

C. Due Dates

- **Letter of Intent Due Date(s)** *(required)* (due by 5 p.m. proposer's local time)**:**

  December 03, 2014

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

  January 28, 2015

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: Standard NSF award conditions apply.

Reporting Requirements: Standard NSF reporting requirements apply.

TABLE OF CONTENTS

I. INTRODUCTION

National economic and societal prosperity is increasingly more dependent upon research and technology-based innovation. Thus, NSF's role of supporting fundamental research across all fields of science and engineering has become ever more relevant to economic competitiveness and value creation. The Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) program establishes and expands partnerships so that existing research discoveries can provide the motivation and foundation to develop technological areas with high potential for fruitful integration into service systems. These strategic partnerships, which create an academe-industry collaborative culture to build innovation capacity, are in a position to advance and adapt technologies elucidated by human factors research in the context of smart service systems so as to expand as well as realize their market potential

Other federal programs also contribute to the goal of innovation. Internal to NSF, there are the following programs: Partnerships for Innovation: Accelerating Innovation Research (PFI:AIR), Innovation Corps (I-Corps[TM]), Small Business Innovation Research/Small Business Technology Transfer Research (SBIR/STTR), Grant Opportunities for Academic Liaison with Industry (GOALI), and Industry University Cooperative Research Centers (I/UCRC). For more information on these programs, go to the Division of Industrial Innovation and Partnerships website: http://www.nsf.gov/div/index.jsp?org=IIP.

II. PROGRAM DESCRIPTION

The service sector was responsible for 79.7% of the U.S. GDP in 2012 [3] and employs the majority of American workers, with projections reaching 80% in the near future [4]. Also notable is the increasing role of engineering and value-added services in the manufacturing sector. Significant advances in, and adaptations of, sensing, actuating, and computational and communication technologies and their integration into smart service systems have the potential for abundant societal and economic benefits. The National Science Foundation invites requests for funding in the area of smart service systems under the Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) solicitation. The hallmark of PFI:BIC is an academe-industry partnership crafted to collaborate on research to advance and adapt key technology for integration into a specified human-centered smart service system. Smart service systems of interest are those that could yield positive social as well as economic outcomes resulting from entering the commercialization process.

The perspectives, competencies, and commitments of both academe and industry are needed to address the central issue of advancing and adapting technology to interact with humans and deliver services. Therefore, technology advancement should be based upon a deep understanding of a human-centered service system. Knowledge gained in the course of the integration process may generate additional research activities and additional discoveries that will become essential part(s) of the system. A clear understanding of the market need and the competitive landscape should help guide project activities. At least one industry partner is expected to contribute market understanding of a promising service application.

Service systems are socio-technical configurations of people, technologies, organizations, and information designed to deliver

services that create and deliver value [5].

A "smart" service system is a system capable of learning, dynamic adaptation, and decision making based upon data received, transmitted, and/or processed to improve its response to a future situation. The system does so through self-detection, self-diagnosing, self-correcting, self-monitoring, self-organizing, self-replicating, or self-controlled functions. These capabilities are the result of the incorporation of technologies for sensing, actuation, coordination, communication, control, etc. The system may exhibit a sequence of features such as detection, classification, and localization that lead to an outcome occurring within a reasonable time.

Human interaction with technologies and with physical and virtual realities can produce and deliver service(s) never before imagined. A signature characteristic of service systems in the NSF context is first and foremost, a smart service system that is human-centered. A human-centered service system involves users, recipients, beneficiaries, providers, and/or decision makers utilizing the information and capability provided by the service. Second, interactions between humans and physical/virtual realities necessarily happen and are integral to the "service". Sometimes, these interactions happen in different sequences and combinations, in parallel or series, among physical and virtual worlds before interacting with the human reality. Sometimes, interactions occur with the human world from the start, but interactions *always* occur. These interfaces with humans can take many forms: e.g., co-creation, interaction, response, needs assessment, surveillance, etc. Third, the interactions need to add value to humans; for an activity to become a service, a human or group of humans need to ultimately benefit from the interactions either directly or indirectly.

The program is seeking proposals with a focus on the integration of a technology (or technologies) into a specified human-centered "smart" service system. These technologies are inspired by existing breakthrough research discoveries and should have the potential to achieve transformational change in an existing service system or to spur entirely new systems. The technologies themselves may or may not be considered "smart", but the creative way in which they are designed, configured, and integrated into a service system makes the system exhibit smart behavior. Effective integration into a human-centered system may require additional research activities and additional discoveries that will become important part(s) of the system. Research in cyber-physical systems, for instance, has enabled creation of systems that collect large amounts of data, analyze it in conjunction with historical data, and control/actuate the physical components in real-time. In addition, such systems can guarantee properties such as security, privacy, timeliness and safety. This research can be effectively leveraged in the creation of smart services.

