



FY 2016

**Small Business Innovation Research
(SBIR) Program – Phase II**

Federal Funding Opportunity (FFO)

ANNOUNCEMENT

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**U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology**

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<http://www.nist.gov/sbir>

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**US DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
FY 2016 SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM – PHASE II
FEDERAL FUNDING OPPORTUNITY (FFO)**

1.0 PROGRAM DESCRIPTION AND FEDERAL AWARD INFORMATION

1.01 Introduction

The National Institute of Standards and Technology (NIST) **invites FY 2015 NIST SBIR Phase I awardees to submit Phase II research applications** under this Federal Funding Opportunity (FFO). **Only NIST SBIR FY 2015 Phase I awardees are eligible to submit applications for Phase II of their projects.**

The Small Business Innovation Research (SBIR) program was originally established in 1982 by the Small Business Innovation Development Act (P.L. 97-219), codified at 15 U.S.C. § 638. It was then expanded and extended by the Small Business Research and Development (R&D) Enhancement Act of 1992 (P.L. 102-564), and received subsequent reauthorization and extensions that include Public Law 112-81, extending SBIR through September 30, 2017.

Eleven federal agencies implement SBIR by setting aside a portion of their extramural research and development budget each year to fund research applications from small science and technology-based firms. The statutory purpose of the SBIR Program is to strengthen the role of innovative small business concerns (SBCs) in Federally-funded research or research and development (R/R&D). Specific program goals are to: (1) stimulate technological innovation; (2) use small business to meet Federal R/R&D needs; (3) foster and encourage participation by socially and economically disadvantaged small businesses and by women-owned small businesses in technological innovation; and (4) increase private sector commercialization of innovations derived from Federal R/R&D, thereby increasing competition, productivity and economic growth.

The NIST SBIR program identifies and solicits applications in topics that fall within NIST's mission and allow collaboration between NIST scientists and the SBIR awardees whenever possible. In order to ensure a greater strategic alignment between the SBIR program and NIST's laboratory research program, the SBIR topics are the priority areas identified in the NIST Programmatic Plan available at: <http://www.nist.gov/director/planning/planning.cfm>.

Subtopics set forth in Section 9 of this FFO are intended to cultivate private sector innovation and foster and encourage participation by minority and disadvantaged persons in technological innovation.

In developing topics and subtopics and when reviewing applications, NIST gives high priority to small business concerns that participate in or conduct energy efficiency or renewable

energy system R&D projects, consistent with Executive Order (EO) 13329 (<http://www.gpo.gov/fdsys/pkg/FR-2004-02-26/pdf/04-4436.pdf>) “Encouraging Innovation in Manufacturing,” the Energy Independence and Security Act of 2007 (P.L. 110-140 § 1203(e), codified at 15 U.S.C. § 638(z)), and the Small Business Administration (SBA) SBIR Policy Directive, § 9, found at http://www.sbir.gov/sites/default/files/sbir_pd_with_1-8-14_amendments_2-24-14.pdf.

Any SBIR award addressing a subtopic that includes a background invention will, as necessary, be granted a non-exclusive research license to use those NIST-owned patented inventions. No commercialization license to make, use or sell products or services incorporating the NIST background invention will be granted until an SBIR awardee applies for, negotiates and receives a research license and complete its Phase II award. All awardees with agreements for technologies that identify specific NIST background inventions will be given the opportunity to negotiate a non-exclusive commercialization license to such inventions as provided in the Federal patent licensing regulations, set forth in 37 C.F.R. Part 404.

Once awarded and, where necessary, granted a license to use NIST technology, it is the goal of this program that the SBIR awardee will be positioned to create and add its own innovation and develop a commercially viable product based on the NIST developed technology.

1.02 Three-Phase Program

The SBIR statute (15 U.S.C. § 638) requires the Department of Commerce (DoC) to establish a three-phase SBIR program by reserving a percentage of its extramural R&D budget to be awarded to small business concerns for innovation research. SBIR policy is provided by the SBA through the [SBIR Policy Directive](#).

The funding vehicles for NIST’s SBIR program are cooperative agreements. NIST’s authority to implement its SBIR program through cooperative agreements is 15 U.S.C. § 272(b)(4). NIST programmatic authorities for the subtopics listed in this FFO are found at 15 U.S.C. § 272(b) and (c). The nature of NIST’s “substantial involvement” will generally be collaboration with the awardees in carrying out the scope of work. Additional forms of substantial involvement that may arise are described in Chapter 5.C of the DoC Grants and Cooperative Agreements Manual, which is available at <http://go.usa.gov/SNJd>. Please note the DoC Grants and Cooperative Agreements Manual is expected to be updated after publication of this funding announcement but prior to issuance of any Phase II awards. Refer to Section 1.05 of this FFO, Contact with NIST, Grant Rules and Regulations, if you seek the information at this link and it is no longer working or you need more information. Grants and agreements administrative requirements set forth at 2 C.F.R. Part 200 will apply to NIST SBIR awards.

1.02.01 Phase I - Feasibility Research

The purpose of Phase I was for NIST to determine the technical feasibility of the research, preliminary commercialization potential of the proposed effort, and the quality of the awardee's performance. Therefore, the application should concentrate on describing research that will significantly contribute to proving the feasibility of the proposed Phase II research, a prerequisite to receiving further support in Phase II.

This FFO is not soliciting applications for Phase I research.

1.02.02 Phase II - Research and Development

All Phase I awardees are given the opportunity to submit a Phase II application following completion of Phase I. This FFO provides instructions for Phase II application preparation and submission requirements.

In Phase II, work from Phase I that exhibits potential for commercial application is further developed. Phase II is the R&D or prototype development phase. To apply for a Phase II award, each Phase I awardee is required to submit a comprehensive application outlining the research. Each NIST Phase II award is for up to \$300,000 and up to a 24 month period of performance. One year after completing Phase II R&D activity, the awardee shall be required to report on its commercialization activities.

This FFO is soliciting applications from FY 2015 Phase I awardees to submit applications for Phase II research and development.

1.02.03 Phase III - Commercialization

Phase III refers to work that derives from, extends, or completes an effort made under prior SBIR funding agreements, but is funded by sources other than the SBIR Program. Phase III work is typically oriented towards commercialization of SBIR research or technology and may be for products, production, services, R/R&D or a combination thereof.

This FFO is not soliciting applications for Phase III activities.

1.02.04 Commercialization Readiness Pilot Program

As allowed in Section 5123 of the SBIR/STTR Reauthorization Act of 2011, Division E of Pub. L. 112-81, NIST has received authorization to establish a Commercialization Readiness Pilot Program (CRPP). NIST may provide supplemental funding (up to an additional ten percent of the Phase II award) to selected awardees after completion of Phase II. The funding would be used to further develop Phase II technologies, to support advancement toward Phase III, and to increase the likelihood of commercialization. NIST is under no obligation to make any CRPP awards.

1.03 SBIR Applicant Eligibility and Limitations

1.03.01 Applicant Qualifications

Under this FFO, only FY 2015 NIST SBIR Phase I awardees are eligible to submit applications. Applicants must qualify as a small business concern for R/R&D purposes, as defined in Section 1.06 of this FFO, at the time of award. In addition, the primary employment of the principal investigator must be with the small business at the time of the award and during the conduct of the proposed research. Primary employment means that more than one-half of the principal investigator's time is spent working with the small business. Primary employment with a small business precludes full-time employment with another organization. Occasionally, deviations from this requirement may occur, which must be approved in writing by the NIST Grants Officer after consultation with the SBIR Program Manager. Further, a small business may only replace the principal investigator on an SBIR Phase I or Phase II award if the NIST Grants Officer provides prior written approval. Personnel obtained through a Professional Employer Organization or other similar personnel leasing company may be considered employees of the awardee.

Phase II R/R&D work must be performed in the United States. However, based on a rare and unique circumstance, approval may be granted for a particular portion of the R/R&D work to be performed or obtained in a country outside of the United States, for example, if a supply or material or other item or project requirement is not available in the United States. The NIST Grants Officer must approve each such specific exception in writing.

NIST has elected to not use the authority that would allow venture capital operating companies (VCOCs), hedge funds or private equity firms to participate in the SBIR Program. Therefore, applications in which work would be performed by VCOCs will not be considered for award.

For Phase II, a minimum of one-half of the research and/or analytical effort must be performed by the awardee. The total cost for all consultant fees, facility leases, usage fees, and other subcontract/subaward or purchase agreements may not exceed one-half of the total award.

All applicants are required to provide certain information via www.SBIR.gov as well as other information required by the [SBIR Policy Directive](#) (see Appendices V-VI). Each SBC applying for a Phase II award is required to update the appropriate information in the SBA Tech-Net database on SBIR.gov for any of its existing and prior Phase II awards.

Applicants may not participate in the selection of any topic or subtopic nor in the review of applications.

The statement of work of an SBIR award awarded under this FFO cannot overlap with the

statement of work of an existing NIST Cooperative Research and Development Agreement (CRADA) with the awardee. NIST will consider the issue of any potential overlap on a case-by-case basis.

1.03.02 Company Registry Requirements

SBA maintains and manages a Company Registry at <http://www.sbir.gov/registration> to track ownership and affiliation requirements for all companies applying to the SBIR Program. **Phase II applicants must register in the Company Registry prior to submitting an application. The applicant must save its information from the registration in a .pdf document and append this document to SF-424 form as described in Section 8.01.(9) of this FFO.** All applicants are required to report and/or update their registration information in the SBA Company Registry prior to each SBIR application submission or if any information changes prior to an award.

1.04 Contact with NIST

In the interest of competitive fairness, all oral or written communication with NIST during the open FFO period is prohibited. Questions and answers will not be accepted through nor posted on Grants.gov.

Applicants may contact the NIST Hollings Manufacturing Extension Partnership (MEP) to be directed to Centers for technical assistance with application preparation. More information on obtaining technical assistance from MEP Centers for application preparation can be found in Section 5.12 of this FFO.

For programmatic, electronic submission, or grants questions, please contact the appropriate individual:

Subject Area	Point of Contact
Programmatic Questions	Mary Clague Phone: (301) 975-4188 Fax: (301) 975-3482 E-mail: mary.clague@nist.gov or J'aime Maynard Phone: (301) 975-8408 E-mail: jmaynard@nist.gov
Electronic Application Submission through Grants.gov	Christopher Hunton Phone: (301) 975-5718 Fax: (301) 975-8884 E-mail: grants@nist.gov

Subject Area	Point of Contact
	or Grants.gov Phone: 800-518-4726 E-mail: support@grants.gov
Grant Rules and Regulations	Robin Bunch Phone: (301) 975-8006 Fax: (301) 975-6368 E-mail: robin.bunch@nist.gov

1.05 Definitions

Except as specifically noted by citation or reference, all definitions below are excerpted from the SBA SBIR Policy Directive, available at http://sbir.gov/sites/default/files/sbir_pd_with_1-8-14_amendments_2-24-14.pdf.

Applicant – The organizational entity that qualifies as a Small Business Concern (SBC) at all pertinent times and that submits a contract proposal or a grant application for a funding agreement under the SBIR Program.

Awardee – The organizational entity that receives an SBIR Phase I, Phase II or Phase III award.

Commercialization - The process of developing products, processes, technologies, or services and the production and delivery (whether by the originating party or others) of the products, processes, technologies, or services for sale to or use by the Federal government or commercial markets.

Cooperative Agreement - A financial assistance mechanism used when substantial Federal programmatic involvement with the awardee during performance is anticipated by the issuing agency. The Cooperative Agreement contains the responsibilities and respective obligations of the parties.

Contract – A mutually binding legal relationship obligating the seller to furnish equipment, goods or services and the buyer to pay for them.

Essentially Equivalent Work - Work that is substantially the same research, which is proposed for funding in more than one contract proposal or grant application submitted to the same Federal agency or submitted to two or more different Federal agencies for review and funding consideration; or work where a specific research objective and the research

design for accomplishing the objective are the same or closely related to another proposal or award, regardless of the funding source.

Feasibility - The practical extent to which a project can be performed successfully.

Funding Agreement - Any contract, grant, or cooperative agreement entered into between any Federal agency and any SBC for the performance of experimental, developmental, or research work, including products or services, funded in whole or in part by the Federal Government.

Joint Venture – See 13 C.F.R. § 121.103(h).

Research or Research and Development (R/R&D) - Any activity that is:

- (1) a systematic, intensive study directed toward greater knowledge or understanding of the subject studied;
- (2) a systematic study directed specifically toward applying new knowledge to meet a recognized need; or
- (3) a systematic application of knowledge toward the production of useful materials, devices, services, or methods, and includes design, development, and improvement of prototypes and new processes to meet specific requirements.

SBIR Technical Data - All data generated during the performance of an SBIR award.

SBIR Technical Data Rights - The rights an SBIR awardee obtains in data generated during the performance of any SBIR Phase I, Phase II, or Phase III award that an awardee delivers to the Government during or upon completion of a Federally-funded project, and to which the Government receives a license.

Small Business Concern (SBC) – A concern that meets the requirements set forth in 13 C.F.R. § 121.702 (available at <http://www.gpo.gov/fdsys/granule/CFR-2011-title13-vol1.CFR-2011-title13-vol1-sec121-702>).

Socially and Economically Disadvantaged SBC (SDB) - See 13 C.F.R. Part 124, Subpart B.

Socially and Economically Disadvantaged Individual - See 13 C.F.R. §§ 124.103 and 124.104.

Subaward – See 2 C.F.R. § 200.92.

Women-Owned Small Business (WOSB) - An SBC that is at least 51% owned by one or more women, or in the case of any publicly owned business, at least 51% of the stock is owned by women, and women control the management and daily business operations.

1.06 Fraud, Waste and Abuse

As defined in the SBIR Policy Directive section 9(f), fraud includes any false representation about a material fact or any intentional deception designed to deprive the United States unlawfully of something of value or to secure from the United States a benefit, privilege, allowance, or consideration to which an individual or business is not entitled. Waste includes extravagant, careless, or needless expenditure of Government funds, or the consumption of Government property, that results from deficient practices, systems, controls, or decisions. Abuse includes any intentional or improper use of Government resources, such as misuse of rank, position, or authority or resources. Examples of fraud, waste, and abuse relating to the SBIR Program include, but are not limited to:

(i) misrepresentations or material, factual omissions to obtain, or otherwise receive funding under, an SBIR award;

(ii) misrepresentations of the use of funds expended, work done, results achieved, or compliance with program requirements under an SBIR award;

(iii) misuse or conversion of SBIR award funds, including any use of award funds while not in full compliance with SBIR Program requirements, or failure to pay taxes due on misused or converted SBIR award funds;

(iv) fabrication, falsification, or plagiarism in applying for, carrying out, or reporting results from an SBIR award;

(v) failure to comply with applicable federal costs principles governing an award;

(vi) extravagant, careless, or needless spending;

(vii) self-dealing, such as making a sub-award to an entity in which the PI has a financial interest;

(viii) acceptance by agency personnel of bribes or gifts in exchange for grant or contract awards or other conflicts of interest that prevents the Government from getting the best value; and

(ix) lack of monitoring, or follow-up if questions arise, by agency personnel to ensure that awardee meets all required eligibility requirements, provides all required certifications, performs in accordance with the terms and conditions of the award, and performs all work proposed in the application.

Report any allegations of fraud, waste and abuse to:

Department of Commerce
Office of Inspector General
Ben Franklin Station, Post Office Box 612

Washington, D.C. 20044

Telephone:

Toll free 1-800-424-5197

TTD 1-855-860-6950

Local 202-482-2495

e-mail: hotline@oig.doc.gov

2.0 CERTIFICATIONS

2.01 Funding Agreement Certification

Awardees will be required to certify size, ownership and other SBIR Program requirements at the time of award and during the funding agreement life cycle using the SBIR Funding Agreement Certification and the SBIR Funding Agreement Certification – Life-Cycle Certification, which are provided in Appendix B of this FFO.

2.02 Research Activities Involving Human Subjects, Human Tissue, Data or Recordings Involving Human Subjects Including Software Testing

Any application that includes research activities involving human subjects, human tissue/cells, or data or recordings from or about human subjects, must satisfy the requirements of the Common Rule for the Protection of Human Subjects (“Common Rule”), codified for the Department of Commerce at 15 C.F.R. Part 27. Research activities involving human subjects who fall within one or more of the classes of vulnerable subjects found in 45 C.F.R. Part 46, Subparts B, C and D must satisfy the requirements of the applicable subpart(s). In addition, any such application that includes research activities on these subjects must be in compliance with all applicable statutory requirements imposed upon the Department of Health and Human Services (DHHS) and other Federal agencies, all regulations, policies and guidance adopted by DHHS, the Food and Drug Administration, and other Federal agencies on these topics, and all Executive Orders and Presidential statements of policy on applicable topics. (Regulatory Resources: <http://www.hhs.gov/ohrp/humansubjects/index.html> which includes links to FDA regulations, but may not include all applicable regulations and policies).

NIST uses the following Common Rule definitions for research and human subjects research:

Research: A systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge. Activities which meet this definition constitute research for purposes of this policy, whether or not they are conducted or supported under a program which is considered research for other purposes. For example, some demonstration and service programs may include research activity.

Human Subject: A living individual about whom an investigator (whether professional or student) conducting research obtains data through intervention or interaction with the individual or identifiable private information.

- (1) *Intervention* includes both physical procedures by which data are gathered and manipulations of the subject or the subject's environment that are performed for research purposes.
- (2) *Interaction* includes communication or interpersonal contact between investigator and subject.
- (3) *Private information* includes information about behavior that occurs in a context in which an individual can reasonably expect that no observation or recording is taking place, and information which has been provided for specific purposes by an individual and which the individual can reasonably expect will not be made public (for example, a medical record). Private information must be individually identifiable (i.e., the identity of the subject is or may readily be ascertained by the investigator associated with the information) in order for obtaining the information to constitute research involving human subjects.

See 15 C.F.R. § 27.102 Definitions.

