



FY 2014

**Small Business Innovation Research
(SBIR) Program**

Federal Funding Opportunity (FFO)

ANNOUNCEMENT

FUNDING OPPORTUNITY NUMBER: 2014-NIST-SBIR-01

Catalog of Federal Domestic Assistance (CFDA) Number: 11.620, Science,
Technology, Business and/or Education Outreach

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

Opening Date: February 19, 2014

Closing Date: May 2, 2014

PROGRAM FFO AVAILABLE IN ELECTRONIC FORM ONLY

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

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**US DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
FY 2014 SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
FEDERAL FUNDING OPPORTUNITY (FFO)**

1.0 PROGRAM DESCRIPTION

1.01 Introduction

The National Institute of Standards and Technology (NIST) invites small businesses to submit Phase I research applications under this Federal Funding Opportunity (FFO). Firms with strong research capabilities in any of the areas listed in Section 9 of this FFO are encouraged to participate. Applications not addressing one of the subtopics in Section 9 are not responsive to this FFO.

The 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 objectives of the SBIR program are to: stimulate technological innovation in the private sector, strengthen the role of small business in meeting Federal R&D needs, foster and encourage participation by socially and economically disadvantaged persons and women-owned small business concerns in technological innovation, and increase private sector commercialization of innovations derived from federal research and development. The NIST FY 2014 Small Business Innovation Research (SBIR) Program identifies and solicits applications in subtopics 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 NIST SBIR program and our laboratory research program, the SBIR topics are the investment priorities areas identified in the NIST Programmatic Plan available at: <http://www.nist.gov/director/planning/planning.cfm>.

NIST offers two types of Subtopics in Section 9 of this FFO: standard research "R" and tech transfer "TT" Subtopics. Both "R" and "TT" subtopics 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, NIST took into consideration Executive Order (EO) 13329 (<http://www.gpo.gov/fdsys/pkg/FR-2004-02-26/pdf/04-4436.pdf>) "Encouraging Innovation in Manufacturing" and The Energy Independence and Security Act of 2007 (P.L. 110-140) to give high priority to small business concerns that participate in or conduct energy efficiency or renewable energy system R&D projects, and the [SBA Policy Directive](#).

1.01.01 NIST SBIR “R” Subtopics

Subtopics with the “R” designation address the objective of stimulating small business innovation in areas that meet NIST’s programmatic goals. The “R” subtopics are designed to give small, high tech companies opportunities to propose cutting-edge innovations that meet NIST’s technological needs and at the same time have market potential beyond NIST.

1.01.02 NIST SBIR “TT” Subtopic

The TT subtopic (9.05.01.40-TT) addresses the objective of increasing the commercial application of innovations derived from Federal R&D. The subtopic identifies commercially promising NIST-derived technologies. While NIST Laboratory scientists conduct breakthrough research that leads to innovations, NIST’s efforts do not extend to product development. The remaining work needed to develop NIST technologies for the marketplace requires innovation from the private sector.

These technologies are either dedicated to the public domain or are patent-protected. If there is no patent or patent application cited, the technology is freely available for use without the need for any license. If the technology cites a patent or patent application, the use of that background invention during the course of the SBIR project requires a patent license. Any application responding to the TT subtopic and requiring a license must include a license application (<http://www.nist.gov/tpo/sbir/upload/NonExclusiveRoyaltyFreePatentLicenseSBIR.pdf>) with the application (not counted toward the application page limitation).

SBIR awards resulting from the TT subtopic will include, as necessary, the grant of a non-exclusive research license to use the NIST-owned patented background inventions specifically identified within the “TT” subtopic being awarded. 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 will be granted until an SBIR awardee applies for, negotiates and receives such a license. Awardees with agreements for technologies that identify specific 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 CFR 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 potentially develop a commercially viable product based on the NIST patent.

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 Small Business Administration (SBA) through the [SBIR Policy Directive](#).

The funding vehicles for NIST's SBIR program in both Phase I and Phase II are cooperative agreements. NIST's authority to implement its SBIR program through cooperative agreements is 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://www.osec.doc.gov/oam/grants_management/policy/documents/FINAL%20Master%20DOC%20Grants%20Manual%202013%20\(03.01.13\)_b.pdf](http://www.osec.doc.gov/oam/grants_management/policy/documents/FINAL%20Master%20DOC%20Grants%20Manual%202013%20(03.01.13)_b.pdf). Grants and agreements administration requirements at 15 C.F.R. Part 14 will apply to NIST SBIR awards to the extent consistent with SBIR requirements.