Often, paradigm-shifting innovation in service systems requires having the user in mind as potential co-creator of the service. Proposals are expected to include research tasks in human factors/cognitive engineering/ behavioral science to study human interaction with the system to assure integration. Human factors research investigates *"…human capabilities and limitations – and the basic understanding of cognitive, physical, behavioral, physiological, social, developmental, affective, and motivational aspects of human performance – to yield design principles; enhance training, selection, and communication; and ultimately improve human-system interfaces and sociotechnical systems that lead to safer and more effective outcomes."* [6]

Competitive proposals are likely to be those that move the state of the art in the direction of autonomy, ability to deal with ambiguity, and cognitive reasoning, as well as provide some type of action beneficial to humans. The resulting system will have the capability to incorporate response to past actions into formulation of subsequent actions. The research plan presents well-thought out activities which take full advantage of the academic and industrial perspectives necessary for these partnerships to advance smart human-centered service systems.

Service systems are becoming increasingly interdependent, often with interconnected configurations of customer-to-customer, provider-to-customer, and provider-to-provider links organized as a large-scale system of systems. Although a service process is performed for the benefit of the customer or user, the degree of customer involvement in the service process depends on the nature of the process.

Smart cities, on-demand transportation, precision agriculture, smart healthcare, and smart infrastructure are all examples of service systems with the potential to improve quality of life. Solutions to improve government services, including self-service and customized service technologies, are also likely to improve efficiency and quality. Examples of other service systems where smart technologies could make a difference include disaster mitigation and humanitarian services, communication services, utilities, consulting and professional services, and hospitality services, to name a few.

In addition, with more frequent and ubiquitous use of networks linking information, people, processes, and products, a number of sectors, including manufacturing, are increasingly interested in services. This movement, termed "servitization" by Vandermerwe and Rada [7] in 1988, is ever more prevalent [8]. "Servitization", that is, the incorporation of services to increase product value and accessibility, leads to the development of service solutions by manufacturing firms. For example, in factories new technologies can drastically impact the supply-chain system. In fact, additive manufacturing technologies will enable forms of manufacturing mass customization that we cannot imagine today, drastically shifting logistic models to satisfy "on demand" processes that could be considered service systems. Smart technology will undoubtedly be needed to adapt supply chains to this new manufacturing paradigm shift where again, the human element will be central [9].

As technological capabilities advance, there will be many challenging new problems related to the "scale effects" in smart service systems. The PFI:BIC research partnership should stimulate considerations of scale that need to be anticipated for successful long-term implementation of smart technologies in services.

Academe-Industry Partnerships

The strategic partnerships among academe, industry, and other stakeholders of the PFI:BIC program aim to build innovation capacity in three key ways: 1) technological innovation capacity, by focusing on technological innovations with significant potential for economic and societal impact; and 2) human innovation capacity, by activating academe-industry partnerships that are anticipated to have indelible effects on the partners; and by the participation of students and/or postdoctoral researchers, who are anticipated to develop the skill-sets, capabilities, and motivation to become future innovators in partnership collaborations, and 3) service system innovation capacity, by using an interdisciplinary and cross-organizational approach to shape smart service systems that integrate technologies considering the humans-in-the-loop from an early juncture in the project.

PFI:BIC partnerships must be of high quality, as evidenced by the partners' expertise, experience, and significant measurable commitment to the project, with clear contributions and technical and/or economic "takeaways" [10] for all parties involved. The partnership should be crafted to achieve research accomplishments that would not have been possible without joining the perspectives of academe and industry at a formative stage. Moreover, it should be clear how the partners specifically complement each other in the context of the project.

The primary members of a partnership are an academic research team and at least one industry partner. It is expected that academic and industry participants will continue to conduct research and build innovation capacity in a similar collaborative manner in the future, whether or not in the context of this specific project or these specific partners [11]. Individual projects might require different configurations of partners, depending on the nature of the service system and the position of potential partners with regard to the final users. Therefore, variation in the numbers and kinds of partners is anticipated. For the purposes of submitting a proposal to this solicitation, partners can broadly be placed in to the following categories.

Primary partner(s). A minimum of one (1) industry partner of any size is required. This partner (i.e., the one that fulfills the minimum requirement) must be U.S.-based and have commercial revenues that include sales, services, or licensing. Grants and government contracts may contribute to its revenues but may not constitute the entirety of its revenues. The project must involve research tasks that demonstrate a highly collaborative research plan with participation of the primary industrial partner with the academic researcher during the life of the award. Note that in regard to industrial partners, subawards only can be allocated to those business partners defined as small business concerns (http://sbir.gov/sites/default/files/elig_size_compliance_guide.pdf). See the Additional Eligibility Information section for details. Note also that in regard to academic partners, subawards may be allocated to other academic institutions.