- 1) **Requirement for Federalwide Assurance.** If the application is accepted for [or awarded] funding, organizations that have an IRB are required to follow the procedures of their organization for approval of exempt and non-exempt research activities that involve human subjects. Both domestic and foreign organizations performing non-exempt research activities involving human subjects will be required to have protocols approved by a cognizant, active IRB currently registered with the Office for Human Research Protections (OHRP) within the DHHS that is linked to the engaged organizations. All engaged organizations must possess a currently valid Federalwide Assurance (FWA) on file from OHRP. Information regarding how to apply for an FWA and register an IRB with OHRP can be found at <http://www.hhs.gov/ohrp/assurances/index.html>. NIST relies only on OHRP-issued FWAs and IRB Registrations for both domestic and foreign organizations for NIST supported research involving human subjects. NIST will not issue its own FWAs or IRB Registrations for domestic or foreign organizations.
- 2) **Administrative Review.** NIST reserves the right to make an independent determination of whether an applicant's activities include research involving human subjects. NIST will conduct an independent administrative review of all applications accepted for funding that include research involving human subjects that were approved by a non-NIST Institutional Review Board (IRB). Research may not start until the NIST Human Subjects Protection Office (HSPO) issues institutional review approval for final action by the NIST Grants Officer. (15 C.F.R. § 27.112 Review by Institution.) If NIST determines that an

application includes research activities which involve human subjects, the applicant will be required to provide additional information for review and approval. The documents required for funded proposals are listed in each section below. Most such documents will need to be produced during the proposal review process; however, the Grants Officer may allow final versions of certain required documents to be produced at an appropriate designated time post-award. If an award is issued, no research activities involving human subjects shall be initiated or costs incurred for those activities under the award until the NIST Grants Officer issues written approval. Retroactive approvals are not permitted.

3) Required documents for proposal review. All applications involving human subject research must clearly indicate, by separable task, all research activities believed to be exempt or non-exempt research involving human subjects, the expected institution(s) where the research activities involving human subjects may be conducted, and the institution(s) expected to be engaged in the research activities.

a. Not research determination. If an activity/task involves human subjects as defined in the Common Rule, but the applicant participant(s) indicates to NIST that the activity/task is not research as defined in the Common Rule, the following information may be requested for that activity/task:

- (1) Justification, including the rationale for the determination and such additional documentation as may be deemed necessary by NIST to review and/or support a determination that the activity/task in the application is not research as defined in the Common Rule.
- (2) If the applicant participant(s) used a cognizant IRB that provided a determination that the activity/task is not research, a copy of that determination documentation must be provided to NIST. The applicant participant(s) is not required to establish a relationship with a cognizant IRB if they do not have one.

NIST will review the information submitted and may coordinate further with the applicant before determining whether the activity/task will be defined as research under the Common Rule in the applicable NIST financial assistance program or project.

b. Exempt research determination with no IRB. If the application appears to NIST to include exempt research activities, and the performer of the activity or the supplier and/or the receiver of the biological materials or data from human subjects **does not** have a cognizant IRB to provide an exemption determination, the following information may be requested during the review process so that NIST can evaluate whether an exemption under the Common Rule applies (see 15 C.F.R. § 27.101(b), (c) and (d)).

- (1) The name(s) of the institution(s) where the exempt research will be conducted.

- (2) The name(s) of the institution(s) providing the biological materials or data from human subjects will be provided.
 - (3) A copy of the protocol for the research to be conducted; and/or the biological materials or data from human subjects to be collected/provided, not pre-existing samples (*i.e.*, will proposed research collect only information without personal identifiable information, will biological materials or data be de-identified and when and by whom was the de-identification performed, how were the materials or data originally collected).
 - (4) For pre-existing biological materials or data from human subjects, provide copies of the consent forms used for collection and a description of how the materials or data were originally collected and stripped of personal identifiers. If copies of consent forms are not available, explain.
 - (5) Any additional clarifying documentation that NIST may deem necessary in order to make a determination whether the activity/task or use of biological materials or data from human subjects is exempt under the Common Rule.
- c. Research review with an IRB.** If the application appears to NIST to include research activities (exempt or non-exempt) involving human subjects, and the proposed performer of the activity has a cognizant IRB registered with OHRP, and linked to their Federalwide Assurance, the following information may be requested during the review process:
- (1) The name(s) of the institution(s) where the research will be conducted;
 - (2) The name(s) and institution(s) of the cognizant IRB(s), and the IRB registration number(s);
 - (3) The FWA number of the applicant linked to the cognizant IRB(s);
 - (4) The FWAs associated with all organizations engaged in the planned research activity/task, linked to the cognizant IRB;
 - (5) If the IRB review(s) is pending, the estimated start date for research involving human subjects;
 - (6) The IRB approval date (if currently approved for exempt or non-exempt research);
 - (7) If any of the engaged organizations has applied for or will apply for an FWA or IRB registration, those details should be clearly provided for each engaged organization.

If the application includes research activities involving human subjects to be performed in the first year of an award, additional documentation may be requested by NIST during pre-award review for those performers, and may include the following for those research activities:

- (1) A signed (by the study principal investigator) copy of each applicable final IRB-approved protocol;

- (2) A signed and dated approval letter from the cognizant IRB(s) that includes the name of the institution housing each applicable IRB, provides the start and end dates for the approval of the research activities, and any IRB-required interim reporting or continuing review requirements;
- (3) A copy of any IRB-required application information, such as documentation of approval of special clearances (*i.e.*, biohazard, HIPAA, etc.) conflict-of-interest letters, or special training requirements;
- (4) A brief description of what portions of the IRB submitted protocol are specifically included in the application submitted to NIST, if the protocol includes tasks not included in the application, or if the protocol is supported by multiple funding sources. For protocols with multiple funding sources, NIST will not approve the study without a non-duplication-of-funding letter indicating that no other federal funds will be used to support the tasks proposed under the proposed research or ongoing project;
- (5) If a new protocol will only be submitted to an IRB if an award from NIST is issued, a draft of the proposed protocol;
- (6) Any additional clarifying documentation that NIST may request during the review process to perform the NIST administrative review of research involving human subjects. (*See* 15 C.F.R. § 27.112 Review by Institution.)

This clause reflects the existing NIST policy and requirements for Research Involving Human Subjects. Should the policy be revised prior to award, a clause reflecting the policy current at time of award may be incorporated into the award.

If the policy is revised after award, a clause reflecting the updated policy may be incorporated into the award.

For more information regarding research projects involving human subjects, contact Anne Andrews, Director, NIST Human Subjects Protection Office (e-mail: anne.andrews@nist.gov; phone: (301) 975-5445).

2.03 Research Applications Involving Live Vertebrate Animals

Any application that includes research activities involving live vertebrate animals, that are being cared for, euthanized, or used by participants in the application to accomplish research goals, teaching, or testing, must meet the requirements of the Animal Welfare Act (AWA) (7 U.S.C. § 2131 et seq.), and the AWA final rules (9 C.F.R. Parts 1, 2, and 3), and if appropriate, the Good Laboratory Practice for Non-clinical Laboratory Studies (21 C.F.R. Part 58). In addition, such applications should be in compliance with the "*U.S. Government Principles for Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training.*" The Principles and guidance on these Principles are available in the National Research Council's "*Guide for the Care and Use of Laboratory Animals,*" which can be obtained from National Academy Press, 500 5th Street, N.W., Department 285, Washington, DC 20055, or as a free PDF online at <http://www.nap.edu/catalog/12910/guide-for-the-care-and-use-of-laboratory-animals-eighth>.

The following requirements do not apply to proposed research using preexisting images of animals or to research plans that do not include live animals. These regulations also do not apply to obtaining stock items from animal material suppliers (*e.g.*, tissue banks), such as cell lines and tissue samples, or from commercial food processors, where the vertebrate animal was euthanized for food purposes and not for the purpose of sample collection.

Custom Collections Harvested from Live Vertebrate Animals: NIST requires documentation for obtaining custom samples from live vertebrate animals from animal material suppliers and other organizations (*i.e.*, universities, companies, and government laboratories, etc.). Custom samples includes samples from animal material suppliers, such as when a catalog item indicates that the researcher is to specify the characteristics of the live vertebrate animal to be used, or how a sample is to be collected from the live vertebrate animal.

Field Studies of Animals: Some field studies of animals may be exempt under the Animal Welfare Act from full review and approval by an animal care and use committee, as determined by each institution. Field study is defined as “...a study conducted on free-living wild animals in their natural habitat.” However, this term excludes any study that involves an invasive procedure or that harms or materially alters the behavior of an animal under study. Field studies, with or without invasive procedures, may also require obtaining appropriate federal or local government permits (*e.g.*, marine mammals, endangered species etc.). If the applicant’s institution requires review and approval by an animal care and use committee, NIST will require that documentation to be provided as described below.

1) Requirement for Assurance.

An applicable assurance for the care and use of the live vertebrate animal(s) to be used in the proposed research is required. NIST accepts three types of assurances, as may be applicable. NIST may request documentation to confirm an assurance, if adequate confirmation is not available through an assuring organization’s website.

The cognizant Institutional Animal Care and Use Committee (IACUC) where the research activity is located may hold one or more applicable assurance, including:

- Animal Welfare Assurance from the Office of Laboratory Animal Welfare (OLAW) indicated by the OLAW assurance number, *i.e.*, A-1234;
- USDA Animal Welfare Act certification indicated by the certification number, *i.e.*, 12-R-3456;
- Association for the Assessment and Accreditation of Laboratory Animal Care (AAALAC) indicated by providing the organization name accredited by AAALAC as listed in the AAALAC Directory of Accredited Organizations.

2) Administrative Review.

NIST reserves the right to make an independent determination of whether an applicant’s research activities involve live vertebrate animals or custom samples from, or field studies

with live vertebrate animals. If NIST determines that the application includes research activities, field studies, or custom samples involving live vertebrate animals, the applicant will be required to provide additional information for review and approval. The documents required for funded proposals are listed in each section below. Some may be requested for a pre-review during the proposal review process; however, the Grants Officer may allow final versions of certain required documents to be produced at an appropriate designated time post-award. If an award is issued, no research activities involving live vertebrate animals subjects shall be initiated or costs incurred for those activities under the award until the NIST Grants Officer issues written approval.

3) Required documents for proposal review. *The applicant should clearly indicate in the application, by separable task, all research activities believed to include research involving live vertebrate animals and the institution(s) where the research activities involving live vertebrate animals may be conducted.*

Documentation of Research Review by an IACUC: If the applicant's application appears to include research activities, field studies, or custom sample collections involving live vertebrate animals the following information regarding review by an applicable IACUC may be requested during the application review process:

- (1) The name(s) of the institution(s) where the research involving live vertebrate animals will be conducted and/or custom samples collected;
- (2) The assurance type and number, as applicable, for the cognizant Institutional Animal Care and Use Committee (IACUC) where the research activity is located. [For example: Animal Welfare Assurance from the Office of Laboratory Animal Welfare (OLAW) should be indicated by the OLAW assurance number, i.e. A-1234; an USDA Animal Welfare Act certification should be indicated by the certification number i.e. 12-R-3456; and an Association for the Assessment and Accreditation of Laboratory Animal Care (AAALAC) should be indicated by AAALAC.]
- (3) The IACUC approval date for the Animal Study Protocol (ASP) (if currently approved);
- (4) If the review by the cognizant IACUC is pending, the estimated- start date for research involving vertebrate animals;
- (5) If any assurances or IACUCs need to be obtained or established, that should be clearly stated.
- (6) If any special permits are required for field studies, those details should be clearly provided for each instance, or indicated as pending.

If the application includes research activities involving vertebrate animals to be performed in the first year of an award, additional documentation may be requested by NIST during pre-award review for those performers, and may include the following for those research activities, which may also include field studies, custom sample collections involving live vertebrate animals:

- (1) A signed (by the Principal Investigator) copy of the IACUC approved ASP;

- (2) Documentation of the IACUC approval indicating the approval and expiration dates of the ASP; and
- (3) If applicable, a non-duplication-of-funding letter if the ASP is funded from several sources.
- (4) If a new ASP will only be submitted to an IACUC if an award from NIST is issued, a draft of the proposed ASP may be requested.
- (5) Any additional clarifying documentation that NIST may request during review of applications to perform the NIST administrative review of research involving live vertebrate animals.

This clause reflects the existing NIST policy for Research Involving Live Vertebrate Animals. Should the policy be revised prior to award, a clause reflecting the policy current at time of award may be incorporated into the award.

If the policy is revised after award, a clause reflecting the updated policy may be incorporated into the award.

For more information regarding research projects involving live vertebrate animals, contact Linda Beth Schilling, Senior Analyst (e-mail: linda.schilling@nist.gov; phone: 301-975-2887).

2.04 Certifications Regarding Federal Felony and Federal Criminal Tax Convictions, Unpaid Federal Tax Assessments and Delinquent Federal Tax Returns

In accordance with Federal appropriations law, an authorized representative of the selected applicant(s) may be required to provide certain pre-award certifications regarding federal felony and federal criminal tax convictions, unpaid federal tax assessments, and delinquent federal tax returns.

3.0 APPLICATION PREPARATION INSTRUCTIONS AND REQUIREMENTS

3.01 Phase II Application Requirements

Only Phase II applications may be submitted in response to this FFO. Only FY 2015 Phase I awardees are eligible to submit FY 2016 Phase II applications.

The application must provide sufficient information to demonstrate that the proposed work represents a sound approach to the investigation of an important scientific or engineering innovation worthy of support. The application must sufficiently address the applicable subtopic in Section 9 (from 2015-NIST-SBIR-01). The application must be self-contained and written with all the care and thoroughness of a scientific paper submitted for publication. It should indicate a thorough knowledge of the current status of research in the subtopic area addressed by the application. Each application should be checked

carefully by the applicant to ensure inclusion of all essential material needed for a complete evaluation.

Phase II applicants may only submit an application under the subtopic under which their Phase I award was made. The Technical Proposal portion of a Phase II application should be more comprehensive than the Technical Proposal for its Phase I application. There is no page limit for Phase II Technical Proposals.

The application must not only be responsive to the specific NIST program interests described in Section 9 of the FFO, but also must serve as the basis for technological innovation leading to new commercial products, processes, or services that benefit the public.

NIST reserves the right to not submit an application for technical review if NIST determines the application has insufficient scientific and technical information, or fails to comply with the administrative procedures as outlined in the applicable Screening Criteria in Section 4.02. Applications that do not meet the screening criteria will be returned to the applicant without further consideration.

All applicants are required to provide information for SBA's database (www.SBIR.gov). The following are examples of the data to be entered by applicants into the database:

- The identity of any business concern or subsidiary established for the commercial application of a product or service for which an SBIR award is made.
- Additional investment from any source, other than Phase I or Phase II awards, to further the research and development conducted under each Phase II award.
- Updated information in the SBA Tech-Net database on sbir.gov for any prior award received by the SBC. The SBC may apportion sales or additional investment information relating to more than one Phase II award among those awards, if it notes the apportionment for each award.

Each Phase II awardee is required to update appropriate information on the award in the database upon completion of the last program objective under the funding agreement and is requested to voluntarily update the information in the database annually thereafter for a minimum period of 5 years.

3.02 Phase II Application

A complete application must include a Technical Proposal (described below) and the forms and documents listed in Section 8.01.

Pages should be of standard size (8 1/2" x 11"; 21.6 cm x 27.9 cm) with margins of 2.5 cm and type at least 10 point font. All units of measurement should be presented in metric units.

The Technical Proposal (see Section 8.01.(6) of this FFO) portion of the application requires the following:

- (a) Cover Sheet (3.02.01) pages 1 and 2, and**
- (b) Technical Content (3.02.02).**

The listing of all forms and documents needed to complete the application is given in Section 8.01 of this FFO.

See Section 6.0 for information on the submission of applications in response to this FFO.

3.02.01 Cover Sheet

Complete the Cover Sheet (Appendix A) as pages 1 and 2 of the Technical Proposal. If you check 'Yes' on #12, your contact information will be provided to the NIST Hollings Manufacturing Extension Partnership (MEP). You may be contacted by your local MEP to explore business-related support services that could potentially benefit your proposed project.

The applicant must provide in the space available on the Cover Sheet an abstract (limited to 200 words) and summary of commercial potential of the research results (limited to 100 words). Each awardee's abstract and summary of commercial potential will be published on the [NIST SBIR website](http://www.nist.gov/sbir) and www.sbir.gov and, therefore, must not contain proprietary information.

3.02.02 Technical Content

Beginning on page 3 of the Technical Proposal, include the following items with headings as shown:

(1) Identification and Significance of the Problem or Opportunity. Make a clear statement of the specific research problem or opportunity addressed, its innovativeness, commercial potential, and why it is important. Explain how it applies to the subtopic.

(2) Phase II Technical Objectives. State the specific objectives of the Phase II effort.

(3) Phase II Work Plan. Include a detailed description of the Phase II R&D plan. The plan should indicate what will be done, where it will be done, and how the research will be carried out. The method(s) planned to achieve each objective or task should be discussed in detail.

(4) Related R/R&D. Describe significant R/R&D that is directly related to the application, including any conducted by the principal investigator or by the proposing SBC. Describe how it relates to the proposed effort, and describe any planned coordination with outside sources. The applicant must persuade evaluators of his or her awareness of key, recent

R/R&D conducted by others in the specific topic area.

(5) Key Individuals and Bibliography of Related Work. Identify key individuals involved in Phase II, including their related education, experience, and publications. Where vitae are extensive, summaries that focus on the most relevant experience and publications are desired.

(6) Relationship with Future R/R&D. Discuss the significance of the Phase II effort in providing a foundation for Phase III. Also state the anticipated results of the proposed approach if Phase II is successful.

(7) Facilities and Equipment. A detailed description, availability, and location of instrumentation and physical facilities proposed for Phase II should be provided.

(8) Consultants, Contracts, and Subawards. The purpose of this section is to show any third party research assistance that would materially benefit the proposed effort and that arrangements for such assistance are in place at time of application submission.

For Phase II, a minimum of one-half of the research and/or analytical effort must be performed by the awardee. Outside involvement in the project is encouraged where it strengthens the conduct of the research. Outside involvement is not a requirement of this program and is limited to no more than one-half of the research and/or analytical effort in Phase II. The total cost for all consultant fees, facility leases, usage fees, and other subcontract/subaward or purchase agreements may not exceed one-half of the total award.