1.02.01 Phase I - Feasibility Research

The purpose of Phase I is 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 research, a prerequisite to further support in Phase II. Each NIST Phase I award is for up to \$90,000 and up to a 6-month period of performance with one additional month allowed for completion of the Final Report.

1.02.02 Phase II - Research and Development

Organizations that receive Phase I awards under this FFO will be given the opportunity to submit a Phase II application following completion of Phase I. Instructions for Phase II application preparation and submission requirements will be provided to Phase I awardees toward the end of the Phase I period of performance. Phase II applicants will be required to provide information for the SBA Tech-Net Database System when advised that this system can accept their input and are requested to voluntarily update the information in the database annually thereafter for a minimum period of five years.

Phase II is the R&D or prototype development phase. To apply for a Phase II award, each Phase I awardee will be 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 the Phase II R&D activity, the awardee shall be required to report on its commercialization activities.

1.02.03 Phase III - Commercialization

In Phase III, it is intended that non-SBIR capital be used by the small business to pursue commercial applications of Phase II. SBIR funds are not available for Phase III.

1.03 SBIR Applicant Eligibility and Limitations

Each applicant for both Phase I and Phase II must qualify as a small business concern for research or R&D (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 with the small business. Primary employment with a small business precludes full-time employment with another organization. Occasionally, deviations from this requirement may occur, and must be approved in writing by the NIST Grants Officer after consultation with the SBIR Program Manager. Further, a small business may replace the principal investigator on an SBIR Phase I or Phase II award, subject to approval in writing by the NIST Grants Officer. Personnel obtained through a Professional Employer Organization or other similar personnel leasing company may be considered employees of the awardee.

For both Phase I and Phase II, the R/R&D work must be performed in the United States. However, based on a rare and unique circumstance, for example, a supply or material or other item or project requirement that is not available in the United States, NIST may allow that particular portion of the R/R&D work to be performed or obtained in a country outside of the United States. Approval in writing by the NIST Grants Officer after consultation with NIST SBIR Program Manager for each such specific condition must be obtained before such R/R&D work may begin.

NIST elects 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. Applications submitted for work to be performed by these types of parties will not be considered for award.

For Phase I, a minimum of two-thirds of the research and/or analytical effort must be performed by the awardee. For Phase II, a minimum of one-half of the research and/or analytical effort must be performed by the awardee. For both Phases, the proportion of effort is determined by the funds listed in labor categories on the SF-424A and the Budget Narrative.

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 CRADA with the awardee. NIST will consider this issue on a case by case basis.

1.04 Performance Benchmarks

In accordance with guidance from the SBA, the NIST SBIR Program is implementing the following two performance benchmarks (available at <http://www.sbir.gov/about/about->

[sbir#embedded_flash_111707621](#) and updated at <http://www.gpo.gov/fdsys/pkg/FR-2014-01-08/pdf/2013-31374.pdf>). The purpose of these benchmark requirements is to ensure that Phase I applicants that have won multiple prior SBIR/STTR awards are making progress towards commercializing the work done under those awards.

Phase I to Phase II Transition Benchmark

The Phase I to Phase II Transition Rate requirement applies only to SBIR and STTR Phase I applicants that have received more than 20 Phase I awards over the past 5 fiscal years, excluding the most recent year. For these companies, the benchmark establishes a minimum number of Phase II awards the company must have received for a given number of Phase I awards received during the 5-year time period in order to be eligible to receive a new Phase I award. This requirement does not apply to companies that have received 20 or fewer Phase I awards over the 5-year period.

The transition rate requirement is that the applicant must have received an average of one Phase II for every four Phase I awards received during the 5-year time period to be eligible for a new Phase I award. The Phase II transition rate is calculated as the total number of SBIR and STTR Phase II awards a company received during the past 5 fiscal years divided by the total number of SBIR and STTR Phase I awards it received during the past 5 fiscal years excluding the most recently-completed year. The benchmark minimum transition rate is 0.25.

Commercialization Benchmark

The Commercialization Benchmark requirement applies to SBIR and STTR Phase I applicants that have received more than 15 Phase II awards over the past 10 fiscal years, excluding the last two years. When effective, the benchmark establishes the minimum required levels of commercialization activity resulting from past Phase II work in order for an awardee to be eligible to receive a new Phase I award. This requirement does not apply to companies that have received 15 or fewer Phase II awards over the 10-year period.

The commercialization rate requirement is that the applicant must have received to date an average of at least \$100,000 of sales and/or investments per Phase II award received, **or** have received a number of patents resulting from the SBIR work equal to or greater than 15% of the number of Phase II awards received during the period.