Additional primary partners. Once the requirement of a minimum of one (1) primary industrial partner has been met, other partners, such as academic institutions, non-profit organizations, public sector organizations, and additional industry partners, including start-ups, can be selected as additional primary partners at the discretion of the PI.

Broader context partner(s). These belong to all of the same categories as primary partners. They are unlikely to appear as participating on the project tasks as presented in the Project Description. Nonetheless, each broader context partner has a role and is *required to supply a Partner Letter.* The role, while meaningful, is not as central as those of the primary partners, and no Cooperative Research Agreements are likely to be needed.

To facilitate the partners' collaboration in an open innovation context, NSF will require signed written cooperative research agreements (CRAs) between the lead institution and the primary industrial partner(s) and other applicable partners at the time of program consideration for recommendation for an award. See the Full Proposal Submission Instructions section for more details.

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[3] Field Listing - GDP composition by sector. CIA World Factbook (2010 and 2012).

[4] Employment Projections program, U.S. Department of Labor, U.S. Bureau of Labor Statistics. http://www.bls.gov/emp/ep_table_201.htm.

[5] Spohrer J., Maglio P. P., Bailey J., Gruhl D. (2007). Steps towards a science of service systems. Computer 40(1):71-77. doi:10.1109/MC.2007.33.

[6] Human Factors: The Journal of the Human Factors and Ergonomics Society (accessed online http://hfs.sagepub.com/ on August 12, 2014).

[7] Vandermerwe, Sandra and Rada, Juan (1988). Servitization of business: Adding value by adding services, European Management Journal, Volume 6, Issue 4, Winter, pp. 314-324.

[8] Turunen, T. (2013). Organizing Service Operations in Manufacturing. Aalto University publication series, Doctoral dissertations, 4/2013. Permanent link: http://urn.fi/URN:ISBN:978-952-60-4962-5

[9] Georgia Tech. "Research @ Tech." *Supply chains and logistics make room for 3D printing.* December 11, 2013. http://www.research.gatech.edu/news/supply-chains-and-logistics-make-room-3d-printing (accessed June 11, 2014).

[10] "Takeaways"-are defined as capabilities, competencies, or more tangible items that one can take possession of and can move forward with (vs. a benefit that may be merely received and enjoyed). Takeaways are for the primary partners--academe, business, and other--and also include the strategy that has the potential to build the innovation capacity.

[11] Rockefeller Foundation (n.d.). "Six Factors that Boost an Organization's Capacity to Innovate"

III. AWARD INFORMATION

Estimated program budget, number of awards and average award size/duration are subject to the availability of funds.

NSF will make awards subject to the availability of funds and quality of proposals. Awards may be up to $1,000,000, with an award duration of three (3) years. *In other words, the total budget request to NSF for the lead institution and all others participating in the project cannot exceed $1,000,000. Ten awards of $1,000,000 each are anticipated.*

As appropriate, awardees have the option to allocate funds for the participation of industrial partners (i.e., small businesses) and other primary partners in the project research activities in the form of subawards. Whether or not the option to allocate funds to the partners is exercised, it should be clear how the funds and other resources of the project (e.g., special facilities, equipment, and students) are shared by the partnership.

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

Proposals may only be submitted by the following:

- U.S. universities and two-and four-year colleges (including community and technical colleges) accredited in, and having a campus located in the U.S., acting on behalf of their faculty members. Such organizations also are referred to as academic institutions. The lead (submitting) organization must be an academic institution.

    Separately submitted collaborative proposals from different organizations requesting an individual award are not permitted.

Who May Serve as PI:

The PI cannot concurrently be a PI on more than one active PFI:BIC award.

A PI who is named in a proposal in response to this program solicitation **may not be named in a proposal for funding consideration in the same fiscal year** to the Partnerships for Innovation: Accelerating Innovation Research (PFI:AIR) program.

Limit on Number of Proposals per Organization: 2

Academic institutions are limited to participation on two (2) proposals as a lead institution preferably involving distinct application areas. A lead academic institution that has submitted a proposal has the option to participate as a subawardee on any other proposal submitted under this solicitation. Lead academic institutions that have submitted a proposal may also provide consultants to other proposals submitted under this solicitation.

Limit on Number of Proposals per PI or Co-PI: 1

Additional Eligibility Info:

Industrial Partner: a minimum of one (1) U.S.-based industrial partner organization must participate on the PFI:BIC proposal.

Revenues: The industrial partner qualifying as meeting the minimum requirement must have commercial revenues that include sales, services, or licensing. Grants and government contracts may contribute to its revenues but may not constitute the entirety of its revenues.

Subawards or Direct Funds from the Grant: Only industrial partners that qualify as a small business per the Small Business Innovation Research program definition (http://sbir.gov/sites/default/files/elig_size_compliance_guide.pdf) can receive subawards. Note that in regard to academic partners, subawards may be allocated to other academic institutions.