No individual or entity may serve as consultant, contractor, or subrecipient if they:

1. had any role in suggesting, developing, or reviewing the NIST subtopic; or
2. have been the recipient of any NIST information on the subtopic not available to the public.

1. Consultant - A person outside the firm, named in the application as contributing to the research, must provide a signed statement confirming his/her availability, role in the project, and agreed consulting rate for participation in the project.

2. Contract - Similarly, where a contract is involved in the research, the contractor institution must furnish a letter signed by an appropriate official describing the programmatic arrangements and confirming its agreed participation in the research, with its proposed budget for this participation.

3. Subawards - As the funding instrument used in this program is financial assistance, an awardee might pass through funds to another organization to carry out part of the Federally-supported project. See 2 CFR §§ 200.92 (subaward), 200.93 (subrecipient), and 200.330 (Subrecipient and contractor determinations), respectively.

Any subrecipient institution must furnish a letter signed by an appropriate official describing the programmatic arrangements and confirming its agreed participation in the research, with its proposed budget for this participation.

(9) Cooperative Research and Development Agreements (CRADA). State if the applicant is a former or current CRADA partner with NIST, or with any other Federal agency, naming the agency, title of the CRADA, and any relationship with the proposed work. The statement of work of an SBIR award awarded under this FFO cannot overlap with the statement of work of an existing CRADA with any federal agency, including NIST, with the awardee. NIST will consider whether there is any overlap on a case by case basis.

(10) Guest Researcher. State if the applicant or any of its consultants, contractors, or subrecipients or their employees is a guest researcher at NIST (see <http://www.nist.gov/tpo/collaborations/guestresearchers.cfm>), naming the sponsoring laboratory.

(11) Cost Sharing. Cost sharing is not required and is not evaluated in the Phase II application review process.

(12) Similar Applications or Awards. WARNING -- While it is permissible to submit identical applications or applications containing a significant amount of essentially equivalent work for consideration under numerous Federal program funding announcements, **it is unlawful to enter into a funding agreement requiring essentially equivalent work to an SBIR award (see 15 U.S.C. § 638(bb)(3)).** If there is any question concerning this, it must be disclosed to the soliciting agency or agencies before award.

If an application submitted in response to this FFO is substantially the same as another application that has been funded, is now being funded, or is pending with another Federal agency, the applicant must provide the following information:

(a) Names and addresses of agencies to which an application was submitted or from which an award was received.

(b) Date of application submission or date of award.

(c) Title, number, and date of FFO(s) under which an application was submitted or award received.

(d) Specific applicable research topic(s) for each application submitted or award received.

(e) Title of research projects for each application submitted or award received.

(f) Name and title of principal investigator or project manager for each application submitted or award received.

If no substantially similar application is under consideration or award for equivalent work received, a statement to that effect **must** be included in this section of the technical content area of the application.

3.02.03 Commercialization Plan

Attach a copy of your commercialization plan that follow the guidelines below.

An important criterion for selection of NIST Phase II awards is the potential for commercial applications of the research as evidenced by one or more of the following:

- The Small Business Concern's record of commercializing SBIR and other research.
- The existence of Phase III follow-on funding commitments from the private sector or non-SBIR Government funding sources; and
- The presence of other indicators of commercial potential of the concept.

There are no page limits (upper or lower) for the commercialization plan because each project is distinct and each company's vision for deploying its technology into the marketplace is unique.

The commercialization plan should provide information directly related to bringing to market the anticipated research results. For more information on preparing a commercialization plan visit the Small Business Administration website, Writing a Business Plan: <http://www.sba.gov/category/navigation-structure/starting-managing-business/starting-business/how-write-business-plan>.

The commercialization plan should indicate how the Phase II research results are to be carried out in Phase III and should address the following areas:

Company - A brief description of your company, the nature of your business and field(s) of interest including core competencies, present size (number of employees and annual sales level), any current products that have had significant sales, history of previous Federal and non-Federal funding, and any growth in the company that can be attributed to the SBIR program.

Commercial Applications - A clear description of the product/service/process you plan on providing as a result of your Phase II research and the potential commercial application or use.

Potential Markets and Customers - Who will be your customers? What market(s) have you identified for this technology? What are your estimates of the size, growth potential, and

monetary value of the market(s)? What is your estimated market share 5 years after the first sale?

Competition - Who are the major competitors in these markets, present or anticipated? What significant advantages do you anticipate your technology will have over the competition? What is innovative about your anticipated technology or products? How do you intend to compete with competitors?

Patent Success - Do you have or intend to file one or more patents as a result of this SBIR project?

Path to Commercialization - A description of the approach you will take to convert your Phase II research results into a viable product/service/process for the marketplace. Include the following to the extent possible:

- a) Time Frame to Market. Include a timeline, with milestones, for bringing the invention to a point of practical application and to the marketplace. What is the estimated date of the first commercial sale?
- b) What are the hurdles or barriers to entry to overcome?
- c) A description of your available resources including manufacturing, marketing, technical, and how they will be employed to fulfill the development of the commercialization plan.
- d) Describe in some level of detail your strategy and the steps you will take to bring this technology to market and sell your product/process/service.
- e) Describe the nature and status of any third party relationships crucial to commercialization including, but not limited to other licenses required, sublicenses of the licensed NIST Invention (for "TT" projects), financing, research, marketing, distribution and manufacturing.

Assistance and Mentoring - Plans for securing needed technical or business assistance through mentoring, partnering, or through arrangements with state assistance programs, SBDCs, Manufacturing Extension Partnership centers, or other assistance providers.

3.02.04 Phase I Final Report

Attach a copy of your Phase I Final Report.

4.0 METHOD OF SELECTION AND EVALUATION CRITERIA

4.01 Introduction

All applications will be evaluated and judged on a competitive basis. Applications will be evaluated using only information provided in the application. Applications will be initially

screened to determine responsiveness, eligibility, and completeness (see Section 4.02). Applications passing these initial screenings will be technically evaluated by NIST employees in accordance with the evaluation criteria (see Section 4.03). Each application will be judged on its own merit. NIST is under no obligation to fund any application or any specific number of applications in a given topic. NIST may elect to fund several or none of the applications for the same topic or subtopic.

4.02 Phase II Screening Criteria

Please carefully read the entire FFO and review the following Screening Criteria to assure that your application meets NIST requirements. Applications that do not satisfy all the screening criteria will be returned to the applicant without further review and will be eliminated from consideration for award. However, NIST, in its sole discretion, may continue the review process for an application that is missing minor non-substantive information which may easily be rectified or cured. The screening criteria are:

- (1) The application must be received by NIST before the deadline specified in Section 6.01.
- (2) The proposing firm must qualify as eligible according to the criteria provided in Section 1.03.
- (3) The Phase II application must meet all of the requirements stated in Section 3.0 and include all forms and certifications listed in Section 8.01.
- (4) All required forms must be complete and signed as necessary.
- (5) The Technical Proposal must contain the Cover Sheet (Appendix A), Technical Content (Section 3.02.02).
- (6) Letters from affiliated parties such as contractors (Section 3.02 (8)) must be included in the Technical Proposal if contractors are used.
- (7) The Phase II application is limited to the subtopic under which the Phase I award was made.
- (8) The Phase II total proposed budget must not exceed \$300,000. For Phase II, a minimum of one-half of the research and/or analytical effort must be performed by the awardee. The total cost for all consultant fees, facility leases, usage fees, and other subcontract/subaward or purchase agreements may not exceed one-half of the total award (Section 1.03).
- (9) The feasibility research duration for the Phase II project must not exceed 24 months.

4.03 Phase II Evaluation Criteria

Phase II applications that comply with the screening criteria will undergo an internal, scored review process.

The applications will be evaluated by NIST employees in accordance with the following criteria:

(1) The technical approach and the anticipated commercial benefits that may be derived from the research. (25 points)

(2) The adequacy of the proposed effort and its relationship to the fulfillment of requirements of the research subtopic. (20 points)

(3) The soundness and technical merit of the proposed approach and its incremental progress toward subtopic solution. (20 points)

(4) Qualifications of the proposed principal/key investigators, supporting staff, and consultants. (15 points)

(5) Consideration of an application's commercial potential as evidenced by the applicant's record of commercializing SBIR or other research; the existence of second phase funding commitments from private sector or non-SBIR funding sources, the existence of third phase follow-on commitments for the subject of the research, and the presence of other indicators of the commercial potential of the idea. (20 points)

Technical reviewers will base their evaluations only on information contained in the application.

Applicants should be specific and clear when writing their applications and not assume information not clearly spelled out can be inferred by the reviewer. No technical clarifications may be made after application submission.

4.04 Phase II Award Selections

Final selection decisions will be made by the Selecting Official, the Director of the NIST Technology Partnerships Office, or designee, based upon scores assigned by the technical reviewers, diversity across the sub-topics and participants, possible duplication of other federally-funded research, and the availability of funding. In the event of a "tie" between applications, manufacturing-related projects, as well as those regarding energy efficiency and renewable energy system will receive priority in the award selection process. NIST may select some, all, or none of the applications, or part(s) of any particular application. Subsequent to the assessment and prior to award, NIST may ask for supplemental information and may negotiate the scope and amount of the award. The final approval of selected applications and issuance of awards will be by the NIST Grants Officer. The award decisions of the NIST Grants Officer are final.

4.04.01 Federal Awarding Agency Review of Risk Posed by Applicants

After applications are proposed for funding by the selecting official, the NIST Grants Management Division (GMD) performs administrative reviews, which may include a review of the financial stability of an applicant, the quality of the applicant's management systems, the history of performance, and/or the applicant's ability to effectively implement statutory, regulatory, or other requirements imposed on non-Federal entities. Upon review of these factors, if appropriate, special conditions that correspond to the degree of risk may be applied to an award.

In addition, prior to making an award where the total Federal share is expected to exceed the simplified acquisition threshold (currently \$150,000), NIST GMD will review and consider the publicly available information about that applicant in the Federal Awardee Performance and Integrity Information System (FAPIS). An applicant may, at its option, review and comment on information about itself previously entered into FAPIS by a Federal awarding agency. As part of its review of risk posed by applicants, NIST GMD will consider any comments made by the applicant in FAPIS in making its determination about the applicant's integrity, business ethics, and record of performance under Federal awards.

4.04.02 Release of Proposal Review Information

After final award decisions have been announced, the reviewers' technical evaluations of applications that passed the screening criteria will be provided to the applicant with written notification of award/non-award. The identity of the reviewers will not be disclosed.

5.0 CONSIDERATIONS

5.01 Awards

Through 2. C.F.R. § 1327.101, the Department of Commerce adopted Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards at 2 C.F.R. Part 200, which apply to awards in this program. Refer to <http://go.usa.gov/SBYh> and <http://go.usa.gov/SBg4>.

The DoC Financial Assistance Standard Terms and Conditions will apply to this award. A current version of these terms, from December 2014, is available at <http://go.usa.gov/hKbj>.

The DoC Pre-Award Notification Requirements for Grants and Cooperative Agreements, 79 FR 78390 (December 30, 2014), are applicable to this FFO and are available at <http://go.usa.gov/hKkR>.

Phase II awards shall be for no more than \$300,000. The R&D activity period of performance

in Phase II will depend upon the scope of the research, but should not exceed 24 months. One year after completing the R&D activity, the awardee shall be required to report on its commercialization activities. The total period of performance for Phase II is 36 months.

It is anticipated that approximately half of the Phase I awardees will receive Phase II awards, depending upon the availability of funds. To provide for an in-depth review of the Phase I final report and the Phase II application, Phase II awards will be made approximately 4 months after the completion of Phase I, contingent upon availability of funds.

Funding for the program listed in this FFO is contingent upon the availability of appropriations. In no event will NIST or DoC be responsible for application preparation costs. This FFO does not obligate NIST or DoC to make any awards under Phase II. Furthermore, NIST will not fund any costs incurred by the applicants before awards are made. Publication of this FFO does not oblige NIST or DoC to award any specific project or to obligate any available funds.

5.02 Reporting Requirements

Phase II awardees will be required to submit three interim progress reports, a final report, and a commercialization report. Generally, Phase II reports are due at 6, 12, 18, 24, and 36 months after award.

Interim progress reports should include technical details regarding the research conducted up to that point in the project and provide detailed plans for the next stages of the project. Consideration will be given to changes from the solicited and proposed milestones if results from experimentation warrant a deviation from plan. Inclusion of proprietary information within the progress reports and final report may be necessary in order to effectively communicate progress and gain appropriate consultation from NIST experts regarding next steps. All such proprietary information must be marked by the awardee according to instructions provided in Section 5.04.02.(d)(1).

Final reports shall include a single-page project summary as the first page. The remainder of the report should indicate the research objectives, research work carried out, results obtained, and estimates of technical feasibility of product commercialization.

All final reports must carry an acknowledgment on the cover page such as: "This material is based upon work supported by the National Institute of Standards and Technology (NIST) under cooperative agreement _____. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of NIST."

The Phase II commercialization report should include the following:

(a) A description of the company's efforts to further develop, commercialize, and derive revenues from the technology resulting from this SBIR award. If work has ended on the

project, please provide an explanation.

(b) Information about any follow-on funding commitment(s) and investments to further the development and/or commercialize the Phase II technology. If follow-on funding was not obtained, provide possible reasons.

(c) Details about products and/or processes being developed, used for other projects, or currently in the marketplace resulting from the SBIR project.

(d) A list of any patents or published patent applications resulting from the SBIR project.

(e) Sales revenue from new products or processes received from the commercialization of this SBIR project include: sales, manufacturing, product licensing, royalties, consulting, contracts, or other.

To help assess the effectiveness of our program in meeting programmatic and SBIR objectives, NIST may periodically request information from small businesses about efforts taken and progress made towards commercialization of the technology after the completion of Phase II awards.

5.03 Payment Schedule

Cooperative agreements will include an award term with electronic payment system information. Pursuant to 2 C.F.R. § 200.305 awardees are to be paid in advance, provided they maintain or demonstrate the willingness to maintain: written procedures that minimize the time elapsing between the transfer of funds and disbursement by the recipient, and financial management systems that meet the standards for fund control and accountability as established in 2 C.F.R. § 200.302. Advances of funds to a recipient organization shall be limited to the minimum amounts needed and be timed to be in accordance with the actual, immediate cash requirements of the recipient organization in carrying out the purpose of the approved program or project.

5.04 Innovations, Inventions and Patents

5.04.01 Proprietary Information Proposals

Information contained in unsuccessful proposals will remain the property of the applicant. The Government may, however, retain copies of all proposals. Public release of information in any proposal submitted will be subject to existing statutory and regulatory requirements. If proprietary information is provided by an applicant in a proposal, which constitutes a trade secret, proprietary commercial or financial information, confidential personal information or data affecting the national security, it will be treated in confidence, to the extent permitted by law. This information must be clearly marked by the applicant with the term “confidential proprietary information” and the following notice must appear on the

title page of the proposal:

“These data shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part for any purpose other than evaluation of this proposal. If a funding agreement is awarded to this applicant as a result of or in connection with the submission of these data, the Government shall have the right to duplicate, use, or disclose the data to the extent provided in the funding agreement and pursuant to applicable law. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data subject to this restriction are contained on pages _____ of this proposal.”

Any other disclaimer may be unacceptable to the Government and may constitute grounds for removing the proposal from further consideration, without assuming any liability for inadvertent disclosure. The Government will limit dissemination of such information to within official channels.

5.04.02 Rights in Data Developed Under SBIR Funding Agreements

In lieu of Department of Commerce Financial Assistance Standard Terms and Conditions (December 2014), Section D.03, the following term and condition will apply to and be included in all SBIR awards issued under this FFO:

(a) Definitions. As used in regards this FFO and awards made pursuant to this FFO: --
“Computer database” or “database” means a collection of recorded information in a form capable of, and for the purpose of, being stored in, processed, and operated on by a computer. The term does not include computer software.

“Computer software” (1) means: (i) computer programs that comprise a series of instructions, rules, routines, or statements, regardless of the media in which recorded, that allow or cause a computer to perform a specific operation or series of operations; and (ii) recorded information comprising source code listings, design details, algorithms, processes, flow charts, formulas, and related material that would enable the computer program to be produced, created, or compiled; and (2) does not include computer databases or computer software documentation.

“Computer software documentation” means owner’s manuals, user’s manuals, installation instructions, operating instructions, and other similar items, regardless of storage medium, that explain the capabilities of the computer software or provide instructions for using the software.

“Data” means recorded information, regardless of form or the media on which it may be recorded. The term includes technical data and computer software. The term does not

include information incidental to contract administration, such as financial, administrative, cost or pricing or management information.

“Form, fit, and function data” means data relating to items, components, or processes that are sufficient to enable physical and functional interchangeability as well as data identifying source, size, configuration, mating and attachment characteristics, functional characteristics, and performance requirements. For computer software it means data identifying source, functional characteristics, and performance requirements but specifically excludes the source code, algorithms, processes, formulas, and flow charts of the software. “Limited rights data” means data (other than computer software) developed at private expense that embody trade secrets or are commercial or financial and confidential or privileged.

“Restricted computer software” means computer software developed at private expense and that is a trade secret; is commercial or financial and confidential or privileged; or is copyrighted computer software; including modifications of the computer software.

“SBIR data” means data first produced by an Awardee that is a small business concern in performance of a small business innovation research award issued under the authority of 15 U.S.C. § 638, which data are not generally known, and which data without obligation as to its confidentiality have not been made available to others by the Awardee or are not already available to the Government.

“SBIR rights” means the rights in SBIR data set forth in the SBIR Rights Notice of paragraph (d) of this clause.

“Technical data” means recorded information (regardless of the form or method of the recording) of a scientific or technical nature (including computer databases and computer software documentation). This term does not include computer software or financial, administrative, cost or pricing, or management data or other information incidental to contract administration. The term includes recorded information of a scientific or technical nature that is included in computer databases. (See 41 U.S.C. § 403(8)).

“Unlimited rights” means the right of the Government to use, disclose, reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, in any manner and for any purpose whatsoever, and to have or permit others to do so.

(b) Allocation of rights.