SBA calculates individual company transition and commercialization rates using SBIR and STTR award information across all federal agencies. SBA will identify, on June 1 of each year, the companies that fail to meet either of these benchmarks. These companies will not be eligible to receive a Phase I award for a period of one year from that date. SBA will notify the companies and the relevant officials at the participating agencies.

Applicants to this FFO that have received more than 20 Phase I awards over the past 5 years and/or more than 15 Phase II awards over the past 10 years across all federal SBIR/STTR agencies should, prior to application preparation, verify that their company's transition and commercialization rates on the Company Registry at [SBIR.gov](http://www.sbir.gov) meets or exceeds the minimum benchmarks. If a company believes that the information used was not complete or accurate, it may provide feedback through the Company Registry at www.sbir.gov. SBA accepts requests for reconsideration of the eligibility determination from April 1st through April 30th of each year. Additional information on the Transition and Commercialization benchmarks is available at [SBIR.gov](http://www.sbir.gov).

1.05 Contact with NIST

In the interest of competitive fairness, all oral or written communication with NIST concerning a specific technical topic or subtopic during the open FFO period is strictly prohibited - with the exception of the public Question and Answer site located at <http://www.nist.gov/sbir>. Applicants may also 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. Questions will be submitted through the aforementioned NIST SBIR website, and all responses will be publicly, though anonymously, posted on the web site accordingly. Questions and answers will not be accepted, or posted on Grants.gov.

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
Electronic application submission	Christopher Hunton Phone: (301) 975-5718 Fax: (301) 975-8884 E-mail: christopher.hunton@nist.gov or Grants.gov Phone: 800-518-4726 E-mail: support@grants.gov
Grants rules and regulations	Calvin Mitchell Phone: 301-975-4585 Fax: 301-975-8884 E-mail: calvin.mitchell@nist.gov

1.06 Definitions

Except as noted below, all definitions are excerpted from the [SBA SBIR Policy Directive](#),

available at http://sbir.gov/sites/default/files/sbir_pd_with_1-8-14_amendments.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.

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.

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.

Contract – A procurement contract under an award or subaward, and a procurement subcontract under a recipient's or subrecipient's contract. See 15 CFR 14.2(i).

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 CFR 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 SBC 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 CFR 121.702 (available at <http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr;sid=03878acee7c064a02cac0d870e00ef43;rgn=div8>).

Socially and Economically Disadvantaged SBC (SDB) - See 13 CFR part 124, Subpart B.

Socially and Economically Disadvantaged Individual - See 13 CFR 124.103 and 124.104.

Subaward – See 15 C.F.R. 14.2(ii), (iii), and 14.5, and OMB Circular A-133, Subpart B.210, Subrecipient and vendor determinations.

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.

1.07 Fraud, Waste and Abuse

As defined in the SBA Policy Directive 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 Certification of Size, Ownership, and SBIR Program Requirements

As required by the SBIR/STTR Reauthorization Act of 2011, 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. The SBIR Funding Agreement Certification and the SBIR Funding Agreement Certification – Life-Cycle Certification are provided in Appendix A of this FFO.

2.02 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. The SBIR Policy Directive requires each SBC applying for a Phase I or Phase II

award to register in the Company Registry prior to submitting an application. The SBC will save its information from the registration in a .pdf document and append this document to last page of the Technical Proposal. **This page will not count towards the 25 page limit.** All applicants are required to report and/or update ownership information to SBA prior to each SBIR application submission or if any information changes prior to award.

2.03 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 involving human subjects, including software testing, must meet the requirements of the Common Rule for the Protection of Human Subjects ("Common Rule"), codified for the Department of Commerce (DoC) at 15 C.F.R. Part 27. In addition, any such application that includes research activities on these topics must be in compliance with any statutory requirements imposed upon the Department of Health and Human Services (DHHS) and other Federal agencies regarding these topics, all regulatory 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 these topics.

NIST reserves the right to make an independent determination of whether an applicant's research activities involve human subjects. NIST policy also requires a NIST administrative review for research involving human subjects approved by a non-NIST Institutional Review Board (IRB). (15 C.F.R. § 27.112 Review by Institution.) If NIST determines that your application involves human subjects, you will be required to provide additional information for review and approval. If an award is issued, no research activities involving human subjects shall be initiated or costs incurred under the award until the NIST Grants Officer issues written approval. Retroactive approvals are not permitted.

NIST will accept applications that include exempt and non-exempt human subjects research activities. 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, if the application is funded. Non-exempt human subjects research activities by either domestic or foreign organizations 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 possessing a currently valid Federal wide Assurance (FWA) on file from OHRP. Information regarding how to apply for an FWA and register and 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.