Project Team and Project Description: Because service systems are socio-technical systems requiring understanding of people, organizations, and information, the team and the project must contain expertise and activity that reflect these requirements. Thus, in addition to the discipline related to the technology, the disciplines to be included in this project are 1) systems engineering or engineering design, 2) computer science/information technology, and 3) human factors/behavioral science/cognitive engineering. **Some teams not experienced with service engineering might benefit from consulting with an individual with expertise in service operations or service systems.** NSF recognizes that the labels for the aforementioned disciplines may vary in different institutions and organizations, so what is important here is to demonstrate the equivalence of the representation of these disciplines. NSF also recognizes that expertise and experience can be demonstrated in myriad ways, including teaching assignations, degrees, publications, and other professional activities and accomplishments. **The proposer will be asked to show how the disciplines will be integrated in the context of the project as part of the research plan in the Project Description.**

Human subjects. Because of the importance of the service system as human-centered, research activities that involve "Human Subjects" might be necessary. PIs should be knowledgeable about whether they will need human subjects' approval. See GPG, Chapter II.D.7: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=papp.

Animal studies. In some contexts, animal studies are an important prelude to, and may be needed in addition to, the involvement of human subjects. PIs should be knowledgeable about whether they will need to seek Institutional Animal Care and Use Committee (IACUC) approval. See GPG, Chapter II.D.6: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=papp.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Letters of Intent *(required):*

To submit a proposal for this opportunity, the submission of a Letter of Intent (LOI) by the lead institution (i.e., the proposing institution) is required. LOIs are to be submitted via FastLane at http://fastlane.nsf.gov/. More comprehensive information on LOIs is available on the PFI:BIC website: http://www.nsf.gov/eng/iip/pfi/bic/BIC_letterofintent.jsp.

PURPOSE

The LOI is a pre-requisite to proposal submission.

- LOIs are necessary to help NSF prepare and deliver the best review process possible, including assembling panels with appropriate reviewer expertise.
- LOIs provide the NSF with an opportunity to examine proposed projects with respect to some eligibility requirements and, in some instances, to identify correctible issues in terms of focus and eligibility.

The LOI will **NOT** be used as a screening device; that is, it will not be used to disallow the submission of a full proposal.

In the event that there are changes to the LOI prior to submission of the proposal, it is important to communicate what those changes are to the Program Director (Dr. Sara Nerlove, telephone: (703) 292-7077, email: snerlove@nsf.gov).

SUBMISSION. **Up to two (2) LOIs per institution can be submitted.**

CONTENT/FORMAT

Letters of intent have length limitations. The first two sections are entitled, respectively, Synopsis (2500 characters maximum, including spaces); and Other Comments (2500 characters maximum, including spaces), which can be used to convey important aspects of the project, such as information about not only the discipline(s) related to the technology, but also the disciplines to be included in this project: 1) systems engineering or engineering design, 2) computer science/information technology, and 3) human factors/behavioral science/cognitive engineering. The Other Comments section also may be utilized to contain information from the Additional Information field *Primary Industrial Partners*, if that information cannot be accommodated in the limited space provided.

Under **Additional Information**, information in only three (3) data fields is permitted. (Each data field can contain a maximum of 255 characters or approximately 30 words for each section.)

For PFI:BIC, these are as follows:

- For the **Service System:** Describe briefly the technology-based "smart" service system that is the focus of the project and how the technology will contribute to the creation or transformation of it.
- For the **Primary Industrial Partner(s)**, provide for each: Name, Founding Date, Number of Employees, Location (City & State), Commercial Revenues for the preceding calendar year, and Project Role (s). Reasonable abbreviations can be used. If you cannot accommodate the information, include the rest of the information under Other Comments (see above).
- For the **Human Factors Tasks** to be carried out which are **essential** to the **operation of the Smart Service System:** List a few major research activities which illustrate inclusion of human-centered considerations.

Letter of Intent Preparation Instructions:

When submitting a Letter of Intent through FastLane in response to this Program Solicitation please note the conditions outlined below:

- Sponsored Projects Office (SPO) Submission is required when submitting Letters of Intent
- A Minimum of 0 and Maximum of 4 Other Senior Project Personnel are allowed
- A Minimum of 0 and Maximum of 4 Other Participating Organizations are allowed
- Service System is required when submitting Letters of Intent
- Primary Industrial Partner(s) is required when submitting Letters of Intent
- Human Factors Research Tasks is required when submitting Letters of Intent
- Submission of multiple Letters of Intent is not allowed

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

- 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 Grant Proposal Guide (GPG). The complete text of the GPG is available electronically on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg. Paper copies of the GPG 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 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: (http://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.