(1) Except as provided in paragraph (c) below regarding copyright, the Government shall have unlimited rights in—

- (i) Data specifically identified in this award as data to be delivered without restriction;
- (ii) Form, fit, and function data delivered under this award;

- (iii) Data delivered under this award (except for restricted computer software) that constitute manuals or instructional and training material for installation, operation, or routine maintenance and repair of items, components, or processes delivered or furnished for use under this award; and
- (iv) All other data delivered under this award unless provided otherwise for SBIR data in accordance with paragraph (d) of this clause or for limited rights data or restricted computer software in accordance with paragraph (f) of this clause.

(2) The Awardee shall have the right to—

- (i) Assert copyright in data first produced in the performance of this award to the extent provided in paragraph (c)(1) of this clause;
- (ii) Protect SBIR rights in SBIR data delivered under this award in the manner and to the extent provided in paragraph (d) of this clause;
- (iii) Substantiate use of, add, or correct SBIR rights or copyright notices and to take other appropriate action, in accordance with paragraph (e) of this clause; and
- (iv) Withhold from delivery those data which are limited rights data or restricted computer software to the extent provided in paragraph (f) of this clause.

(c) Copyright.

(1) *Data first produced in the performance of this award.*

- (i) Except as otherwise specifically provided in this award, the Awardee may assert copyright subsisting in any data first produced in the performance of this award.
- (ii) When asserting copyright, the Awardee shall affix the applicable copyright notice of 17 U.S.C. § 401 or § 402 and an acknowledgment of Government sponsorship (including award number).
- (iii) For data other than computer software, the Awardee grants to the Government, and others acting on its behalf, a paid-up nonexclusive, irrevocable, worldwide license to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the Government. For computer software, the Awardee grants to the Government, and others acting on its behalf, a paid-up, nonexclusive, irrevocable, worldwide license in such copyrighted computer software to reproduce, prepare derivative works, and perform publicly and display publicly, by or on behalf of the Government.

(2) *Data not first produced in the performance of this award.* The Awardee shall not, without prior written permission of the Grants Officer, incorporate in data delivered under this award any data that are not first produced in the performance of this award unless the Awardee: (i) identifies such data; and (ii) grants to the Government, or acquires on its behalf, a license of the same scope as set forth in subparagraph (c)(1) of this clause.

(3) *Removal of copyright notices.* The Government will not remove any copyright notices placed on data pursuant to this paragraph (c), and will include such notices on all reproductions of the data.

(d) Rights to SBIR data.

(1) The Awardee is authorized to affix the following “SBIR Rights Notice” to SBIR data delivered under this award and the Government will treat the data, subject to the provisions of paragraphs (e) and (f) of this clause, in accordance with such Notice:

SBIR Rights Notice

These SBIR data are furnished with SBIR rights under Award No. _____ (and contract or subaward _____, if appropriate). For a period of 4 years, unless extended, after acceptance of all items to be delivered under this award, the Government will use these data for Government purposes only, and they shall not be disclosed outside the Government (including disclosure for procurement purposes) during such period without permission of the Awardee, except that, subject to the foregoing use and disclosure prohibitions, these data may be disclosed for use by support contractors and/or subrecipients. After the protection period, the Government has a paid-up license to use, and to authorize others to use on its behalf, these data for Government purposes, but is relieved of all disclosure prohibitions and assumes no liability for unauthorized use of these data by third parties, except that any such data that is also protected and referenced under a subsequent SBIR award shall remain protected through the protection period of that subsequent SBIR award. This Notice shall be affixed to any reproductions of these data, in whole or in part.

(End of notice)

(2) The Government’s sole obligation with respect to any SBIR data shall be as set forth in this paragraph (d).

(e) Omitted or incorrect markings.

(1) Data delivered to the Government without any notice authorized by paragraph (d) of this clause shall be deemed to have been furnished with unlimited rights. The Government assumes no liability for the disclosure, use, or reproduction of such data.

(2) If the unmarked data has not been disclosed without restriction outside the Government, the Awardee may request, within six months (or a longer time approved by the Grants Officer in writing for good cause shown) after delivery of the data, permission to have authorized notices placed on data at the Awardees expense, and the Grants Officer may agree to do so if the Awardee—

- (i) Identifies the data to which the omitted notice is to be applied;
- (ii) Demonstrates that the omission of the notice was inadvertent;
- (iii) Establishes that the use of the proposed notice is authorized; and

(iv) Acknowledges that the Government has no liability with respect to the disclosure or use of any such data made prior to the addition of the notice or resulting from the omission of the notice.

- (3) If the data has been marked with an incorrect notice the Grants Officer may—
- (i) Permit correction, at the Awardee's expense, if the Awardee identifies the data and demonstrates that the correct notice is authorized, or
 - (ii) Correct any incorrect notices.

(f) Protection of limited rights data and restricted computer software. The Awardee may withhold from delivery qualifying limited rights data and restricted computer software that are not identified in paragraphs (b)(1)(i), (ii), and (iii) of this clause. As a condition to this withholding the Awardee shall identify the data being withheld and furnish form, fit, and function data instead.

(g) Contracting and Subawards. The Awardee shall obtain from its contractors and subawardees all data and rights therein necessary to fulfill the Awardee's obligations to the Government under this award. If a contractor or subawardee refuses to accept terms affording the Government those rights, the Awardee shall promptly notify the Grants Officer of the refusal and not proceed with the contract or subaward without further authorization in writing from the Grants Officer.

(h) Relationship to patents. Nothing contained in this subsection shall imply a license to the Government under any patent or be construed as affecting the scope of any license or other right otherwise granted to the Government.

5.04.03 NIST-Owned Patented Background Inventions

Awardees receiving SBIR awards for a subtopic based on a NIST-owned patented background invention, will, upon the license application by the awardee to a NIST licensing officer, be granted a non-exclusive research license to use those NIST-owned patented background inventions. SBIR applicants are hereby notified that no exclusive or non-exclusive commercialization license to make, use or sell products or services incorporating the NIST background invention is granted until an SBIR awardee applies for, negotiates and receives such a license. Awardees under subtopics based on NIST-owned patented background inventions will be given the opportunity to negotiate a non-exclusive commercialization license to such background inventions. If available, awardees may be given the opportunity to negotiate an exclusive commercialization license to such background inventions. License applications will be treated in accordance with Federal patent licensing regulations as provided in 37 C.F.R. Part 404.

5.04.05 Invention Reporting

SBIR awardees must report inventions to the NIST SBIR Program Office within 2 months of

the inventor's report to the awardee. Inventions must also be reported through the iEdison Invention Reporting System at www.iedison.gov.

5.05 Cost Sharing

Cost sharing is permitted for applications under this program FFO; however, cost sharing is not required and will not be considered in the evaluation of applications.

5.06 Profit or Fee

A reasonable profit or fee is allowed.

5.07 Joint Ventures or Limited Partnerships

See [13 C.F.R. § 121.103\(h\)](#). Joint ventures and limited partnerships are eligible, provided the entity created qualifies as a small business as defined in this FFO. The awardee may enter into contracts, subawards, or other agreements with universities or other non-profit organizations, subject to the conditions in Section 5.08, below.

5.08 Research and Analytical Work

For Phase II, a minimum of one-half of the research and/or analytical effort, per Section 1.03, must be performed by the applicant. The total cost for all consultant fees, facility leases, usage fees, and other subcontract/subaward or purchase agreements may not exceed one-half of the total award.

5.09 Awardee Commitments

Upon award of a funding agreement, the awardee will be required to make certain legal commitments through acceptance of numerous Special Award Conditions (SAC) in the funding agreement. Awards also will be governed by the Department of Commerce Financial Assistance Standard Terms and Conditions (December 2014); the Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards at 2 C.F.R. Part 200, adopted by the Commerce Department through 2 C.F.R. § 1327.101; and the DoC Pre-Award Notification Requirements for Grants and Cooperative Agreements, 79 FR 78390 (December 30, 2014).

The following statements are illustrative of the typical types of terms and conditions to which the awardee will be required to commit. This list is not a complete list of terms and conditions to be included in Phase II funding agreements, and is not the specific wording of such terms and conditions.

(1) Access to Records. Government officials have the right of timely and unrestricted access to records of awardees, including access to personnel for discussion related to the records. See 2 C.F.R. § 200.336.

(2) Termination. Awards may be terminated (a) by the NIST Grants Officer, if an awardee materially fails to comply with the terms and conditions of an award, or for cause; (b) by the NIST Grants Officer with the consent of the awardee, in which case the two parties shall agree upon the termination conditions, including the effective date and, in the case of partial termination, the portion to be terminated; (c) by the awardee upon sending to the NIST Grants Officer written notification setting forth the reasons for such termination, the effective date, and, in the case of partial termination, the portion to be terminated. See [2 C.F.R. §§ 200.338-342](#).

(3) Non-Discrimination. The awardee will be required to comply with statutory and other non-discrimination requirements. No person in the United States shall, on the ground of race, color, national origin, handicap, age, religion, or sex, be excluded from participation in, be denied the benefits of, or be subject to discrimination under any program or activity receiving Federal financial assistance. See Department of Commerce Financial Assistance Standard Terms and Conditions, Section K.

(4) Audit Requirements. Government officials may conduct an audit of an award at any time. Unless otherwise specified in the award, for-profit organizations that expend \$750,000 or more in Department of Commerce funds during their fiscal year must have an audit conducted for that year in accordance with Subpart F of 2 C.F.R. Part 200. See Department of Commerce Financial Assistance Standard Terms and Conditions, Section F.

(5) Codes of Conduct. Pursuant to the certification in Form SF-424B, paragraph 3, the awardee must maintain written standards of conduct to establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain in the administration of the award. See Department of Commerce Financial Assistance Standard Terms and Conditions, Section J.01.

5.10 Additional Information

If there is any inconsistency between the information contained herein and the terms of any resulting SBIR funding agreement, the terms of the funding agreement are controlling.

Before award of a SBIR funding agreement, the Government may request the applicant to submit certain organizational, management, personnel, and financial information to assure responsibility of the applicant.

The Government is not responsible for any funds expended by the applicant before award of any funding agreement.

This program FFO is not an offer by the Government and does not obligate the Government to make any specific number of awards. Also, awards under the SBIR Program are contingent upon the availability of funds.

The SBIR Program is not a substitute for existing unsolicited application mechanisms. Unsolicited applications will not be accepted under the SBIR Program.

If an award is made pursuant to an application submitted under this SBIR Program FFO, a representative of the awardee will be required to certify that the concern has not previously been, nor is currently being, paid for essentially equivalent work by any Federal agency. The responsibility for the performance of the principal investigator, and other employees or consultants who carry out the proposed work, including those of subrecipients or contractors, lies with the management of the organization receiving an award.

NIST is committed to the goal of commercialization of the results of SBIR projects and may provide discretionary technical and commercialization assistance to awardees as allowed by legislation.

5.11 Technical Assistance for Application Preparation and Project Conduct

Applicants may wish to contact the NIST Hollings Manufacturing Extension Partnership (MEP), a nationwide network of locally managed extension centers whose sole purpose is to provide small- and medium-sized manufacturers with the help they need to succeed. The centers provide guidance to high-technology companies seeking resources and teaming relationships. To be referred to an MEP center for technical assistance, call 1-800-MEP-4-MFG (1-800-637-4634) or visit MEP's website at <http://www.nist.gov/mep>.

MEP Centers are also prepared to provide referrals to state and local organizations offering resources and technical assistance to all NIST SBIR applicants after awards have been announced. If you would like your local MEP Center to contact you, please respond affirmatively to the statement (#12) about MEP on the Cover Sheet.

6.0 SUBMISSION OF APPLICATIONS

6.01 Deadline for Applications

Phase II electronic applications must be received no later than 11:59 p.m. Eastern Time, May 5, 2016. Paper applications must be received by NIST by 5:00 p.m. Eastern Time, May 5, 2016.

Electronic applicants should be aware, and factor in their application submission planning, that the Grants.gov system is expected to be closed for routine maintenance at these times: from 12:01 a.m. Eastern Time, Saturday, February 20, 2016 until Monday, February 22, 2016 at 6:00 a.m. Eastern Time; and from 12:01 a.m. Eastern Time, Saturday, March 19, 2016 until Monday, March 21, 2016 at 6:00 a.m. Eastern Time, and from 12:01 a.m. Eastern Time, Saturday, April 16, 2016 until Monday, April 18, 2016 at 6:00 a.m. Eastern Time, and that applications cannot be submitted during those time spans.

Applicants are cautioned to be careful of unforeseen delays that can cause late arrival of applications, with the result that they **will not** be forwarded for evaluation. For security purposes, applications may not be submitted via e-mail.

Applications not received by the specified due date and time or that do not adhere to the other requirements of this FFO (*see* Section 4.02 Screening Criteria) will not be considered and will be returned without review. NIST determines whether applications submitted by paper have been received by the deadline by the date and time it was physically received by NIST at its Gaithersburg, MD campus. For electronic submissions, NIST will consider the date and time recorded by www.grants.gov as the official submission time.

NIST strongly recommends that applicants do not wait until the last minute to submit an application. NIST will not make allowance for any late submissions. To avoid any potential processing backlogs due to last minute Grants.gov registrations, applicants are highly encouraged to begin their Grants.gov registration process early.

When developing your submission timeline, please keep in mind that: (1) all applicants are required to have a current registration in the System for Award Management (SAM.gov); (2) the free annual registration process in the electronic System for Award Management (SAM.gov) (*see* Section 6.03.(2).b. of this FFO) may take between three and five business days or as long as more than two weeks; (3) electronic applicants are required to have a current registration in Grants.gov; and (4) applicants using Grants.gov will receive a series of e-mail messages over a period of up to two business days before learning whether a Federal agency's electronic system has received its application. **Please note that a federal assistance award cannot be issued if the designated recipient's registration in the System for Award Management (SAM.gov) is not current at the time of the award.**

Electronic applicants will find instructions on registering with SAM.gov as part of the Grants.gov process at: <http://www.grants.gov/web/grants/applicants/organization-registration.html>

Paper applicants will find instructions on registering with SAM.gov by going to www.sam.gov and choosing "Create User Account".

6.02 Address to Request Application Package

The standard application package, consisting of the standard forms, i.e., SF-424, SF-424A, SF-424B, SF-LLL, and the CD-511, is available at www.grants.gov. The standard application package may be requested by contacting the NIST personnel listed below:

J'aime Maynard by phone: (301) 975-8408 or by e-mail: jmaynard@nist.gov .

It can also be obtained by writing to:

National Institute of Standards and Technology
NIST SBIR Program Office
Attn: J'aime Maynard
100 Bureau Dr., MS 2200
Gaithersburg, MD 20899

Please see Section 8.01 for a complete list of required forms and documents.

6.03 Application Submission

Applications may be submitted by paper or electronically through Grants.gov.

Supplementary material, revisions, substitutions, audio or video tapes, or computer storage media or devices will **not** be accepted. While applicants may not submit replacement pages or missing documents after an application has been submitted, they may submit complete, new applications including such information so long as they are submitted by the required deadline.

(1) Paper applications must be submitted to:

National Institute of Standards and Technology
NIST SBIR Program Office
Attn: J'aime Maynard
100 Bureau Dr., MS 2200
Gaithersburg, MD 20899

If hand delivered, 24-hours' notice must be given to the NIST SBIR Program Office prior to delivery. All applicants must contact J'aime Maynard at (301) 975-8408 or jmaynard@nist.gov to arrange hand delivery of application packages. Applications may **not** be dropped off at the NIST Visitor Center. Hand delivery will only be accepted through prior arrangement.

Secure packaging is mandatory. Do not send separate "information copies". Do not use special bindings or covers.

(2) Electronic applications must be submitted via Grants.gov at www.grants.gov, under announcement 2016-NIST-SBIR-02.

a) Submitters of electronic applications should carefully follow specific Grants.gov instructions to ensure the attachments will be accepted by the Grants.gov system. A receipt from Grants.gov indicating an application is received does not provide information about whether attachments have been received. For further information or questions regarding applying electronically for the 2016-NIST-SBIR-02 announcement, contact Christopher Hunton by phone at 301-975-5718 or by e-mail at grants@nist.gov.

b) Applicants are strongly encouraged to start early and not wait until the approaching due date before logging on and reviewing the instructions for submitting an application through Grants.gov. The Grants.gov registration process must be completed before a new registrant can apply electronically. If all goes well, the registration process takes three (3) to five (5) business days. If problems are encountered, the registration process can take up to two (2) weeks or more. Applicants must have a valid unique entity identifier number and must maintain a current registration in the Federal government's primary registrant database, the System for Award Management (<https://www.sam.gov/>), as explained on the Grants.gov Web site. *See also* Section 8.02 of this FFO. After registering, it may take several days or longer from the initial log-on before a new Grants.gov system user can submit an application. Only authorized individuals(s) will be able to submit an application, and the system may need time to process a submitted application. Applicants should save and print the proof of submission they receive from Grants.gov. If problems occur while using Grants.gov, the applicant is advised to (a) print any error message received and (b) call Grants.gov directly for immediate assistance. If calling from within the United States or from a U.S. territory, please call 800-518-4726. If calling from a place other than the United States or a U.S. territory, please call 606-545-5035. Assistance from the Grants.gov Help Desk will be available around the clock every day, with the exception of Federal holidays. Help Desk assistance will resume at 7:00 a.m. Eastern Time the day after Federal holidays. For assistance using Grants.gov, you may also contact support@grants.gov.

c) To find instructions on submitting an application on Grants.gov, Applicants should refer to the "Applicants" tab in the banner just below the top of the www.grants.gov home page. Clicking on the "Applicants" tab produces two exceptionally useful sources of information, "Applicant Actions" and "Applicant Resources," which applicants are advised to review.

Applicants will receive a series of e-mail messages over a period of up to two business days before learning whether a Federal agency's electronic system has received its application. Closely following the detailed information in these subcategories will increase the likelihood of acceptance of the application by the Federal agency's electronic system.

Applicants should pay close attention to the guidance under "Applicant FAQs," as it contains information important to successful submission on Grants.gov, including essential details on the naming conventions for attachments to Grants.gov applications.

The Grants.gov Online Users Guide available at the Grants.gov site (<http://go.usa.gov/cjaEh>) provides vital information on checking the status of applications. See especially the “Check My Application Status” option, found by clicking first on Applicants, and then by clicking on Applicant Actions.