The applicant should clearly indicate in the application, by separable task, all research activities believed to be exempt or non-exempt research involving human subjects and the

expected institution(s) where the research activities involving human subjects may be conducted.

If an activity/task involves data obtained through intervention or interaction with living individuals or identifiable private information obtained from or about living individuals but the applicant participant(s) believes that the activity/task is not research as defined under the Common Rule, the following may be requested for that activity/task:

Justification, including the rationale for the determination and in some cases additional documentation, to support a determination that the activity/task in the application is not research as defined under the Common Rule. See 15 C.F.R. § 27.102. This may result in a NIST determination. If the applicant participant(s) uses a cognizant IRB that provides an IRB approval, a copy of that IRB approval documentation will be required by NIST. The applicant participant(s) is not required to establish a relationship with a cognizant IRB if they do not have one, but if the applicant participant(s) has a cognizant IRB that requires review of the activity/task, or the applicant participant(s) elects to obtain IRB review, a copy of the IRB approval documentation will be required by NIST.

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). The name(s) of the institution(s) where the exempt research will be conducted; and/or from which biological materials, or data from human subjects will be provided.

- a. A copy of the protocol of 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).
- b. 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.
- c. Any additional clarifying documentation that NIST may request during the review process in order to make a determination that the activity or use of biological materials or data from human subjects is exempt under the Common Rule (see 15 C.F.R. § 27.101).

If the application appears to NIST to include research activities (exempt or non-exempt) involving human subjects, and the performer of the activity has a cognizant IRB, 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 FWAs or IRB registrations are being applied for, that should be clearly stated.

Additional documentation may be requested by NIST for performers with a cognizant IRB during review of the application, and may include the following for research activities involving human subjects that are planned in the first year of the award:

- (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 may be requested;
- (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.)

2.04 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 be in compliance with 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. In addition, such applications must meet the requirements of the Animal Welfare Act (7 U.S.C. § 2131 et seq.), 9 C.F.R. Parts 1, 2, and 3, and if appropriate, 21 C.F.R. Part 58. These regulations 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 sample collection. NIST does require 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.

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.

NIST reserves the right to make an independent determination of whether an applicant's research activities involve live vertebrate animals or custom samples from live vertebrate animals. If NIST determines that the application includes research activities or custom samples involving live vertebrate animals, you will be required to provide additional information for review and approval. If an award is issued, no research activities involving live vertebrate animals subjects shall be initiated or costs incurred under the award until the NIST Grants Officer issues written approval.

If the applicant's application appears to include research activities or custom sample collections involving live vertebrate animals the following information may be requested during the application review process:

- (1) The name(s) of the institution(s) where the animal research 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 (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.

Additional documentation may be requested by NIST during review of the application and may include the following for research activities and/or custom sample collections involving live vertebrate animals that are planned in the first year of the award:

- (1) A signed (by the principal investigator) copy of the IACUC approved Animal Study Application (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 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.

For more information regarding human subjects or research projects involving live vertebrate animals, contact Linda Beth Schilling, Senior Coordinator and Policy Advisor for Human & Animal Subjects Research at NIST (e-mail: linda.schilling@nist.gov; phone: 301-975-2887).

2.05 DoC Representation by Corporations Regarding an Unpaid Delinquent Tax Liability or a Felony Conviction Under Any Federal Law

In accordance with the Federal appropriations law expected to be in effect at the time of project funding, NIST anticipates that the selected applicants will be provided a form and asked to make a representation regarding any unpaid delinquent tax liability or felony conviction under any Federal law.

3.0 APPLICATION PREPARATION INSTRUCTIONS AND REQUIREMENTS

3.01 Application Requirements

NIST reserves the right to not submit to technical review any application which it determines has insufficient scientific and technical information, or one which fails to comply with the administrative procedures as outlined on the Checklist of Requirements in Section 8.02. Applications that do not successfully pass the screening criteria given in Section 4.02 will be returned to the applicant without further consideration. The applicant 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.

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. The application will be peer reviewed as a scientific paper.

All units of measurement should be presented in metric units.

The application must not only be responsive to the specific NIST program interests described in Section 9 of the FFO, but also serve as the basis for technological innovation leading to new commercial products, processes, or services that benefit the public. An applicant may submit applications on multiple subtopics or multiple applications on one subtopic under this FFO. When the proposed innovation applies to more than one subtopic, the applicant must submit its application under the subtopic that is most relevant to the applicant's technical concept.

3.02 Phase I Application

A complete application must include a Technical Proposal and additional forms and documents, as described below.