Guide to Submission of a Full Proposal

Note: the submission criteria outlined below are in addition to requirements contained within the NSF Grant Proposal Guide (GPG) or NSF Grants.gov Application Guide.

Active and early collaboration among the primary project partners is highly encouraged, beginning with the proposal preparation stage, including a discussion about the content and requirements of a fully executed Cooperative Research Agreements (CRAs). (NOTE THIS ONLY WOULD BE NEEDED UPON NOTIFICATION THAT THE PROGRAM IS CONSIDERING A RECOMMENDATION FOR AWARD.)

A. Cover Sheet

The Cover Sheet is automatically generated by FastLane or Grants.gov based on information entered into the "Cover Sheet" module. The title for each project should be preceded by PFI:BIC. If the project contains proprietary information, be sure that the box labelled Proprietary and Privileged Information is marked [see the GPG: http://www.nsf.gov/pubs/policydocs/pappguide/nsf14001/gpg_1.jsp#proprietary]

B. Project Summary

Proposals that do not contain the Project Summary, including an *overview* and separate statements on *intellectual merit* and *broader impacts*, will not be accepted by FastLane or will be returned without review. Additional instructions for preparation of the Project Summary are available in FastLane. The Project Summary should be written in the third person and shall begin as follows: "This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project...." Provide the title of the proposed PFI:BIC project, the name of the PI, and the lead institution.

Box 1: Overview including Naming the Primary Industry Partner(s), and Key Words: A summary paragraph describing the potential outcome(s) of the proposed activity. Provide a statement of objectives and methods to be employed.

Provide a list of key words or phrases that identify the areas of expertise in science or engineering, which are to be invoked in reviewing the proposal. Identify the application area to which the smart service system innovation is to be initially directed.

Box 2: Intellectual Merit: No proprietary information should be included in the summary. Describe the potential of the proposed activity to enhance scientific and technological understanding both at the level of the technology and of the smart service system.

Box 3: Broader Impacts: Describe the potential of the proposed activity to contribute to economic impact and contribute to the achievement of specific, desired societal outcomes. Information on the potential commercial value can be included in this section.

The aggregate of the three text boxes cannot exceed 4,600 characters, including spaces.

C. Table of Contents

The table of contents is automatically generated by FastLane or Grants.gov.

D. Project Description

The project description cannot exceed 15 pages and must include the following parts:

Part 1. Narrative Description: Proposers (primary academic and industrial partner(s) and other primary partners, if applicable) are encouraged to frame the proposal narrative to convey a convincing story. That is, rather than simply describing the potential of the technology, the novelty or significance of the proposed smart service system and the research plan, proposers should present a compelling story to clearly articulate why this partnership provides the best approach for achieving the greatest impact. This story, while specific to each proposal, should contain at least the following elements: the importance of the research discovery; how the partnership came about; the exciting potential of the discovery to expand the capability of the technology and the way that the technology can be harnessed in the service system, including market needs that might be addressed; how the partnership might evolve if the project is successful; and how the outcomes of the collaboration across organizations and disciplines will be greater than the sum of the outcomes of the primary individual partners alone. The research plan should also show how the research activities integrate knowledge and approaches from the different disciplines. Include, if applicable, lineage relating to research discoveries in past NSF awards. For each previously funded project, include the directorate name, division name, and award number.

Part 2. Management Plan: Provide a description of the respective roles, responsibilities, and resources of the partnership.

Part 3. Timetable: Provide a table of the research tasks to be conducted, the designated partners to accomplish each task, and the timeline associated with each task.

Part 4. Intellectual Property: Include a discussion of any relevant background intellectual property held by the proposing institution and/or the industry partner, its availability for licensing, and an assessment of how another party might patent or practice around both background and anticipated intellectual property assets. Discuss any relevant findings from the patent search of similar technologies (see supplemental documents).

Part 5. Results from Prior NSF Support: If any PI or Co-PI identified on the project has received NSF funding in the past five years; information on the award(s) is required. Each PI and Co-PI who has received more than one award (excluding amendments) must report on the award most closely related to the proposal. The following information must be provided:

- NSF award number, amount and period of support
- title of the project
- number of publications resulting from the NSF award

E. References Cited

Provide a comprehensive listing of relevant reference sources, including patent citations.

F. Biographical Sketches

All participating personnel from industry and other (types of) primary partners (if applicable) as well as from academe who are not PIs or Co-PIs should be classified as "Non-Co-PI/Senior Personnel". Provide relevant biographical information for the Principal Investigator (PI), Co-Principal Investigators (Co-PIs), and Senior Personnel (including any consultant(s), and/or key member(s) on each subaward). This information should take the form of short "Biographical Sketch" documents (two pages maximum per person). Within each document, include at the top of the first page: the person's name, category of participation (PI, Co-PI, Industry/Other Organization Consultant, Academic Consultant, Industry Subawardee, Academic Subawardee, Industry/Other Organization Participant), and affiliation. Biographical sketches of industry participants need not conform to the standard academic format.