The application must be both received and validated by Grants.gov. The application is “received” when Grants.gov provides the applicant a confirmation of receipt and an application tracking number. If an applicant does not see this confirmation and tracking number, the application has not been received. After the application has been received, it must still be validated. During this process, it may be “validated” or “rejected with errors.” To know whether the application was rejected with errors and the reasons why, the applicant must log in to Grants.gov, select “Applicants” from the top navigation, and select “Track my application” from the drop-down list. If the status is “rejected with errors,” the applicant may still seek to correct the errors and resubmit your application before the deadline. If the applicant does not correct the errors, the application will not be forwarded to NIST by Grants.gov.

NIST uses the Tracking Numbers assigned by Grants.gov, and does not issue Agency Tracking Numbers.

All applicants, both electronic and paper submitters, should be aware that adequate time must be factored into applicants’ schedules for delivery of their application. Submitters of electronic applications are advised that volume on Grants.gov may be extremely heavy leading up to the deadline date, and if Grants.gov is unable to accept applications electronically in a timely fashion, applicants are encouraged to exercise their option to submit applications in paper format. Submitters of paper applications should allow adequate time to ensure a paper application will be received on time, taking into account that Federal Government security screening for U.S. Postal Service mail may delay receipt of mail for up to two (2) weeks and that guaranteed express mailings and/or couriers are not always able to fulfill their guarantees.

Refer to important information in Section 6.01 Deadline for Applications, to help ensure your application is received on time.

Any amendments to this FFO will be announced through Grants.gov. Applicants can sign up for Grants.gov FFO amendments or may request copies from J’aime Maynard by telephone at (301) 975-8408, or by email to jmaynard@nist.gov.

7.0 SCIENTIFIC AND TECHNICAL INFORMATION SOURCES

Background information related to the NIST research programs referenced within the subtopics identified in Section 9.0 of this FFO may be found within the NIST website at: www.nist.gov. The NIST Virtual Library, <http://nvl.nist.gov/> may also provide valuable

scientific and technical information resources. Wherever possible, reference citations are provided within the individual subtopics.

8.0 SUBMISSION FORMS AND CERTIFICATIONS

8.01 Required Forms and Documents

A complete application contains the Technical Proposal elements described in Section 3.02 and the following forms and documents:

(1) SF-424, Application for Federal Assistance. The SF-424 must be signed by an authorized representative of the applicant organization.

SF-424, Item 12, should list the FFO number 2016-NIST-SBIR-02.

For SF-424, Item 21, the list of certifications and assurances is contained in the SF-424B.

(2) SF-424A, Budget Information – Non-Construction Programs. The Grant Program Function or Activity on Line 1 under Column (a) should be entered as Science, Technology, Business and/or Education Outreach. The Catalog of Federal Domestic Assistance Number in on Line 1 under Column (b) should be entered as 11.620.

(3) SF-424B, Assurances - Non-Construction Programs.

(4) CD-511, Certification Regarding Lobbying.

(5) SF-LLL, Disclosure of Lobbying Activities (if applicable).

(6) Technical Proposal, including forms and documents described in Section 3.02 of this FFO. Be sure to read all of Section 3.02 very carefully. Use the Cover Sheet found in Appendix A of this FFO as pages 1 and 2 of the Technical Proposal, and follow the guidance regarding the Technical Content.

(7) Budget Narrative. There is no set format for the Budget Narrative; however, it should provide a detailed breakdown of each of the object class categories as reflected on the SF-424A. Provide enough information to allow NIST to understand how funds will be used and clearly demonstrate that proposed costs fall within the spending limitations specified in Section 1.03 of this FFO (For Phase II, a minimum of one-half of the research and/or analytical effort, per Section 1.03, must be performed by the applicant. The total cost for all consultant fees, facility leases, usage fees, and other subcontract/subaward or purchase agreements may not exceed one-half of the total award.)

The proposed budget should reflect planned costs, but the awardee must charge actual costs to the award consistent with cost principles applicable to the type of awardee in accordance with the Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards at 2 C.F.R. Part 200, which apply to awards in this program. More information is available at <http://go.usa.gov/SBYh> and <http://go.usa.gov/SBg4>. The awardee should have an accounting system that tracks costs per SBIR award and an allocation plan for activities that may be shared among multiple SBIR awards.

(8) Indirect Cost Rate Agreement. If indirect costs are included in the proposed budget, provide a copy of the current, approved negotiated agreement if this rate was negotiated with a cognizant Federal agency. Applicants without an established rate may propose estimated indirect costs at a rate not to exceed 40 percent of the total direct costs. If an applicant proposes a rate not to exceed 40 percent and is selected for an award, NIST will not require the applicant to provide further justification for the proposed rate and will pay indirect costs at that rate.

NIST will only enter negotiations for an indirect cost rate agreement at Phase II with awardees who request an indirect rate greater than 40 percent of the total direct costs in the award.

(9) SBA Company Registry Form. SBA maintains and manages a Company Registry at <http://www.sbir.gov/registration> to track ownership and affiliation requirements for all companies applying to the SBIR Program. The SBIR Policy Directive requires each Phase II applicant to register in the Company Registry prior to submitting an application. The applicant must save its information from the registration in a .pdf document and attach this document to the SF-424 as described below.

(10) Data Management Plan. In accordance with the Office of Science and Technology Memorandum for the Heads of Executive Departments and Agencies of February 22, 2013¹, *Increasing Access to the Results of Federally Funded Scientific Research*, and as implemented through NIST Policy 5700.00,² *Managing Public Access to Results of Federally Funded Research*, and NIST Order 5701.00,³ *Managing Public Access to Results of Federally Funded Research*,” applicants must include a Data Management Plan (DMP) or explain why data sharing and/or preservation are not within the scope of their proposal.

The DMP is a supplementary document of not more than two pages that must include, at a minimum, a summary of proposed activities that are expected to generate data, a

¹ https://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf

² <http://www.nist.gov/open/upload/Final-P-5700.pdf>

³ http://www.nist.gov/open/upload/Final-O-5701_0.pdf

summary of the types of data expected to be generated by the identified activities, a plan for storage and maintenance of the data expected to be generated by the identified activities, and a plan describing whether and how data generated by the identified activities will be reviewed and made available to the public. As long as the DMP meets these NIST requirements, it may take the form specified by the applicant's institution or some other entity (e.g., the National Science Foundation⁴ or the National Institutes of Health⁵). Some organizations' templates are available on the Internet⁶.

For the purposes of the DMP, NIST adopted the definition of "research data" at 2 C.F.R. § 200.315(e)(3) (available at <http://go.usa.gov/3sZvQ>).

Reasonable costs for data preservation and access may be included in the application.

The sufficiency of the DMP will be considered as part of the administrative review (see Section 4.02. of this FFO); however, the DMP will not be evaluated against any evaluation criteria.

If submitting the application electronically via Grants.gov, items (1) through (5) above are part of the standard application package in Grants.gov and can be completed through the download application process. **Items (6) through (10) must be completed and attached by clicking on "Add Attachments" found in item 15 of the SF-424, Application for Federal Assistance. This will create a zip file that allows for transmittal of the documents electronically via Grants.gov.** Applicants should carefully follow specific Grants.gov instructions at www.grants.gov to ensure the attachments will be accepted by the Grants.gov system. **A receipt from Grants.gov indicating an application is received does not provide information about whether attachments have been received.**

If submitting an application by paper, all of the required application documents should be submitted in the order listed above.

8.02 Unique Entity Identifier and System for Award Management (SAM)

Pursuant to 2 C.F.R. Part 25, applicants and recipients (as the case may be) are required to: (i) be registered in SAM before submitting its application; (ii) provide a valid unique entity identifier in its application; and (iii) continue to maintain an active SAM registration with current information at all times during which it has an active Federal award or an application or plan under consideration by a Federal awarding agency, unless otherwise excepted from these requirements pursuant to 2 C.F.R. § 25.110. NIST will not make a Federal award to an applicant until the applicant has complied with all applicable unique entity identifier and SAM requirements and, if an applicant has not fully complied with the

⁴ <http://www.nsf.gov/bfa/dias/policy/dmp.jsp>

⁵ http://grants.nih.gov/grants/policy/data_sharing/data_sharing_guidance.htm#inc

⁶ <https://www.cic.net/projects/technology/shared-storage-services/data-management-plans>

requirements by the time that NIST is ready to make a Federal award pursuant to this FFO, NIST may determine that the applicant is not qualified to receive a Federal award and use that determination as a basis for making a Federal award to another applicant.

9.0 RESEARCH TOPIC AREAS

The research topic areas that will be supported by NIST's SBIR program are those aligned with NIST's investment priority areas identified in NIST's Three-Year Programmatic Plan: <http://www.nist.gov/director/planning/planning.cfm>.

9.01 Advanced Manufacturing

9.01.01.73-R Category-Theoretic Tools to Support Manufacturing Information Integration

This subtopic is calling for a software tool to test the categorical formalism on integration problems in smart manufacturing and additive manufacturing. Category theory has been identified as a flexible and straightforward mathematical formalism for establishing compatibility of information structures and setting up the required information exchange. The software tool must enable the creation of the category-theoretic mappings needed for integrating different information models in multiple domains. In addition, the tool must be scalable so that it can be used to solve integration problems of varying size and complexity and integration problems that change as systems evolve over time. This is crucial to the eventual commercialization of the tool.

The project goal is to develop prototype tools that can represent manufacturing information objects, currently stored in Excel spreadsheets or SQL-type databases, as categories and demonstrate that the tools enable the integration of information across these two representations.

Phase I activities and expected results:

- Develop a small-scale manufacturing-related demonstration software tool that can visually represent the information objects.
- Demonstrate how to merge the databases.
- Demonstrate how to answer a selected set of queries using the merged database.

Phase II activities and expected results:

- Expand the small-scale manufacturing-related demonstration software tool developed in Phase I to integrate software tools when data is captured in Excel spreadsheets.
- Demonstrate that the tool works for a small manufacturing example.
- Demonstrate that the new tool works on realistic problems that involve both databases and Excel spreadsheets.

NIST will be available to assist the awardee to choose scenario and information objects.

Reference:

1. Spivak, D. *Category Theory for Scientists*, MIT Press. (October 2014).

9.01.02.73-R Computer Aided Standards Development (CASD) – A Software Tool to Automate the Standards Development Process

The development of documentary and test standards is a long and tedious process. Challenges facing standards developers include complex, inadequately defined terminology, and rapidly changing associated information content. Even after a standard is “set,” its implementation and adoption can be hampered by the gap between the technical requirements of that standard and the technology required to implement those requirements.

NIST seeks a software tool that will make the process of designing and developing documentary standards faster, more robust, and more integrated. The model for this subtopic is the so-called Computer Aided Software Engineering (CASE) tool, itself modeled after the Computer Aided Design (CAD) tool, but applied to standards development and deployment. The tool should provide the following capabilities for standards development and deployment:

- Categorize and organize standards’ content in a structured information model, supporting modularization and reuse.
- Establish terminology connections between related standards, and maintain semantic consistency across standards.
- Generate a visual representation and navigation scheme for the standard, so that the standard may be communicated to the end-user through interactive means (such as a touch-screen tablet).
- Provide an underlying formal model that is amenable to testing and verification, and that facilitates the implementation of the standard by automatic or semiautomatic generation of software modules. This should allow software implementers to extract portions of the standard to meet specific implementation requirements

Standards development organizations (SDOs) and the scientific and engineering societies that participate in those organizations will benefit greatly from such a tool. Vendors will benefit from the tool since it would pull from the existing standard, populate the tool, and allow a consistent assessment for the vendor to identify the requirements. NIST will greatly benefit from such a tool to enable better testing of standards for broad industry deployment. Such a tool will also allow NIST to develop metrics to assess the “quality” of a standard, and to verify whether an implementation meets a standard’s scope and requirements.

The life-cycle of a standard may involve three broad stages [1]. First is the development stage, in the course of which stakeholders gather within committees, prepare a draft, and come to a consensus on a final standard. The second stage is the deployment stage, which

may include a pilot-scale implementation, followed by industry-wide implementation. The third stage is the maintenance stage, in which the standard is revised and maintained. A well-defined underlying information structure/model will facilitate the implementation of all three stages. In addition, it can support the instantiation and communication of the standard to the end-users using the varied digital media available today. Even though information management and software tools have advanced considerably over the recent decades, SDOs rarely take advantage of those advancements.

The goals of this project are the following: 1) Build a framework for developing a taxonomy and ontology for the terminology and concepts contained in a standard; 2) Capture the requirements of a standard in a formal model; and 3) Develop a standard as a structured information model, instead of a simple text document.

Additional tools to automatically verify these models for consistency and generate other artifacts such as documents and software implementation modules can be also developed. All of these will be supported by a tool that will allow standards developers and end-users to interactively view and navigate the information models. Such technology will greatly improve the deployment, adoption, and maintenance of standards.

The outcome of this effort will bring together SDOs, software implementers, and end-users (both manufacturers and their consumers) under a single framework and allow them to exchange standards information in an unambiguous and efficient manner. While the focus of this SBIR subtopic will be related to standards in manufacturing, the general methodology is applicable to other industry sectors.

Phase I activities and expected results:

- Expand on the NIST Ontological Visualization Interface for Standards (NOVIS) tool [2, 3] to develop a taxonomy editor for standards. This should include a classification scheme and underlying ontology modeling the concepts and relationships.
- Develop a formal representation scheme to capture the requirements for a standard. This may be based on the Framework for Analysis, Comparison, and Test of Standards (FACTS) work [4].
- Develop an export/import mechanism for the information content of a standard and associated document formats.
- Develop a business case for a Computer Aided Standards Development (CASD) tool working with standards developing organizations, such as, ASME, ASTM, IEEE, OMG, and ISO.

Phase II activities and expected results:

- Design an initial architecture and software for realizing a computer aided tool for standards development.
- Develop a Computer Aided Standards Development (CASD) tool and a comprehensive case study/demonstration.

- Design an interface between a CASD tool and document generation software, in the form of a plug-in to a document editor that interfaces with the underlying CASD model.
- Design a mechanism for automatic or semiautomatic generation of software to implement modules of the standard.
- A framework for a standards repository where the standards may reside as information models. The framework should support version control, cross standard linking, and maintenance of information consistency across standards.

NIST will consult and provide input to assess progress and performance.

References:

1. Cargill, C.F., *Why Standardization Efforts Fail*, The Journal of Electronic Publishing. (2011).
2. Narayanan, A., et al., *A Methodology for Handling Standards Terminology for Sustainable Manufacturing*, NIST Interagency/Internal Report (NISTIR) – 7965. (2013).
3. Lechevalier, D., et al., *NIST Ontological Visualization Interface for Standards User's Guide*, NIST Interagency/Internal Report (NISTIR) – 7945. (2013).
4. Witherell, P.W., et al., *FACTS: A Framework for Analysis, Comparison, and Test of Standards*, NIST Interagency/Internal Report (NISTIR) – 7935. (2013).

9.01.03.68-R High-Throughput Manufacturing Methods for Engineered MRI Contrast Agents

Microfabricated magnetic imaging agents with greater sensitivity and new functionality for magnetic resonance imaging (MRI) have recently been demonstrated at NIST [1-4]. The technology relies on thin-film fabrication methods adapted from the semiconductor industry. This “top-down” approach is expensive and suffers from low yield compared to “bottom-up” methods based on chemical synthesis for making other types of contrast agents. NIST seeks applications focused on the development and demonstration of high-throughput techniques for making this new class of MRI contrast agent in sufficient quantity that biologists and physicians can explore new applications. These methods must achieve the necessary control of dimensional and materials properties at nanometer size scales. In addition, manufacturing methods must lead to materials that can be readily prepared for animal studies and potentially for clinical trials using methods currently available in the biomedical community.

The technical proposal must provide details on how to achieve the following goals:

1. Manufacturing methods will lead to contrast agents with the sensitivity and functionality similar to those demonstrated at NIST using wafer-based manufacturing methods. For T2* agents (see Ref. [1]), this implies micrometer-scale magnetic particles with sizes and magnetic moments that vary by no more than 5 to 10 % (ideally less) from one particle to another. For multispectral agents (see Refs. [2-4]), this implies, in addition, that magnetic particle shapes are sufficiently well controlled and similar to one

another to ensure that the resulting shifted nuclear magnetic resonance (NMR) water linewidths generated by single particles, as well as by ensembles of particles, are no more than 10 to 20 % (ideally less) of the NMR frequency shift itself. For example, methods for making hollow magnetic nano-cylinders [3] should ideally have control to within a few percent over the thickness of the cylinder wall as well as the length and diameter of the cylinder. Depending on cylinder size, this may translate to control of a few nanometers for wall thickness and of a few tens of nanometers for cylinder length.

2. Manufacturing methods should be capable of producing millimolar solutions in 0.1 liter batches for in-vivo biological applications.
3. Manufacturing methods should have promise for producing contrast agents at a cost that is comparable with that of current imaging agents for MRI.

NIST seeks applications that address the issues identified above, as well as methods that streamline wafer based manufacturing (such as nano-imprinting), use roll-to-roll transfer techniques, use chemical synthesis approaches, or a combination of any of the above.

Phase I activities and expected results:

Demonstrate a manufacturing method for producing contrast agents that have sensitivity and functionality similar to those of microfabricated contrast agents that have been produced at NIST using wafer-based manufacturing methods.

Phase II activities and expected results:

Show the capability of the manufacturing method developed in Phase I for producing millimolar solutions of sufficient quantities at a cost that is comparable to that of current MRI contrast agents.

NIST will be available for consultation and collaboration, including testing contrast agents for sensitivity and functionality.

References:

1. G. Zabow, S.J. Dodd, E. Shapiro, J. Moreland, A.P. Koretsky, *Microfabricated High-Moment Micrometer-Sized MRI Contrast Agents*, *MAGNETIC RESONANCE IN MEDICINE* 65, 645–655. (2011).
2. G. Zabow, S.J. Dodd, A.P. Koretsky, *Ellipsoidal Microcavities: Electromagnetic Properties, Fabrication, and Use as Multispectral MRI Agents*, *SMALL* 10, 1902–1907. (2014).
3. G. Zabow, S.J. Dodd, J. Moreland, A.P. Koretsky, *The Fabrication of Uniform Cylindrical Nanoshells and their Use as Spectrally Tunable MRI Contrast Agents*, *NANOTECHNOLOGY* 20, 385301. (2009).
4. G. Zabow, S.J. Dodd, J. Moreland, A.P. Koretsky, *Micro-Engineered Local Field Control for High-Sensitivity Multispectral MRI*, *NATURE* 453, 1058–1062. (2008).