For the Technical Proposal (see Section 8.01.(6) of this FFO):

- (a) Key Information (3.02.01) pages 1 and 2,
- (b) Technical Content (3.02.02) pages 3 through 25, and
- (c) SBA Company Registry document (3.02.03) last page of the Technical Proposal, – not included in the 25 page count.

Additional forms and documents needed to complete the application are described in Section 8.01 of this FFO.

The additional required forms and documents in Section 8.01 are not included in the 25 page count. See Section 6.0 for information on the submission of applications in response to this FFO.

3.02.01 Key Information

1. Agency, Funding Application Number, Subtopic Number and Title
2. Project Title
3. Name, Title, and Contact Information (address, phone, and email) of the Principal Investigator
4. Abstract and Commercial Potential:
The applicant must provide 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](https://www.nist.gov/sbir) and www.sbir.gov and, therefore, must not contain proprietary information.
5. Certifications:
Does the applicant certify that it is a small business concern (SBC) and meets the definition as stated in this FFO?

Will the primary employment of the principal investigator be with the SBC at the time of award and during the conduct of research?

Will a minimum of two-thirds of the research be performed by the SBC in Phase I?

The applicant and/or principal investigator (**choose one:** “has” or “has not”) submitted applications for essentially equivalent work under other Federal program FFOs and (**choose one:** “has” or “has not”) received other Federal awards for essentially equivalent work? If yes, what agency? If “has”, see 3.02.02 Technical Content (13) Similar Application or Awards for additional details that must be provided.

6. The following items are for statistical purposes:

Does the applicant qualify as a socially and economically disadvantaged SBC and meet the definition as stated in this FFO?

Does the applicant qualify as a woman-owned SBC and meet the definition as stated in this FFO?

Does the applicant qualify as a HUBZone-owned SBC and meet the definition as stated in this FFO? (See <http://www.sba.gov/hubzone/> for additional information about the SBA’s HUBZone program.)

Does the applicant qualify as veteran-owned SBC?

Does the applicant qualify as a service-disabled veteran-owned SBC?

Year SBC founded.

Number of employees.

7. Statements:

Will the applicant permit the Government to disclose contact information if your 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?

Does the applicant authorize contact information and project title to be provided to the NIST Manufacturing Extension Partnership Program after awards have been announced? If ‘Yes,’ your contact information will be provided to NIST Hollings Manufacturing Extension Partnership (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.

8. Legend for Proprietary Information:

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.

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 a 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:

“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 application. 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 application.”

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.

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. Show how it applies to a specific subtopic in Section 9.

(2) Phase I Technical Objectives. State the specific objectives of the Phase I effort, including the technical questions it will try to answer, to determine the feasibility of the proposed approach.

(3) Phase I Work Plan. Include a detailed description of the Phase I feasibility research 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 I, including their related education, experience, and publications. Where vitae are extensive, summaries that focus on the most relevant experience and publications are desired and may be necessary to meet application size limitations. List all other commitments that key personnel have during the proposed period of performance.

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

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

(8) Consultants, Contracts, and Subawards. The purpose of this section is to show that: research assistance from outside the firm materially benefits the proposed effort, and arrangements for such assistance are in place at time of application submission.

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 1/3 of the research and/or analytical effort in Phase I, per Section 1.03.

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. This statement is part of the page count.

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. This letter is part of the page count.

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. In this situation, a "subaward" relationship fits the circumstances more appropriately than a contract for providing goods or services. See 15 C.F.R. 14.2(ii), (iii), and 14.5, and OMB Circular A-133, Subpart B.210, Subrecipient and vendor determinations.

The 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. This letter is part of the page count.

(9) Potential Commercial Application. Describe in detail the commercial potential of the proposed research, how commercialization would be pursued and potentially used by the private sector and/or the Federal Government. Address the following:

(a) Market opportunity – Describe the current and anticipated target market, the size of the market, and include a brief profile of the potential customer.

(b) Technology and competition – Describe the competitive landscape, the value proposition and competitive advantage of the product or service enabled by the proposed innovation. Also include what critical milestones must be met to get the product or process to market and the resources required to address the business opportunity.

(c) Finances – Describe your strategy for financing the innovation.

(10) 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 NIST CRADA with the awardee. NIST will consider this issue on a case by case basis.

(11) 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.

(12) Cost Sharing. Cost sharing is not required.

(13) 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 funding agreements requiring essentially equivalent work.** 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 so provide the following information:

(a) Names and address 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.