G. Budget, Subaward Budgets, and Consultants

The NSF Summary Proposal Budget is generated in FastLane or Grants.gov. Prepare a budget for each year. The system will automatically generate a cumulative budget for the entire project. All PIs, Co-PIs, and at least one named individual designated as responsible for the leadership of each subaward--this individual(s) must be listed under "A. Senior Personnel" on the subaward budget--and must spend time for which he/she receives salary. The amount of time may be limited, as deemed appropriate; but there must be a formal commitment.

In the budget justification, clarify how many individual participants there are under each of the categories of "B. Other Personnel" (e.g., 2 students per year cumulates to a total of 6 students on the cumulative budget, which in turn may actually mean that e.g., there are 2 students on the project for 3 years each, or 6 students, for one year each; it is useful to be able to count heads vs. person years).

Travel costs can be included with careful justification, containing as much specificity as possible regarding the parties, locations/events, and purpose. Foreign travel is allowed.

The NSF does not intend to fund industrial or business research and development. Awarded funds may be allocated in the form of subawards, as appropriate, for participation of the industry in the project research activities, but subawards for industry are optional. The NSF will not provide funds for subawardees to businesses that do not meet the definition of a small business concern (http://sbir.gov/sites/default/files/elig_size_compliance_guide.pdf). It should be clear in the budget justification and narrative how the NSF funds are shared by the partnership. In the "Facilities, Equipment, and Other Resources" section of the proposal, it should be clear how the other resources of the project (e.g., special facilities, equipment, and students) are shared by the partnership and where they are located.

If consultants are used, consultant letter(s) must be provided with the number of days and the dollar amount per day, and the role of the consultant; provide an explicit statement that the consultant's role is deemed reasonable and necessary for the project (see below, Section J. Supplementary Documents).

H. Current and Pending Support

The proposal should provide information regarding all research to which the Principal Investigator and other senior personnel either have committed time or have planned to commit time. For all ongoing and proposed projects, the following information should be provided for the Principal Investigator and anyone designated as Senior Personnel in the submitted budget. (Use NSF Form 1239.)

- Name of sponsoring organization and add the award number as a reference;
- Title and performance period of the proposal; and
- Person-months/calendar months (per year) devoted to the project by the Principal Investigator and each of the senior personnel.

The proposal being submitted is considered "pending" (i.e., this proposal) and therefore MUST appear in the Current and Pending Support module.

I. Facilities, Equipment, and Other Resources

Discuss requirements for and the availability of facilities, equipment, and other resources for the proposed work provided by the lead academic institution and each of the partners.

J. Supplementary Documents

Proposals missing any of the required documents outlined below will be returned without review.

The following information must be provided as supplementary documents (unless otherwise indicated) and submitted to the Supplementary Docs module in FastLane or Grants.gov. Place the documents 1-8 in the order in which they are listed.

1) Project Framework (2 pages). Consider the project framework as the PFI:BIC equivalent of an "elevator" speech. [Please use the template located: here] Describe clearly and briefly (using no less than a 11-point font) the following items:

- Maximum 1 page, 1st page:
    - Problem: Frame the focus of the project research as a problem
    - Solution: Describe how this problem could be solved by a smart service system
    - Market: Demonstrate the team's knowledge about the competitive landscape/state of the art by describing how the particular solution proposed is distinct (a detailed market analysis is premature and not necessary--but say what you can about potential market segment, size, and characteristics). A Letter of Support from a participant(s) in the market may lend credibility to this assessment. "See Letters of Support" also in this section (J. Supplementary Documents).
- Maximum 1 page, 2nd page:
    - Partners: Describe the primary project partners and why this partnership is the appropriate partnership to carry out this project.
    - Contributions: Describe the specific contributions (facilities, resources, know-how, expertise, etc.) of each partner
    - Objectives: Describe the objectives or takeaway(s) for each partner. If the project is successful, how will these takeaways be implemented following the term of the award?

2) Partnership List. Provide a list of all the partner entities and all the participating individuals from those entities, subdivided into the following categories:

- Primary Partners
    - Lead institution
    - Industrial partner(s) those (one or more) that qualify for the minimum requirement , provide founding date, number of employees, location (City & State), commercial revenues (from the previous year or some other appropriate time period), and project role(s)
    - Other primary partners (if any, e.g., academic, other private sector organizations, public sector organizations, others)
- Broader Context Partners
    - Academic institutions
    - Private sector organizations, including for-profit, non-profit businesses, foundations, etc.
    - Public sector organizations, including state and local governments, federal government laboratories
    - Other broader context partners (if any)

In listing the personnel from each entity participating in the PFI:BIC, project, provide the individual's title. For each of the individuals from an academic institution, include the department and/or school/college with which the individual is associated.