9.01.04.68-R Laser Power Meter for Manufacturing Applications

The decreasing cost and increasing efficiency of high-power lasers is revolutionizing manufacturing in the U.S. and around the world. Multi-kilowatt lasers are now routinely used for welding, cutting, and additive manufacturing. Precision control of these processes, and thus the uniform quality of the manufactured product, requires a meter that can measure the power of such lasers with an uncertainty of only a few percent. Historically, NIST's standards for power measurements of high-power lasers have been massive thermal detectors [1]. While suitably accurate, their size, cost, and technical characteristics (e.g. temporal response) are not optimal for use in manufacturing operations. For example, an important goal is to incorporate a power meter into the head of a laser welder, measuring the output power in real time and without sacrificing laser power or beam quality.

NIST seeks further innovation to improve the state-of-the-art, leading to the commercialization of smaller, faster, and cheaper power meters, which would also have high accuracy. One approach would be a device based on our recent demonstration showing that the inherent force in light (radiation pressure) can be exploited to measure high-power lasers in a manner that could be 1/10th the cost, 10 times the speed, a fraction of the size, and yet with accuracy that is comparable to the existing technology of large thermal detectors [2]. NIST is especially interested in the development of a second-generation radiation pressure power meter.

The goal of the project is to develop a small, fast, rugged radiation pressure sensor capable of measuring, in situ, high power laser radiation up to 10 kW (5 kW/cm²).

- Small: Dimensions less than 50 mm x 50 mm x 50 mm
- Damage threshold: 5 kW/cm²
- Temporal Response: 10 ms
- Reflectance: Primary reflected beam contains 99.99 % of input
- Robust: Survives acceleration of 3 g, operates with sensor in random physical orientation and in motion (up to 1 m/s).
- Signal processing/data access: by separate (external) processor (Laptop, FPGA, Raspberry PI, etc.)

Phase I activities and expected results:

- Develop suitable force-sensor mechanism (capacitive, current compensation, pressure, etc.).
- Demonstrate performance and calibration of force-sensor mechanism by using calibrated masses, or other means.
- Determine suitable high-reflectance mirror.
- Engineer packaging for small volume and ruggedization.

Phase II activities and expected results:

- Demonstrate temporal response.

- Demonstrate optical power density survivability and thermal management.
- Incorporate pressure sensor (power meter) into a laser-welding head, to demonstrate integration with real-world manufacturing processes.

NIST will be available to assist the awardee by discussing NIST's research and ideas. The NIST 10 kW laser and laser-welding booth are available for device testing in collaboration with NIST; NIST can aid in determining the accuracy of the developmental power meter through comparison with NIST's Flowing Water Optical Power Meter. Temporal response can be determined by using NIST's modulated laser source.

References:

1. C. L. Cromer, X. Li, J. H. Lehman, and M. L. Dowell, *Absolute High-Power Laser Measurements with a Flowing Water Power Meter*, presented at the 11th Conference on New Developments and Applications in Optical Radiometry, Maui, Hawaii, USA. (September 19–23, 2011). See also: http://www.nist.gov/pml/div686/laser_power_meter.cfm.
2. P.A. Williams, J.A. Hadler, R. Lee, F.C. Maring, and J.H. Lehman, *Use of Radiation Pressure for Measurement of High-Power Laser Emission*, *Optics Letters*, 38, 4248-4250. (2013). See also: <http://www.nist.gov/pml/div686/laser-102213.cfm>.
3. U.S. Patent Application No. 2014/030-7253, *Optical Meter and Use of Same*. See: <http://appft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fmetahtml%2FPTO%2Fsearch-bool.html&r=1&f=G&l=50&co1=AND&d=PG01&s1=20140307253.PG.NR.&OS=DN/20140307253&RS=DN/20140307253>.

See also:

<http://tsapps.nist.gov/techtransfer/index.cfm?event=public.techdisplay&ItemID=409>

9.01.05.68-R Optical Microscopy as Applied to Fabrication of Atomic-Scale Devices

NIST seeks development of an optical imaging system that has micrometer resolution, an image field of 50 to 200 micrometers, and a depth of focus that ensures image quality over the field of view of interest. Such a system must have a working distance of nominally 20 cm, image an object that is in vacuum, and potentially have flexibility to work around obstructed sight paths.

To set the context, NIST is interested in developing new methods to fabricate atomically precise electronic devices. One of the primary challenges in this field, however, is in connecting these atomic-scale devices to macroscopic electrical contacts, enabling external measurement and additional fabrication steps. A new advance that links the atomic scale fabrication to macroscopic processes via imaging and fiducial markings is needed. Ideas for solving this challenge include stereo microscopy, a through-focus 3-D image reconstruction capability, and vacuum-compatible optical imaging. A product developed under this

subtopic should be marketable as a tool for those doing research in atomic-scale devices, and ultimately in their commercial production.

The goal is to develop a solution to locating 50 nm sized features relative to larger fiducial markings, enabling future measurement and process steps on tools such as an SEM-based, e-beam lithography system. The objective is to design an imaging system that enables the relative position of near atomic scale features and their local contacts to be accurately determined to several nanometers of overlay. Numerous users of scanning tunneling microscopy (STM) systems will benefit from this desperately needed capability. The project should demonstrate the concept (in Phase I) as well as develop a working prototype system (in Phase II) capable of being implemented in a vacuum system with an STM. The prototype must be the basis for an actual system to be developed and sold commercially to the STM and atomic-scale device fabrication communities.

Phase I activities and expected results:

Demonstration of a concept that clearly allows optical imaging of an STM tip and its relative position to optically visible fiducial markings. The system must allow the tip position to be accurately estimated relative to fiducial markings.

Phase II activities and expected results:

Development of a prototype system as defined in Phase I.

NIST will collaborate using its STM Ultra-High Vacuum facilities to help in the design and testing.

References:

1. Fuechsle, Martin, et al. *A Single Atom Transistor*, Nature Nanotechnology, Vol. 7, p. 242 (2012).
2. Morton, John, et al. *Embracing the Quantum Limit in Silicon Computing*, Nature 479, p. 345 (2011).

9.01.06.73-R Predictive Modeling Tools for Metal-Based Additive Manufacturing

NIST seeks the development of tools that rely on a suite of physics-based and empirical models to support predictive analyses of metal-based additive manufacturing (AM) processes and products. Physics-based models will be developed in such a way to ensure reusability in a predictive environment, irrespective of product geometry. The tool will support reliable and repeatable microstructure and performance predictions for various geometries for a given process and material. Such a tool should:

- Provide a set of physics-based and empirical models for metal powder-bed fusion manufacturing processes.
- Demonstrate scaling and composability of such models to support geometry-independent reusability.

- Provide ranges of parameter values for which models can be assumed reliable and accurate.
- Provide support for in situ feedback to allow for real-time adjustments during manufacture.

The successful development of such a tool will provide industry with a mechanism to move away from empirical testing and instead rely more on modeling and simulation, enabled primarily by measurement science underpinnings. As a potential means for qualifying AM parts, the tool will support NIST's mission by reducing AM part lead-times and enabling SME's to expand their market participation.

Industry relies heavily on the manufacturing of coupons to qualify metal parts created using AM processes. Predictive models provide a means for industry to move away from their dependence on testing and towards an environment supported by models and simulation. The transition to modeling and simulation for part qualification is underway, albeit very cautiously and deliberately. Current qualification through modeling and simulation is achieved only with very specific models deployed under very specific circumstances.

The goal of this project is to develop a tool that will support the broader application of physics-based and empirical models as a means for product qualification. This will be achieved by developing sets of composable models, each model accompanied with clear application boundaries. These models must be composable to a level of granularity that microstructure, and to an extent performance, can be predicted to a degree of certainty, for a given set of process parameters and irrespective of geometry. This tool will be an early step in allowing industry to move away from 100% testing and towards reliable modeling and simulation in AM.

As AM nears production-ready capabilities, advancements in modeling and simulation have become increasingly necessary. Many institutions, especially universities and small companies, do not have the resources to test each part created. Nor do these institutions have the resources for developing reliable predictive models. Development for this tool will focus on support for composable modeling for metal powder bed fusion processes, including direct metal laser sintering and selective laser melting, though the principles applied during its development should support broader applications. Therefore, one goal of this project will be to provide a foundation for developing similar tools in the future for other processes, including those that build parts using polymer-based processes.

Phase I activities and expected results:

- Development of a set of parameterized, composable models to support predictive analysis in a proof-of-concept operating environment.
- Development of a specified set of operating conditions for which the models are applicable, including the degree of certainty that they are able to predict performance.

- Demonstration of model composability and reliability by predicting the microstructure, to a specified degree of certainty, for several basic shapes.
- Prediction of fabricated part performance of several basic shapes, to a specified degree of certainty.

Phase II activities and expected results:

- Demonstration of automated or semi-automated model composition to predict microstructure to a specified degree of certainty.
- Demonstration of identification of in situ adjustments based on real-time predictive analysis.
- Development of a tool from which models can be rapidly called and stored on demand.
- Demonstration of model composability and reliability by predicting the microstructure, to a specified degree of certainty, on complex geometry.
- Prediction of fabricated part performance of complex geometry, to a specified degree of certainty.

NIST staff from the Measurement Science for Additive Manufacturing Program in the Engineering Laboratory will work with the awardee, providing consultation and assessment of performance and progress, to develop the fundamental measurement science for this predictive tool. This will support development of a tool necessary to support composable predictive modeling for manufacturing with metal powder bed fusion processes, similar to how finite element analysis is used in conventional machining.

References:

1. Pollock, Neil, and Robin Williams. *Software and Organisations: The Biography of the Enterprise-Wide System or How SAP Conquered the World*. Taylor & Francis US. (2008).
2. Bourell, D., Leu, M., Rosen, D., eds. *Roadmap for Additive Manufacturing: Identifying the Future of Freeform Processing*, (<http://wohlersassociates.com/roadmap2009.pdf>). (2009).
3. Energetics Incorporated, *Measure Science Roadmap for Metal-based Additive Manufacturing*, (http://events.energetics.com/NIST-AdditiveMfgWorkshop/pdfs/NISTAdd_Mfg_Report_FINAL.pdf). (May 2013).

9.01.07.63-R Stroboscopic Method for Dynamic Imaging in a Transmission Electron Microscope at GHz Frequencies

A large portion of the global information technology (IT) infrastructure relies on nanoscale devices operating between 1 and 5 GHz. Familiar examples are GPS (1.5 GHz), cellular and wireless communication (2.4 GHz), dynamic random access memory (DRAM, 2 GHz) and computer processors (3 GHz). Although of wide-interest and the subject of many research and development efforts, the capability of directly imaging the propagating electromagnetic waves in a device is not available.

Transmission Electron Microscopy (TEM) is the gold standard technique in spatially-resolved imaging. However, dynamic events are not temporally resolved because the signals are time-averaged on the order of a second. Until recently, TEM has been ruled out as a viable time-resolved technique^{1, 2}. If the TEM had the power to obtain nanoscale spatial resolution and collect images at high sampling rates, entirely new modes of observation and investigation will become available.

The goal of this project is to enable imaging of periodic, ultrafast phenomena at GHz frequencies and sub-nanometer spatial resolution to enable new measurements for magnetic data storage, advanced materials, electrochemical systems, and wireless communication. This goal shall be accomplished through the design and development of an electron beam modulator that can be integrated with a TEM to allow the capture of rapidly changing structures or features using stroboscopic methods.

Phase I activities and expected results:

- Demonstration of the feasibility of modulating a 200 – 300 keV electron beam either spatially or temporally at a frequency that is tunable between 1 and 10 GHz.
- Demonstration that the modified beam maintains sufficient spatial/energy coherence so that it remains useful for imaging.

Phase II activities and expected results:

- Build and test the electron modulator, working collaboratively with NIST and making use of a NIST- owned TEM as part of that collaboration, if applicable.

NIST will work collaboratively to design and develop the beam modulator concept with the awardee. The awardee shall provide expertise in constructing and testing of the device (Phase II). NIST will collaborate by integrating this device into an existing microscope.

References:

1. B. Barwick, H. S. Park, O.-H. Kwon, et al., *Science* 322, 1227. (2008).
2. J. S. Kim, T. LaGrange, B. W. Reed, et al., *Science* 321, 1472. (2008).

9.01.08.61-R Tuning Germanium Crystal Reflectivity and Mosaic

The standard for performance in monochromatic scattering of neutrons and x-rays has been pyrolytic graphite crystals (PG). PG has the disadvantages of scattering higher order wavelengths and it has only two useful reflections (002 and 004) that limit flexibility in desired wavelength and resolution. If the properties of germanium crystals could be tuned so that the reflectivity performance is comparable or superior to PG, then germanium would replace PG for many applications with improved performance and flexibility, since it rejects higher order wavelength contamination and has a much larger range of useful lattice spacings than PG. NIST seeks a new processing technology to make the performance of germanium comparable to that of PG.

The main goal of this project is to find a manufacturing technique that can improve the scattering performance of germanium crystals. The NIST Center for Neutron Research would serve as the main bridge for this project by testing the germanium crystal performance.

Phase I would consist of completing feasibility tests to find a manufacturing technique that is promising. This means the production of germanium crystals with peak reflectivities comparable to those of pyrolytic graphite (0.6 and higher) and mosaics in the range 15' to 40'. The NCNR neutron scattering results from Phase I, will be published in open literature.

Phase II would consist of tuning the manufacturing process to obtain a commercial product.

NIST will provide assistance in the form of neutron beam time, at no-cost, at the NCNR, including staff assistance with data taking, analysis and discussion. The use of the NCNR under this subtopic is for non-proprietary research purposes where results are publishable and available to the general public in the literature.

9.02 Climate Change and Clean Energy

9.02.01.77-R Large-Area, Uniform Infrared Detector Development for 1 μm to 4.5 μm

Remote-sensing systems for Earth monitoring often detect infrared radiation in the 2 μm to 2.5 μm and the 3 μm to 5 μm atmospheric windows, where radiation absorption is low. Calibrating such systems can be more difficult than calibrating optical systems that use visible light, because—among other reasons—a type of measurement standard that is available for visible light is not yet available for this spectral range. This subtopic is referring to so-called “trap” detectors. A “trap” detector includes an assembly of photodiodes (or similar devices) arranged such that, in optical series, they adsorb (that is, “trap”) virtually all incident radiation. (Only a very small fraction of the incident radiation is lost due to reflection out of the detector.) The references, below, show examples of such designs.

Trap detectors have proven to be highly useful as precision standards for measuring optical power (and related quantities, such as irradiance) in the visible and ultraviolet wavelength ranges. An enabling technology was the silicon photodiode, once they became available sufficiently large and with sufficient spatial uniformity. However, until recently, sufficiently large and uniform photodetectors for infrared radiation were not available.

NIST believes that this is changing, and that detectors made with infrared-sensitive materials (e.g. InAs, GaInAsSb, etc.) are within the state-of-the-art in large area (e.g., 1.5 cm^2 active area) and with a spatial variability of internal quantum efficiency of less than 0.1 % between 1 μm and 4.5 μm . In addition, the internal quantum efficiency of the detectors (i.e., the device efficiency after taking into account the radiation loss due to front-surface reflection) must be close to unity.

The goals of the project are to engineer, build, and demonstrate a trap-detector design that takes advantage of modern uniform, large-area infrared detectors. Ultimately, the goal is for the awardee to market such detectors to the infrared measurement community, for applications including radiation thermometry. The trap detectors must be useable at ambient temperatures of $-20\text{ }^{\circ}\text{C}$ and warmer, having internal thermo-electric coolers. The goal is to have a spatial uniformity of response over the input aperture of 0.1% or better at all wavelengths between $1\text{ }\mu\text{m}$ and $4.5\text{ }\mu\text{m}$, where the source is a tunable laser beam of 0.2 mm diameter. An unvignetted acceptance angle of at least 7° is required. An ideal trap detector (3-element reflectance, 6-element tunnel, etc.) would have a 5 mm diameter precision entrance aperture. The design task includes precision electronics to accurately sum the signals from the individual photodetectors.

Phase I activities and expected results:

- An overall design an infrared trap detector, including optical, electrical, mechanical, and thermal factors.
- Identification, development, and/or fabrication of single-element detectors that are consistent with the overall design.
- Demonstration that the single-element detectors meet the design requirements, e.g., in spatial and spectral uniformity.

Phase II activities and expected results:

- Build and demonstrate the performance of the infrared trap detectors. Performance includes spatial uniformity when measuring infrared power, and angular uniformity when measuring infrared irradiance. It also includes demonstrating linearity of response and a minimization of signal noise.
- Iteration to improve the design and its performance.

NIST will consult and provide applicable background information. NIST will collaborate with the awardee in determining the performance of the single-element detectors and the trap detector prototypes.

References:

1. Eppeldauer G. P. and Lynch D. C., *Opto-Mechanical and Electronic Design of a Tunnel-Trap Si-Radiometer*, J. Res. Natl. Inst. Stand. Technol. Vol. 105, No. 6, pp. 813–828. (2000).
2. Fox, N. P., *Trap Detectors and Their Properties*, Metrologia 28, 197. (1991).

9.03 Cybersecurity

9.03.01.77-R A Verifier for Multicore C11 or C++11 Code

The 2011 ISO/IEC standards for C [1] (C11) and C++ [2] (C++11) introduced a portable, relaxed multithreaded memory model. Instead of guaranteeing sequential consistency [3] for all legal (data-race-free) programs, these standards allow each atomic shared memory operation to specify the degree of memory consistency it requires. The compiler has to add

only the synchronization needed to achieve the specified degree of consistency on a given architecture. The compiler also gains the freedom to reorder shared memory operations within a thread. With per-core processing throughput stagnant but core counts growing, engineers increasingly use this technology (in combination with lock-free synchronization [4]) to improve system performance, responsiveness and robustness, to reduce power consumption, and to maintain scalability on modern multicore and many-core processors. With the dominant role of C/C++ in systems software, much of our computing infrastructure (and many of our devices) will depend on such code.