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

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

(14) Prior SBIR Phase II Awards. If the SBC has received more than 15 Phase II awards in the prior 5 fiscal years, the SBC must submit in its Phase I application: name of the awarding agency; date of award; funding agreement number; amount of award; topic or subtopic title; follow-on agreement amount; source and date of commitment; and current commercialization status for each Phase II award. This required application information will not be counted toward the Technical Proposal pages limitation.

3.02.03 SBA Company Registry Document (see Section 2.02)

4.0 METHOD OF SELECTION AND EVALUATION CRITERIA

4.01 Introduction

All Phase I and Phase II applications will be evaluated and judged on a competitive basis. 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 to determine the most promising technical and scientific approaches. 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 proposed approaches to the same topic or subtopic.

4.02 Phase I Screening Criteria

Phase I applications that do not satisfy all the screening criteria shall be returned to the applicant without further review and will be eliminated from consideration for award (see

Section 8.02.(8) of this FFO). The screening criteria are:

- (a) The proposing firm must qualify as eligible according to the criteria provided in Section 1.05.
- (b) The Phase I application must meet all of the requirements stated in Section 3.0.
- (c) The Phase I application must be limited to one subtopic and clearly address research for that subtopic.
- (d) Phase I total application budget must not exceed \$90,000.
- (e) The feasibility research duration for the Phase I project must not exceed 6 months.
- (f) The application must contain information sufficient to be peer reviewed as research.
- (g) The complete application must contain all required documents as listed in Section 8.

4.03 Phase I Evaluation Criteria

Phase I applications that comply with the screening criteria will undergo an internal, two-step scored review process. Phase II applications are internally evaluated using Step 1 only.

Step 1: The applications will be rated 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 ratings 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. The Selecting Official will determine the score above which applications will be considered “technically superior.” Applications not rated as technically superior will not be considered further.

Step 2 (Phase I only): A panel composed of NIST employees will review the content of applications rated as technically superior in Step 1 and score them based on the following evaluation factors and develop a final ranking based on:

(1) The potential of the proposed research to meet NIST program priorities (<http://www.nist.gov/director/planning/planning.cfm>).

(2) Economic impact (e.g., ability of the company to develop a commercially viable product, service or process); record of past performance for SBIR and STTR awards; assessment of whether the applicant’s participation would diversify the nature and types of firms participating in the NIST SBIR program; existence of outside, non-SBIR, funding or partnering commitments; and/or the presence of other relevant supporting material contained in the application that indicates the commercial potential of the idea (such as letters of support, journal articles, literature, Government publications). Per 15 U.S.C. 638(dd)(7), Investment of venture capital or from hedge funds or private equity firms will not be considered.

(3) SBIR program priorities (manufacturing-related research; energy efficiency or renewable energy; participation by minority and disadvantaged persons and HUBZones).

Final Action: Final selection decisions will be made by the Selecting Official, the Director of the NIST Technology Partnerships Office, or designee, based upon ratings assigned by the selection panel (Phase I) or evaluators (Phase II), 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 elect to fund one, several or none of the applications received on a given subtopic. NIST may ask for supplemental information prior to award and reserves the right to negotiate the scope and amount of the award. NIST also reserves the right to reject an application where information is uncovered that raises a reasonable doubt as to the responsibility of the applicant. 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 Phase II Evaluation Criteria

During the feasibility study project performance period, all Phase I awardees will be provided instructions for preparation and submission of Phase II applications.

Phase II applications that comply with the screening criteria as stated in those instructions will be rated by NIST scientists or engineers in accordance with the Step 1 evaluation criteria. The Step 2 evaluation is not used for Phase II applications.

4.05 Release of Application Review Information

After final award decisions have been announced, the 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

Successful applicants will receive a cooperative agreement from the NIST Grants Officer. A sample award cover page, i.e., CD-450, Financial Assistance Award is available at http://ocio.os.doc.gov/s/groups/public/@doc/@os/@ocio/@oitpp/documents/content/ev01_002513.pdf and the DoC Financial Assistance Standard Terms and Conditions (January 2013) are available at http://www.osec.doc.gov/oam/grants_management/policy/documents/DOC_Standard_Terms_and_Conditions_01_10_2013.pdf.

The DoC Pre-Award Notification Requirements for Grants and Cooperative Agreements, 77 FR 74634 (December 17, 2012), are applicable to this announcement, except to the extent any provision may be inconsistent with SBIR requirements, and are available at <https://www.federalregister.gov/articles/2012/12/17/2012-30228/departments-of-commerce-pre-award-notification-requirements-for-grants-and-cooperative-agreements>.