3) Organizational/Role Diagram. Provide an organizational chart that identifies the role(s) to be played by each of the partners. Note that in addition to the discipline related to the technology, disciplines to be included in this project are 1) systems engineering or engineering design, 2) computer science/information technology, and 3) human factors/behavioral science/cognitive engineering.

4) Partnership Letter(s)

- Primary Partners. Provide partnership letters from the primary industrial partner(s). Each partner should explicitly make a commitment, either financial or in-kind. These letters must be provided on letterhead, signed by the appropriate institution or partner representative and begin with a statement that confirms the partnership between the academic team and the industrial partner.

    The partnership letter should include answers to the following questions:

    - What do you stand to gain from participating in this partnership project?
    - What do you have to offer to this partnership project?
    - The following is optional: Briefly make any comments you wish to make about your relationship to any of the partners, how you came to join this partnership, past experience, etc.

- Broader Context Partners (s): Provide letters from all other partners engaged in the proposed project, including the nature of their respective commitments to the partnership.

5) Cooperative Research Agreements (CRAs). A letter (not an official legal document at this point, but one signed by an appropriate person at the lead institution) must be submitted with the proposal. The letter should state that CRAs will be provided upon notification that the program is *considering* a recommendation for award. The lead institution must provide signed written CRAs between the lead institution and the partners in a timely fashion when notification of program consideration for an award recommendation is received. Partners on all proposals should be aware of this requirement and prepared to comply promptly in the event of consideration of the proposal for an award. This may mean working out a draft CRA in advance.

The CRAs, which are specifically intended for this project and for the benefit and mutual understanding of the primary partners, outline any issues surrounding the intellectual property that each party may bring to the table or intellectual property that could be an outcome of the relationship. CRAs also cover other pertinent matters surrounding the conduct of the partnership. Typical "Articles" in CRAs might include the following: Research, Publication, Intellectual Property, Term and Termination, Proprietary Information, General, Appendix A (Research Project Title, Research Project Description, Collaborators, Investigators, Scope of Work). NSF is not responsible for the type or content of agreement reached between the parties. There is no template provided by the program. Should it be useful to adapt a CRA template from another source, please do so.

6) Preliminary Patent Search. Provide a preliminary patent search and accompanying discussion to support the feasibility of obtaining needed licenses and/or sufficient protection for the intellectual property developed.

7) Support Letters. Begin with "This letter of support....". Support letters are one form of providing evidence of market validation and the potential value of the project. For example, a signed letter on letterhead from a creditable individual holding a position in recognized entity(ies) in the market (potential future customer, potential licensee, large corporation, etc.) may be included in the supplementary documents to lend credibility to the proposer's assessment of the market and need for an intended application of the technology. Letters indicating potential investment upon the achievement of project milestones would also be appropriate. Make sure support letters are distinct from each other, and note also that they are not to be confused with Partner Letters, which carry a specified commitment.

8) Student Mentoring Plans. In addition to the NSF-wide required mentoring plan for Postdoctoral Researchers (see 10, below), a mentoring plan for each different level of students, Graduate Students and/or Undergraduate Students, receiving support from the budget of this proposal is required. Mentoring plans should be concise and specifically focused on the anticipated role of the students on the PFI:BIC academe-industry partnership project and how the students participating in this project will take advantage of this special interdisciplinary, cross-organizational context. For example, provide a description of their opportunity to work with the industrial partner and to benefit from real life interdisciplinary experiences that foster an innovation culture in the next generation of researchers.

Note that the following 2 items for inclusion as Supplementary Documents are NSF-wide requirements:

9) Data Management Plan. A Data Management Plan is required for all proposals submitted to NSF. Please reference the data management requirements at this link http://www.nsf.gov/pubs/policydocs/pappguide/nsf11001/gpg_2.jsp#dmp

10) Postdoctoral Researcher Mentoring Plan (if applicable). If more than one postdoctoral researcher is supported on the proposal, the proposer may wish to provide a separate mentoring plan for each researcher. The mentoring plan for PFI:BIC should contain specific reference to role of the (each particular) postdoctoral researcher on the PFI:BIC academe-industry partnership project.

K. Single Copy Documents

Proposers are encouraged to supply an annotated list of suggested reviewers, complete with affiliation and contact information. Proposers are also encouraged to email this information directly to the cognizant Program Director (Dr. Sara Nerlove at snerlove@nsf.gov) at the time of the submission of the LOI. In addition, the proposal can also designate and label an individual(s) who is a definitive specialist in the areas/technical subtleties of the proposal. Be particularly mindful about potential conflicts of interest. Avoid selecting any individuals who may have a conflict of interest, or an appearance of a conflict of interest, with the PI, Co-PIs or any of the senior personnel on the project (including personnel on any subawards) or with the industrial partner(s).