Validating code written to the new model is difficult [5]. Beyond the usual problems of validating multithreaded code (e.g., an exponentially growing number of possibly relevant schedules), the new freedoms granted to compilers and hardware make thorough testing of a library practically impossible, since a bug might manifest only under some specific compiler or hardware reordering. This makes quality assurance and certification of libraries or systems containing such code by testing alone infeasible.

The only practical approach to this assurance challenge is formal verification, that is, a verification tool proves mathematically (typically guided by annotations provided by the software maker) that code meets its formal specifications. Because the software maker has done the hard work (annotation), a customer or certification authority can check the code for correctness by simply running the verifier on the annotated code, without having to trust the software maker. Thanks to improvements in technology, deductive verification is now practical for realistic code, and has been used to verify sophisticated software such as OS kernels [6], optimizing compilers [7], and concurrent system-level code [8].

A practical and sound deductive verifier for C11/C++11 code would allow library writers and device engineers to conclusively prove, to customers and certification authorities, that their code indeed meets its functional specifications. Such proofs enable development of an ecosystem of portable, trustworthy, and efficient software libraries.

Hard real-time guarantees are critical in some cybersecurity applications (e.g., to prove availability), as well as in software embedded in medical devices, manufacturing, and advanced communications. While real-time behavior is inherently nonportable and goes beyond the language standards, verification support for real-time properties would greatly extend the utility of the verifier.

The goal of this project is to construct a practical verifier for C11 and/or C++11, and to demonstrate its practicality. The verifier should have the following properties:

- The verifier targets C11 or a subset of C++11 with at least the full capabilities of C11.
- The verifier allows specification and sound verification of functional correctness.
- Verification is driven by specifications, and perhaps additional annotations, in the code itself; these annotations should be sensible to engineers.

- The verification methodology respects standard modular programming practice, such as information hiding, data abstraction, and separate specification/verification of libraries and concurrent components.
- The verification methodology supports specification of the behavior of external entities (e.g. devices) with which the software is designed to interact (e.g., through memory-mapped I/O), and verification of the behavior of the combined system.
- (optional) Verification may support specification and verification of real-time guarantees, based on Worst Case Execution Time (WCET) assumptions expressed through annotations.

NIST emphasizes that the desired outcome of the project is a practical tool that can be used as an aide to produce efficient, verified code, particularly libraries. NIST is interested in the utility of the tool, not in the novelty of the underlying technology.

Phase I activities and expected results:

The Phase I project should produce a verifier design (architecture and specification), a methodology for its use, a full-scale prototype development plan, and evidence that the proposed verifier can be built and will meet the project goals. The evidence should include examples of how code might be annotated to verify programs using (1) standard program control structures (references to stack/heap objects, loops, function calls, framing, termination, etc.), (2) data structures (structs/unions, abstraction, type invariants, etc.), (3) concurrency (locks, weak memory types, lock-free data structures, linearizability, etc.), (4) external devices/entities (modelling, verification of the composite system), and optionally (5) real-time constraints. The Phase I report should also describe some possible verification examples to be tackled in Phase II, and outline how these examples would be verified using the proposed methodology.

Phase II activities and expected results:

Phase II work should consist of construction of a prototype verifier based on the design proposed in Phase I, and demonstration of the verifier on some small but interesting examples. The prototype should cover the essential programming mechanisms of C11 (and, in particular, should handle the C11 memory model), but need not cover all language features. Suitable demonstration examples include lock-free hashtables (using hazard pointers), a toy infusion pump, a robust flash-based key-value store, etc.

NIST will have staff available to discuss reasonable subsets of C11 or C++11, possible types of example software to verify, and usable specification and annotation formalisms.

References:

1. ISO/IEC 9899:2011 – Information technology – Programming languages – C.
2. ISO/IEC 14882:2011 – Information technology – Programming languages – C++.
3. S. Adve and H.-J. Boehm, *Memory Models: A Case for Rethinking Parallel Languages and*

Hardware. CACM Col. 53 No. 8. (2010).

4. M. Herlihy and N. Shavit, *The Art of Multiprocessor Programming*. Morgan Kaufman. (2012).

5. M. Batty, S Owens, S Sarkar, P. Sewell, and T. Weber, *Mathematizing C++ Concurrency*. In POPL (2011).

6. The CompCert C Compiler: <http://compcert.inria.fr/compcert-C.html>.

7. The open sourcing of seL4: <http://www.sel4.systems/>.

8. VCC, mechanical verifier for concurrent C programs: <http://vcc.codeplex.com/>.

9.03.02.77-R Access Control Policy Tool

Nearly all applications that deal with financial, privacy, safety, or defense include some form of access control. Access control is concerned with determining the allowed activities of legitimate users, mediating every attempt by a user to access a resource in the system. Access control policies are high-level requirements that specify how access is managed and who may access information under what circumstances [1]. For instance, policies may pertain to resource usage within or across organizational units or may be based on need-to-know, competence, authority, obligation, or conflict-of-interest factors.

Access control policies are increasingly written in policy specification languages such as XACML [2] and enforced through a Policy Decision Point (PDP) implementation. Some example PDP implementations include Sun XACML [3] and XACML .NET [4]. In such a way, the correctness of specified access control policies plays a crucial role in assuring adequate security. One of the techniques for increasing confidence on the correctness of access control policies is to conduct systematic policy testing: requests as test inputs and responses as test outputs.

There are two fundamental problems in systematic policy testing: (1) coverage criteria such as structural coverage criteria [5] to decide the adequacy of test inputs and decide when to stop testing and (2) request generation to satisfy coverage criteria and detect faults in policies.

To provide high security confidence levels for the nation's critical IT infrastructure, it is important to provide a tool, which can thoroughly and automatically check the syntactic and semantic faults of AC policies before deploying them for operation. NIST's effort of developing the tool – Access Control Policy Tool (ACPT) – [6] provides (1) GUI templates for composing AC policies, (2) property checking for AC policy models through an SMV (Symbolic Model Verification) model checker, (3) complete test suite generated by NIST's combinatorial testing tool ACTS [7], and (4) XACML policy generation as output of verified model. Through the four major functions, ACPT performs all the syntactic and semantic

verifications as well as the interface for composing and combining AC rules for AC policies; ACPT assures the efficiency of specified AC policies, and eliminates the possibility of making faulty AC policies that leak the privacy information or prohibit legitimate information sharing. To enhance the usability (comparing with ACPT) a tool with additional user interfaces, policy importing, and general security property specification capabilities need to be developed.

In addition to fundamental functions for verification and testing of access control models as provided by ACPT, advanced features are required for more capable and flexible use of access control policy tool. NIST seeks development of additional access control policy test capabilities, which may include: (1) easy and general user interface for policy property specification, (2) specification of object attributes inheritance relations, (3) more granular property verification results, (4) API or mechanism for acquiring or consuming information about users attributes, resources, environment, and inheritance relations, (5) more policy combination algorithms, (6) import XACML policies, (7) running under OSX and Linux in addition to Window system. (Awardee is encouraged to use NIST's ACPT as the baseline system for the project, ACPT web page and source code are available at <http://csrc.nist.gov/groups/SNS/acpt/acpt-beta.html>).

Phase I activities:

Plan, specification and design for the access control policy tool development.

Phase I expected results:

Completed development plan, specification, and design including test plan for the proposed capabilities.

Phase II activities:

Code development, documentation, and testing of the access control policy tool capabilities.

Phase II expected results:

A robust beta version of access control policy tool that contains the proposed enhance capabilities, documentation for the code and user manual, and testing results to verify the completeness of the development.

In addition to ACPT source code, NIST would provide consultation, input, and discussion with the awardee to help with the evaluation of the proposed development.

References:

1. V. C. Hu, D. F. Ferraiolo, and D. R. Kuhn, *Assessment of Access Control Systems*, NIST IR 7316, Computer Security Division, Information Technology Laboratory, National Institute of Standards and Technology. (September 2006).
2. XACML. <http://www.oasis-open.org/committees/xacml/>.

3. Sun XACML. <http://sunxacml.sourceforge.net/>.

4. XACML .NET. <http://mvpos.sourceforge.net/>.

5. V. C. Hu, D. R. Kuhn, T. Xie, J. Hwang, *Model Checking for Verification of Mandatory Access Control Models and Properties*, Int'l Journal of Software Engineering and Knowledge Engineering (IJSEKE) regular issue IJSEKE Vol. 21 No. 1. (2011).

6. Computer Security Resource Center, Access Control Policy Tool (ACPT):
<http://csrc.nist.gov/groups/SNS/acpt/index.html>.

7. Computer Security Resource Center, Automated Combinatorial Testing for Software (ACTS): <http://csrc.nist.gov/groups/SNS/acts/>.

9.03.03.77-R Analysis and Visualization Tools for Automated Email Abuse Reports

Email coming from spoofed senders (referred to as phishing) is often used to inject malware into an enterprise. Several new technologies have been proposed to combat phishing by having the sending domain state its sending policy and vouch for sent email [1] [2]. Recently, a consortium of email providers developed a new technique called Domain-Based Message Authentication, Reporting and Conformance (DMARC) [3] [4] that allows sending domains to advertise their anti-phishing policies and provides a means to report global validation results of those policies back to the sending domains. This enables the sender to see how its anti-phishing techniques are interpreted by outside receivers as well as receive alerts if a phishing campaign has been launched using their domain as the spoofed sender.

DMARC has two key functions: First, the ability to authoritatively state the email sending policy and security technologies in use for a sender, and second, to set up a means to receive reports from recipients about email streams and (possible) intercepted phishing attacks. This standardized way of stating where to send abuse reports is very powerful and allows a domain to be alerted when a third party (i.e. an attacker) is spoofing their domain when sending email to a victim. This reporting allows for a more coordinated response and aids in investigation of the incident.

Currently, there is a lack of tools available for domain owners to parse and extract data from forensic reports. A phishing campaign conducted against one or several organizations could consist of hundreds or thousands of spoofed emails. These emails could come from various sources and forensic reports could identify the possible origin of the attacks. Forensic reports from different sources could be used to identify botnets in use and other intelligence that can be used to stop the campaign as quickly as possible.

The goal of the project is to design, develop and test a tool that takes multiple forensic reports (possibly stored in a database) and extract statistics and any other useful intelligence. The tool should also have dashboard front end that gives the user a quick

summary of current or recent sets of forensic reports as well as alleged sources and targets. The tool should also allow a user to query for a set of reports based on date(s), target, or other relevant criteria. The tool should also allow for exporting of data and reports.

Tools to do other functions of DMARC are out of the scope for this project, but the tool may need to integrate into other DMARC reporting tools.

Phase I consists of designing, and documenting a database and associated processes and algorithms used to parse and analyze a collection of forensic reports. DMARC forensic reports are sent as an XML formatted file, but could be stored in a different format that allows for more flexibility in searching if necessary. Phase I also consists of developing and designing a dashboard front end to the tool that presents a visualization of key statistics and allows a user to perform searches over the report database.

Phase II consists of more robust development of the report analyzing tool and user front end. The front end should be cross platform or accessed via a web browser.

NIST will be available to act as subject matter experts in DMARC and Domain Name System (DNS) as needed. NIST would also be available to help test the developed algorithm or system as necessary.

References:

1. S. Kitterman. *Sender Policy Framework (SPF) for Authorizing Use of Domains in Email, Version 1*. RFC 2708. (April 2014).
2. E. Allman, J. Callas, M. Delany, M. Libby, J. Fenton and M. Thomas. *DomainKeys Identified Mail (DKIM) Signatures*. RFC 4870. (May 2007).
3. M. Kucherawy and E. Zwicky. *Domain-based Message Authentication, Reporting and Conformance (DMARC)*. Work in Progress. (Dec 2014).
4. Peterson, Alec. *How DMARC is Saving Email: The New Authentication Standard Putting an End to Email Abuse*. <http://www.messagesystems.com/pdf/message-systems-ebook-how-dmarc-is-saving-email.pdf> (2013).

9.03.04.77-R Improving Robustness and Security in Home Routers

The majority of small offices and homes connect to the Internet through a so-called small office/home office router (SOHO). These systems run their own embedded software and provide basic network services for a small network: both wireless and wired. This embedded software is usually proprietary to the manufacture, but open source SOHO router software exists [1][2]. These open source implementations often use (modified) well-known software packages to provide common network functions for a home network.

Recent security research has been focused on addressing vulnerabilities in embedded systems through penetration testing [3]. While very useful, penetration testing may not fully exercise all the individual components that are part of the router firmware. A more thorough testing of the open source components may be able to uncover and address issues like "Heartbleed" that compromised every system that relied on OpenSSL for Transport Layer Security (TLS) [4].

While there has been some recent research focused on assessing the vulnerabilities in SOHO routers [3], there has been little research or development focused on how SOHO routers could significantly improve the security posture of home networks. Customer premise / SOHO routers can serve as innovation platforms, implementing leading edge security services on behalf of the wide range of systems (e.g., computers, appliances, sensors) that they connect to the Internet. For example, a router can detect that a secure connection to a particular website or service is possible and proxy a secure connection to that site, even though the originating host did not choose to use a secure connection. In effect, acting as a Man-in-the-Middle (MITM), only this MITM improves overall security rather than launching attacks.

The new SOHO router capabilities of interest include:

- Ability to intercept and provide opportunistic encryption for protocols that can optionally use TLS (e.g. HTTP), but are instead operating in an insecure mode.
- Support of DANE (DNS-based Authentication of Named Entities) [5] techniques for discovery, retrieval and validation of keying material.
- Ability to act as a Domain Name System Security Extensions (DNSSEC) validating cache.
- Ability to utilize DNS privacy techniques such as query minimization.
- Full support of IPv6 [6] and HomeNet [7] router standards.
- Full support for current requirements [8] for customer edge routers.
- Ability to intercept traffic going to known malware sites to prevent data exfiltration and/or infected host systems from communicating with Command & Control sites.

The goal of the project is to design, develop and test a set of security tools that are part of the embedded system of a home router. These tools will allow the home router to act as a security proxy to protect insecure systems on a home network. The tools should have little or no necessary user bootstrap configuration but should be able to work without user action (although a user could alter the configuration if desired).

Phase I consists of identifying a suitable open source SOHO router implementation and performing a full security analysis of the candidate software. Any vulnerability discovered should be documented and reported as necessary (e.g. to the NIST National Vulnerability Database (NVD) if found to be a vulnerability to a widely used package). The second part would be to produce a plan on how to include new capabilities for new security services in home router firmware. A proof of concept version of code should be developed to insure

correctness and for testing, but does not need to necessarily be already part of the embedded software in the home router.

Phase II consists of more robust development of the code based on the architecture developed in Phase I. A new branch of the candidate open source router firmware should be used as the code base.

NIST will be available to act as subject matter experts in DNS, DNSSEC and DANE as needed. NIST would also be available to help set up testing and evaluation of any algorithm or finished code as necessary.

References:

1. OpenWrt, a Linux distribution for embedded devices: <https://openwrt.org/>.
2. DD-WRT, a Linux based alternative OpenSource firmware: <http://www.dd-wrt.com/site/index>.
3. Constantin, Lucian. *Fifteen New Vulnerabilities Reported During Router Hacking Contest* PC World. (Aug 12, 2014). <http://www.pcworld.com/article/2464300/fifteen-new-vulnerabilities-reported-during-router-hacking-contest.html>.
4. Wheeler, David. *How to Prevent the next Heartbleed*. (April 2014). <http://www.dwheeler.com/essays/heartbleed.html>.
5. Dane Status Pages, *DNS-based Authentication of Named Entities*: <https://tools.ietf.org/wg/dane/>.
6. Singh, H., et al. RFC6204 *Basic Requirements for IPv6 Customer Edge Routers* - <http://www.rfc-editor.org/rfc/rfc6204.txt> (April 2011).
7. *Home Networking (HomeNet) specifications*: <https://datatracker.ietf.org/wg/homenet/documents/>.
8. Woodyatt, J. RFC6092 *Recommended Simple Security Capabilities in Customer Premises Equipment (CPE) for Providing Residential IPv6 Internet Service*: <http://www.rfc-editor.org/rfc/rfc6092.txt> (2011).

9.04 Health Care and Bioscience

- 9.04.01.63-R Dual Pulse Continuum Laser Source for Time-Domain Coherent Raman Imaging**
Broadband Coherent Anti-Stokes Raman Scattering (BCARS) [1-5] offers noninvasive, label-free, three-dimensional chemical imaging of materials and biological systems. Single-frequency Coherent Anti-Stokes Raman Scattering (CARS) microscopy, introduced in 1999,

also offers 3D label-free imaging, but does not provide the chemical sensitivity that is so important in complex biological systems.

Discrimination of critical chemical composition changes in biological tissues (e.g. for diagnostics), and analysis of complex materials requires spectral data over a wide frequency range. Spectral range in the vibrational fingerprint region (500 cm^{-1} to 1800 cm^{-1}) offered by BCARS makes possible label-free imaging and the chemical sensitivity needed to fully characterize subtle changes in biological and material systems that are concomitant with processes of interest such as disease progress and cellular differentiation.

Recent innovations in experimental technique and improvements in data analysis have brought the possibility of widespread use of BCARS much closer. The new techniques developed by NIST are based on a “3-color” CARS signal generation mechanism that relies on intrapulse generation of vibrational coherence in the sample [6] that produces signals in the fingerprint spectral region with unprecedented strength and clarity. While this new approach is very powerful, it requires advanced performance from the laser system and significant complexity in the detection scheme. Commercialization of such a BCARS system is presently untenable due to the complexity of the laser sources and supporting apparatus.

In order to remove a crucial barrier to commercialization and wide dissemination of BCARS microscopy, proposals are invited for design studies of a user-friendly laser source for a time-domain coherent Raman spectroscopy instrument. The characteristics of the desired laser source are given below:

NIST seeks development of a laser that would produce two broadband laser pulses (bandwidth of $>3000 \text{ cm}^{-1}$) with spectral content between 930 nm and 1400 nm, with repetition rates that are mismatched by a precise and time-invariant offset. Highly stabilized dual-comb laser systems are available commercially, and are used for applications such as optical clocks, however they are very expensive, and use the wrong wavelengths for coherent Raman imaging. The system we propose would have relaxed specifications for absolute repetition rate, and could be manufactured at much lower cost than the commercially available comb lasers. Also, availability of such a laser would make performing BCARS microscopy quite straightforward.