Contingent upon availability of funds, NIST anticipates making a total number of approximately eight (8) Phase I awards of no more than \$90,000 each. The total performance period shall be no more than seven (7) months beginning on the agreement start date. A period of one (1) month is allotted after the six (6) month R&D duration for the awardee to prepare and submit a final report.

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 25 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 37 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 5 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 either Phase I or 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 I awardees will be required to submit a progress report three months after award and a final report. Phase II awardees will be required to submit three progress reports, a final report, and a commercialization report. Phase II reports are due at 6, 12, 18, 24, and 36 months after award.

Phase I and Phase II 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.

Final reports submitted under Phase I and Phase II 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.

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 information provided in the Phase II commercialization update reports will be compiled and used as general statistics to help determine the value of the NIST SBIR Program.

The Phase II commercialization update 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 progress taken towards commercialization of the technology after the completion of Phase I and II awards.

5.03 Payment Schedule

Cooperative agreements will include an award term with electronic payment system information. Pursuant to 15 C.F.R. 14.22(b), 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 15 C.F.R. 14.21. 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

Rights in Data Developed Under SBIR Funding Agreements and Copyrights - In lieu of Department of Commerce Financial Assistance Standard Terms and Conditions (January 2013), Section L.04.c. and d., the following term and condition will be included in all SBIR awards issues under this FFO:

Rights in Data -- SBIR Program

(a) *Definitions.* As used in this clause--

“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.

(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 contract 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) of this clause 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. 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 clause 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.

(End of Clause)

Patents- Rights to inventions created by an awardee under an SBIR award issued pursuant to this FFO will be governed by Department of Commerce Financial Assistance Standard Terms and Conditions (January 2013), section L.04.a.

NIST-Owned Patented Background Inventions - Awardees of SBIR awards made subsequent to the "TT" subtopic in this FFO (9.05.01.40-TT), will, upon the license application by the awardee to a NIST licensing officer, be granted a non-exclusive research license to use NIST-owned patented background inventions which are specifically identified within the subtopic being awarded. 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 that identify specific 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 CFR Part 404.

Any invention developed by awardee during the course of the SBIR award period of performance is subject to the terms discussed in the Patents section.

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. Cost sharing will not be considered in evaluation of your Phase I application.

5.06 Profit or Fee

A reasonable profit or fee is allowed.

5.07 Joint Ventures or Limited Partnerships

See [13 CFR 121.103\(h\)](http://www.ecfr.gov/cgi-bin/retrieve.cfm?id=32%2F121.103(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.

5.08 Research and Analytical Work

For Phase I, a minimum of two-thirds of the research and/or analytical effort, per Section 1.03, must be performed by the proposing SBC unless otherwise approved in writing by the Grants Officer after consultation with the agency SBIR Program Manager. For Phase II, a minimum of one-half of the research and/or analytical effort must be performed by the applicant unless otherwise approved in writing by the Grants Officer after consultation with the agency SBIR Program Manager.

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 Phase I funding agreement. The award will be governed by the DOC Financial Assistance Standard Terms and Conditions (January 2013), General Research Terms and Conditions, applicable OMB Cost Principles, and Uniform Administrative Requirements and Special Award Conditions that will be incorporated into the award.

The outline that follows is illustrative of the types of terms and conditions to which the awardee would commit. This list is not a complete list of terms and conditions to be included in Phase I funding agreements, and is not the specific wording of such terms and conditions.

5.10 Summary Statements

The following statements are examples of some of the topic areas that will be addressed in the award 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 15 C.F.R. 14.53.

(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; (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 [15 C.F.R. 14.61](#).

(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 Commerce Financial Assistance Standard Term and Condition C.

(4) Audit Requirements. Government officials may conduct an audit of an award at any time. Unless otherwise specified in the award, commercial organizations not required to follow OMB Circular A-133, *"Audits of States, Local Governments, and Non-Profit Organizations,"* have a program-specific audit performed by an independent auditor when the Federal share amount awarded is \$500,000 or more over the duration of the project period. See 15 C.F.R. 14.26 and Commerce Financial Assistance Standard Term and Condition D.

(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 Commerce Financial Assistance Term and Condition I.01.

5.11 Additional Information

This program FFO is intended for informational purposes and reflects current planning. 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 in either Phase I or Phase II.

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 may provide technical assistance to awardees as allowed by legislation.

5.12 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 appropriately to the statement about MEP in 3.02.01.

6.0 SUBMISSION OF APPLICATIONS

6.01 Deadline for Applications

Electronic applications must be received no later than 11:59 p.m. Eastern Time, Friday, May 2, 2014. Paper applications must be received by NIST by 5:00 p.m. Eastern Time on Friday, May 2, 2014.