B. Budgetary Information

Cost Sharing: Inclusion of voluntary committed cost sharing is prohibited

Other Budgetary Limitations:

Limitations:

NSF will not provide salary support for personnel employed by Federal Agencies or Federally Funded Research and Development Centers.

Budget Limitations:

Proposers may request up to $1,000,000 from NSF for an award duration of three (3) years.

C. Due Dates

- **Letter of Intent Due Date(s)** *(required)* (due by 5 p.m. proposer's local time)**:**

  December 03, 2014

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

  January 28, 2015

D. FastLane/Grants.gov Requirements

For Proposals Submitted Via FastLane:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: https://www.fastlane.nsf.gov/a1/newstan.htm. For FastLane user support, call the FastLane Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov. The FastLane Help Desk answers general technical questions related to the use of the FastLane system. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

Before using Grants.gov for the first time, each organization must register to create an institutional profile. Once registered, the applicant's organization can then apply for any federal grant on the Grants.gov website. Comprehensive information about using Grants.gov is available on the Grants.gov Applicant Resources webpage: 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 are strongly encouraged to use FastLane 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 GPG as Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: http://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 *Investing in Science, Engineering, and Education for the Nation's Future: NSF Strategic Plan for 2014-2018*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

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

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

A. Merit Review Principles and Criteria

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

1. Merit Review Principles

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

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

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

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

2. Merit Review Criteria

All NSF proposals are evaluated through use of the two National Science Board approved merit review criteria. In some instances,

however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. **Both** criteria are to be given **full consideration** during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (GPG 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 GPG 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

Other additional review criteria are as follows:

- The promise of the technology to be advanced, adapted, and integrated into a smart service system that has the potential for social and economic impact.
- The value of the research tasks to be carried out, including those that consider human factors, to advance, adapt, and integrate the technology into a smart service system.
- The quality of the primary partnership (e.g., expertise, achievements, complementarities, commitment) as integral to the planning and execution of these activities.
- The likelihood that the nature of the participation of students and/or postdoctoral researchers in this culture of collaboration will prepare them to be future innovators.

B. Review and Selection Process

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

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

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF strives to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. Large or particularly complex proposals or proposals from new awardees may require additional review and processing time. The time interval begins on the deadline or target date, or receipt date, whichever is later. The interval ends when the Division Director acts upon the Program Officer's recommendation.

After programmatic approval has been obtained, the proposals recommended for funding will be forwarded to the Division of Grants and Agreements for review of business, financial, and policy implications. After an administrative review has occurred, Grants and Agreements Officers perform the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments, obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

Once an award or declination decision has been made, Principal Investigators are provided feedback about their proposals. In all cases, reviews are treated as confidential documents. Verbatim copies of reviews, excluding the names of the reviewers or any reviewer-identifying information, are sent to the Principal Investigator/Project Director by the Program Officer. In addition, the proposer will receive an explanation of the decision to award or decline funding.

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

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

B. Award Conditions

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

*These documents may be accessed electronically on NSF's Website at http://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 http://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

C. Reporting Requirements

For all multi-year grants (including both standard and continuing grants), the Principal Investigator must submit an annual project report to the cognizant Program Officer at least 90 days prior to the end of the current budget period. (Some programs or awards require submission of more frequent project reports). Within 90 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 http://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

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:

- Sara B. Nerlove, ENG/IIP/PFI:BIC, Program Director, telephone: (703) 292-7077, email: snerlove@nsf.gov

- Alexandra Medina-Borja, ENG/OAD, telephone: (703) 292-7557, email: amedinab@nsf.gov

- Chris Paredis, ENG/CMMI, telephone: (703) 292-2241, email: cparedis@nsf.gov

- Leon Esterowitz, ENG/CBET, telephone: (703) 292-7942, email: lesterow@nsf.gov

- Gurdip Singh, CISE, telephone: (703) 292-8950, email: gsingh@nsf.gov

- Alexander Leonessa, ENG/CBET, telephone: (703) 292-2678, email: aleoness@nsf.gov

For questions related to the use of FastLane, contact:

- FastLane Help Desk, telephone: 1-800-673-6188; e-mail: fastlane@nsf.gov.

For questions relating to Grants.gov contact:

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

IX. OTHER INFORMATION

The NSF website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this website by potential proposers is strongly encouraged. In addition, "NSF Update" is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF Grants Conferences. Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. "NSF Update" also is available on NSF's website at https://public.govdelivery.com/accounts/USNSF/subscriber/new?topic_id=USNSF_179.

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.

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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.

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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.

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The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by 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
Arlington, VA 22230

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