The goals of the proposed work are to demonstrate feasibility for design and construction of a single turnkey laser source that would be suitable for time-domain coherent Raman spectroscopy, and to demonstrate its reliability.

Phase I activities and expected results: Design a dual-pulse laser source to have the following characteristics:

- Two trains of broadband, compressible laser pulses, each with repetition rate of approximately 500 -MHz, but with a fixed repetition rate mismatch 0.1 MHz, where each pulse train contains pulses that:

- Have > 3000 wavenumbers of spectral bandwidth between 930 nm and 1400 nm
 - Are compressible to near transform limit (< 10 fs)
 - Have average power of at least 150 mW
- Stability of the difference in repetition rates of the two pulse trains is better than 0.001 over a 1 hour time period

Demonstrate that individual components of the laser system can function independently

Phase II activities and expected results: Assemble and test the laser system for the following:

- Pulse compressibility
- Pulse power stability
- Repetition rate mismatch stability

NIST will be available for consultation on progress and performance.

References:

1. T. W. Kee and M. T. Cicerone, *Simple Approach to One-Laser, Broadband Coherent Anti-Stokes Raman Scattering Microscopy*, Opt. Lett. 29, 2701-2703. (2004).
2. Y. J. Lee, Y Liu, M. T. Cicerone, *Characterization of 3-Color CARS in a 2-Pulse Broadband CARS Spectrum*, Opt. Lett. 32, 3370-3372. (2007).
3. Y. J. Lee and M. T. Cicerone, *Vibrational Dephasing Time Imaging by Time-Resolved Broadband Coherent Anti-Stokes Raman Scattering Microscopy*, Appl. Phys. Lett. 92, 041108. (2008).
4. Y X Liu, Y J Lee and M T Cicerone, *Broadband CARS Spectral Phase Retrieval Using a Time-Domain Kramers-Kronig Transform*, Optics Letters 34:9, 1363-1365. (2009).
5. Sapun H Parekh, Young Jong Lee, Khaled A Aamer, and M.T. Cicerone, *Label-Free Cellular Imaging by Broadband Coherent Anti-Stokes Raman Scattering Microscopy*, Biophysical Journal 99:8, 2695-2704. (2010).
6. Camp, J. J., Lee, Y. J., Heddleston, J. M., Hartshorn, C. M., et al. *High-Speed Coherent Raman Fingerprint Imaging of Biological Tissues*, Nat Photon 8, 627-634. (2014).

9.05 Technology Transfer

9.05.01.40-TT NIST Tech Transfer

NIST has numerous technologies that require additional research and innovation to advance them to a commercial product. The goal of this SBIR subtopic is for small businesses to advance NIST technologies to the marketplace. The Technology Partnerships Office at NIST will provide the Awardee with a no-cost research license for the duration of the SBIR award. When the technology is ready for commercialization, a commercialization license will be negotiated with the Awardee.

Applications may be submitted for the development of any NIST-owned technology that is covered by a pending U.S. non-provisional patent application or by an issued U.S. patent. Available technologies can be found on the NISTTech website <http://tsapps.nist.gov/techtransfer/> and are identified as “available for licensing” under the heading “Status of Availability.” Some available technologies are described as only being available non-exclusively, meaning that other commercialization licenses may currently exist or it is a joint invention between NIST and another institution. More information about licensing NIST technologies is available at <http://www.nist.gov/tpo/Licensing.cfm>.

The technical portion of an application should include a technical description of the research that will be undertaken. Included in this technical portion of the application, the applicant should provide a brief description of a plan to manufacture the commercial product developed using the NIST technology. Absence of this manufacturing plan will result in the application being less competitive.

Appendix A. COVER SHEET

(A fillable version of the Cover Sheet is available at <http://www.nist.gov/sbir>)

Application to National Institute of Standards and Technology (NIST) Small Business Innovation Research (SBIR) Program 2016-NIST-SBIR-02 Cover Sheet			
Name of Submitting Firm		Click here to enter text.	
Subtopic Number	Click here to enter text.	Project Title	Click here to enter text.
Principal Investigator (PI) Name	Click here to enter text.		PI Title Click here to enter text.
PI Phone #	Click here to enter text.	PI E-mail	Click here to enter text.
NIST may verify the following responses with information provided elsewhere in your application or by independent sources.			
THE APPLICANT CERTIFIES THAT:			
1. It is a small business concern (SBC) and meets the definition as stated in this Federal Funding Opportunity (FFO).		<input type="checkbox"/> Yes <input type="checkbox"/> No	
2. The primary employment of the PI will be with the SBC at the time of award and during the conduct of research.		<input type="checkbox"/> Yes <input type="checkbox"/> No	
3. A minimum of either two-thirds for Phase I or one-half for Phase II of the research will be performed by the SBC as determined by data provided in the Budget Narrative. See FFO Section 1.03 for details on funding determination.		<input type="checkbox"/> Yes <input type="checkbox"/> No	
4. The applicant and/or PI <input type="checkbox"/> has / <input type="checkbox"/> has not submitted applications for essentially equivalent work under other Federal program FFOs and <input type="checkbox"/> has / <input type="checkbox"/> has not received other Federal awards for essentially equivalent work. If "has", what agency? Click here to enter text.			
See FFO Section 3.02.02(13) (Phase I) for additional details that must be provided.			
THE FOLLOWING ITEMS ARE FOR STATISTICAL PURPOSES:			
5. The applicant qualifies as a socially and economically disadvantaged SBC and meets the definition as stated in this FFO.		<input type="checkbox"/> Yes <input type="checkbox"/> No	
6. The applicant qualifies as a woman-owned SBC and meets the definition as stated in this FFO.		<input type="checkbox"/> Yes <input type="checkbox"/> No	
7. The applicant qualifies as a HUBZone-owned SBC and meets the SBA's definition (see http://www.sba.gov/hubzone).		<input type="checkbox"/> Yes <input type="checkbox"/> No	
8. The applicant qualifies as a veteran-owned SBC.		<input type="checkbox"/> Yes <input type="checkbox"/> No	
The applicant qualifies as a service-disabled veteran-owned SBC.		<input type="checkbox"/> Yes <input type="checkbox"/> No	
9. Year SBC founded:		Click here to enter text.	
10. Number of Employees:		Click here to enter text.	
STATEMENTS:			

<p>11. The applicant will permit the Government to disclose contact information if this application does not result in an award, to appropriate local and State-level economic development organizations that may be interested in contacting you for further information.</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> No</p>
<p>12. The applicant authorizes contact information and project title to be provided to the NIST Manufacturing Extension Partnership (MEP) after awards have been announced. If 'Yes' your contact information will be provided to NIST MEP. If so, you will be contacted by your local MEP to explore business-related support services that could benefit the potential of the project you proposed.</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> No</p>
<p>TECHNICAL ABSTRACT (limit to 200 words):</p>	
<p>Click here to enter text.</p>	
<p>POTENTIAL COMMERCIAL APPLICATION OF THE RESEARCH: (limit to 100 words)</p>	
<p>Click here to enter text.</p>	
<p>OTHER INFORMATION:</p>	
<p>Information contained in unsuccessful applications will remain the property of the applicant. The government may, however, retain copies of all applications. Public release of information in any application submitted will be subject to existing statutory and regulatory requirements.</p> <p>Applicants are discouraged from submitting proprietary information unless the information is deemed essential for proper evaluation of the application. If proprietary information provided by an applicant in an application constitutes trade secret, proprietary commercial or financial information, confidential personal information, or data affecting national security, it will be treated in confidence to the extent permitted by law. This information must be clearly marked by the applicant with the term 'confidential proprietary information' and the following legend must appear in this section of the application.</p> <p>PROPRIETARY NOTICE</p> <p>"These data shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part for any purpose other than evaluation of this proposal. If a funding agreement is awarded to this applicant as a result of or in connection with the submission of these data, the Government shall have the right to duplicate, use, or disclose the data to the extent provided in the funding agreement and pursuant to applicable law. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data subject to this restriction are contained on pages _____ of this proposal."</p> <p>The use of any other legend is unacceptable to the Government and may constitute grounds for removing the application from further consideration without assuming any liability for inadvertent disclosure.</p> <p>OMB Control No. 0693-0072</p> <p>Expiration Date: 10/31/2017</p>	

Appendix B. CERTIFICATIONS

SBIR Funding Agreement Certification (at time of award)

All small businesses that are selected for award of an SBIR funding agreement must complete this certification at the time of award and any other time set forth in the funding agreement that is prior to performance of work under this award. This includes checking all of the boxes and having an authorized officer of the awardee sign and date the certification each time it is requested.

Please read carefully the following certification statements. The Federal government relies on the information to determine whether the business is eligible for a Small Business Innovation

Research (SBIR) Program award. A similar certification will be used to ensure continued compliance with specific program requirements during the life of the funding agreement. The definitions for the terms used in this certification are set forth in the Small Business Act, SBA regulations (13 C.F.R. Part 121), the SBIR Policy Directive and also any statutory and regulatory provisions referenced in those authorities.

If the funding agreement officer believes that the business may not meet certain eligibility requirements at the time of award, they are required to file a size protest with the U.S. Small Business Administration (SBA), who will determine eligibility. At that time, SBA will request further clarification and supporting documentation in order to assist in the verification of any of the information provided as part of a protest. If the funding agreement officer believes, after award, that the business is not meeting certain funding agreement requirements, the agency may request further clarification and supporting documentation in order to assist in the verification of any of the information provided.

Even if correct information has been included in other materials submitted to the Federal government, any action taken with respect to this certification does not affect the Government's right to pursue criminal, civil or administrative remedies for incorrect or incomplete information given in the certification. Each person signing this certification may be prosecuted if they have provided false information.

The undersigned has reviewed, verified and certifies that (all questions must be responded to by checking the appropriate box):

(1) The business concern meets the ownership and control requirements set forth in 13 C.F.R. § 121.702.

Yes No

(2) If a corporation, all corporate documents (articles of incorporation and any amendments, articles of conversion, by-laws and amendments, shareholder meeting minutes showing officer elections, organizational meeting minutes, all issued stock certificates, stock ledger, buy-sell agreements, stock transfer agreements, voting agreements, and documents relating to stock

options, including the right to convert non-voting stock or debentures into voting stock) evidence that it meets the ownership and control requirements set forth in 13 C.F.R. § 121.702.

Yes No N/A Explain why N/A:

(3) If a partnership, the partnership agreement evidences that it meets the ownership and control requirements set forth in 13 C.F.R. § 121.702.

Yes No N/A Explain why N/A:

(4) If a limited liability company, the articles of organization and any amendments, and operating agreement and amendments, evidence that it meets the ownership and control requirements set forth in 13 C.F.R. § 121.702.

Yes No N/A Explain why N/A:

(5) The birth certificates, naturalization papers, or passports show that any individuals it relies upon to meet the eligibility requirements are U.S. citizens or permanent resident aliens in the United States.

Yes No N/A Explain why N/A:

(6) It has no more than 500 employees, including the employees of its affiliates.

Yes No

(7) SBA has not issued a size determination currently in effect finding that this business concern exceeds the 500 employee size standard.

Yes No

(8) During the performance of the award, the principal investigator will spend more than one half of his/her time as an employee of the awardee or has requested and received a written deviation from this requirement from the funding agreement officer.

Yes No Deviation approved in writing by funding agreement officer: _____ %

(9) All, essentially equivalent work, or a portion of the work proposed under this project (check the applicable line):

Has not been submitted for funding by another Federal agency.

Has been submitted for funding by another Federal agency but has not been funded under any other Federal grant, contract, subcontract or other transaction.

A portion has been funded by another grant, contract, or subcontract as described in detail in the application and approved in writing by the funding agreement officer.

(10) During the performance of award, it will perform the applicable percentage of work unless a deviation from this requirement is approved in writing by the funding agreement officer (check the applicable line and fill in if needed):

- SBIR Phase I: at least two-thirds (66 2/3%) of the research.
 SBIR Phase II: at least half (50%) of the research.
 Deviation approved in writing by the funding agreement officer: _____ %

(11) During performance of award, the research/research and development will be performed in the United States unless a deviation is approved in writing by the funding agreement officer.

- Yes No Waiver has been granted

(12) During performance of award, the research/research and development will be performed at my facilities with my employees, except as otherwise indicated in the SBIR application and approved in the funding agreement.

- Yes No

(13) It has registered itself on SBA's database as majority-owned by venture capital operating companies, hedge funds or private equity firms.

- Yes No N/A Explain why N/A:
-

(14) It is a Covered Small Business Concern (a small business concern that:

(a) was not majority-owned by multiple venture capital operating companies (VCOCs), hedge funds, or private equity firms on the date on which it submitted an application in response to an SBIR FFO; and (b) on the date of the SBIR award, which is made more than 9 months after the closing date of the FFO, is majority-owned by multiple venture capital operating companies, hedge funds, or private equity firms).

- Yes No

It will notify the Federal agency immediately if all or a portion of the work proposed is subsequently funded by another Federal agency.

I understand that the information submitted may be given to Federal, State and local agencies for determining violations of law and other purposes.

I am an officer of the business concern authorized to represent it and sign this certification on its behalf. By signing this certification, I am representing on my own behalf, and on behalf of the business concern that the information provided in this certification, the application, and all other information submitted in connection with this application, is true and correct as of the date of submission. I acknowledge that any intentional or negligent misrepresentation of the information contained in this certification may result in criminal, civil or administrative sanctions, including but not limited to: (1) fines, restitution and/or imprisonment under 18 U.S.C. § 1001; (2) treble damages and civil penalties under the False Claims Act (31 U.S.C.

§ 3729 *et seq.*); (3) double damages and civil penalties under the Program Fraud Civil Remedies Act (31 U.S.C. § 3801 *et seq.*); (4) civil recovery of award funds, (5) suspension and/or debarment from all Federal procurement and nonprocurement transactions (FAR Subpart 9.4 or 2 C.F.R. Part 180); and (6) other administrative penalties including termination of SBIR/STTR awards.

Signature _____ **Date** ___/___/___

Print Name (First, Middle, Last)

Title

Business Name

—

SBIR Funding Agreement Certification (Life-Cycle Certification)

All SBIR Phase I and Phase II awardees must complete this certification at all times set forth in the funding agreement (see §8(h) of the SBIR Policy Directive). This includes checking all of the boxes and having an authorized officer of the awardee sign and date the certification each time it is requested.

Please read carefully the following certification statements. The Federal government relies on the information to ensure compliance with specific program requirements during the life of the funding agreement. The definitions for the terms used in this certification are set forth in the Small Business Act, the SBIR Policy Directive, and also any statutory and regulatory provisions referenced in those authorities.

If the funding agreement officer believes that the business is not meeting certain funding agreement requirements, the agency may request further clarification and supporting documentation in order to assist in the verification of any of the information provided.

Even if correct information has been included in other materials submitted to the Federal government, any action taken with respect to this certification does not affect the Government's right to pursue criminal, civil, or administrative remedies for incorrect or incomplete information given in the certification. Each person signing this certification may be prosecuted if they have provided false information.

The undersigned has reviewed, verified and certifies that (all boxes must be checked):

(1) The principal investigator spent more than one half of his/her time as an employee of the awardee or the awardee has requested and received a written deviation from this requirement from the funding officer.

Yes No Deviation approved in writing by funding agreement officer: _____ %

(2) All, essentially equivalent work, or a portion of the work performed under this project (check applicable line):

Has not been submitted for funding by another Federal agency.

Has been submitted for funding by another Federal agency but has not been funded under any other Federal grant, contract, subcontract or other transaction.

A portion has been funded by another grant, contract, or subcontract as described in detail in the application and approved in writing by the funding agreement officer.

(3) Upon completion of the award it will have performed the applicable percentage or work, unless a deviation from this requirement is approved in writing by the funding agreement officer (check the applicable line and fill in if needed):

SBIR Phase I: at least two-thirds (66 2/3%) of the research.

SBIR Phase II: at least half (50%) of the research.

Deviation approved in writing by the funding agreement officer: _____ %

(4) The work is completed and it has performed the applicable percentage of work, unless a deviation from this requirement is approved in writing by the funding agreement officer (check the applicable line and fill in if needed):

- SBIR Phase I: at least two-thirds (66 2/3%) of the research.
- SBIR Phase II: at least half (50%) of the research.
- Deviation approved in writing by the funding agreement officer: _____ %
- N/A because work is not completed.

(5) The research/research and development is performed in the United States unless a deviation is approved in writing by the funding agreement officer.

- Yes
- No
- Waiver has been granted

(6) The research/research and development is performed at my facilities with my employees, except as otherwise indicated in the SBIR application and approved in the funding agreement.

- Yes
- No

It will notify the Federal agency immediately if all or a portion of the work authorized and funded under this award is subsequently funded by another Federal agency.

I understand that the information submitted may be given to Federal, State and local agencies for determining violations of law and other purposes.

I am an officer of the business concern authorized to represent it and sign this certification on its behalf. By signing this certification, I am representing on my own behalf, and on behalf of the business concern, that the information provided in this certification, the application, and all other information submitted in connection with the award, is true and correct as the date of submission. I acknowledge that any intentional or negligent misrepresentation of the information contained in this certification may result in criminal, civil or administrative sanctions, including but not limited to: (1) fines, restitution and/or imprisonment under 18 U.S.C. § 1001; (2) treble damages and civil penalties under the False Claims Act (31 U.S.C. § 3729 *et seq.*); (3) double damages and civil penalties under the Program Fraud Civil Remedies Act (31 U.S.C. § 3801 *et seq.*); (4) civil recovery of award funds, (5) suspension and/or debarment from all Federal procurement and nonprocurement transactions (FAR Subpart 9.4 or 2 C.F.R. Part 180); and (6) other administrative penalties including termination of SBIR/STTR awards.

Signature _____ **Date** ___ / ___ / ___

Print Name (First, Middle, Last)

Title

Business Name