Applications not received by the specified due date and time or that do not adhere to the other requirements of this FFO (see checklist in Section 8.02) 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 submission, NIST will consider the date and time stamped on the validation generated 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, keep in mind that (1) a free annual registration process in the electronic System for Award Management (SAM) (see Section VI.2.b.) may take between three and five business days or as long as more than six weeks, and (2) applicants using Grants.gov will receive a series of receipts over a period of up to two business days before learning via a validation or rejection whether a Federal agency's electronic system has received its application.

6.02 Application Submission

Applications may be submitted by paper or electronically.

(1) Paper applications must be submitted to:

National Institute of Standards and Technology
NIST SBIR Program Office
Attn: Mary Clague
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 Mary Clague at 301-975-4188 or mary.clague@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 2014-NIST-SBIR-01.

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 2014-NIST-SBIR-01 announcement, contact Christopher Hunton by phone at 301-975-5718 or by e-mail at christopher.hunton@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 Dun and Bradstreet Data Universal Numbering System (DUNS) 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. 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 the "Grant Applicants" page.

In addition to following the "Steps" and instructions described in the "Applicant Actions" section and its subcategories, further detailed instructions are described in "Applicant Resources" and all of its subcategories. This appears in the box near the top left of the Grant Applicants page. Applicants should follow the links associated with each subcategory.

Applicants will receive a series of receipts during a process of up to two business days before the application is either validated as electronically received by the Federal agency system, or rejected by it.

Applicants should pay close attention to the instructions 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.

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 on 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.

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 Mary Clague by telephone at (301) 975-4188, or by email to mary.clague@nist.gov to request copies.

7.0 SCIENTIFIC AND TECHNICAL INFORMATION SOURCES

Background information related to the NIST research programs referenced within the subtopics 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 3.0 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. The FFO number 2014-NIST-SBIR-01 must be identified in item 12 of the SF-424. The list of certifications and assurance referenced in item 21 of the SF-424 is contained in the SF-424B.
- (2) SF-424A, Budget Information – Non-Construction Programs.**
- (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 letters from affiliated parties such as contractors (see Section 3.02 of this FFO).

(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.

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 15 C.F.R. 14.27 or 24.22, as applicable. The awardee should have an accounting system that tracks costs per SBIR firm and an allocation plan for activities that may be shared among multiple SBIR firms.

(8) Indirect Cost Rate Agreement. If indirect costs are included in the proposed budget, provide a copy of the approved negotiated agreement if this rate was negotiated with a cognizant Federal audit agency. If the rate was not established by a cognizant Federal audit agency, provide a statement to this effect. If the successful applicant includes indirect costs in the budget and has not established an indirect cost rate with a cognizant Federal audit agency, the applicant will be required to obtain such a rate.

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 (8) 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 Checklist of Requirements

Please review this checklist carefully to assure that your application meets the NIST requirements. Failure to meet these screening requirements will result in your application being returned without consideration. **Please see Section 6.01 for application deadline.**

(1) All components of the Technical Proposal are included, including letters from affiliated parties such as contractors (see Section 3.02 of this FFO).

(2) All components of the application are included (see Section 8.01 of this FFO).

(3) All required signatures are included.

(4) The proposed budget is \$90,000 or less. No more than one-third of the budget is allocated to consultants and/or subcontractors.

(5) The SBA Company Registry document (*see* Section 2.02 of this FFO) is the last page of the Technical Proposal (*see* Section 3.02 and Section 8.01.(6) of this FFO).

(6) The Technical Proposal (key information and technical content, *see* Section 3.02 and Section 8.01.(6) of this FFO) is 25 pages or less in length.

(7) The application is limited to only one of the subtopics in Section 9.

(8) 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 once an application has been submitted, an applicant may submit a complete, new application including such information by the required deadline.

(9) Employer/Taxpayer Identification Number (EIN/TIN), Dun and Bradstreet Data Universal Numbering System (DUNS), and System for Award Management (SAM). All applicants for Federal financial assistance are required to obtain a universal identifier in the form of DUNS number and maintain a current registration in the Federal government's primary registrant database, SAM. On the form SF-424 items 8.b. and 8.c., the applicant's 9-digit EIN/TIN and 9-digit DUNS number must be consistent with the information in SAM (<https://www.sam.gov/>) and the Department of Treasury's Automated Standard Application for Payment System (ASAP). For complex organizations with multiple EIN/TIN and DUNS numbers, the EIN/TIN and DUNS numbers MUST be the numbers for the applying organization. Organizations that provide incorrect/inconsistent EIN/TIN and DUNS numbers may experience significant delays in receiving funds if their application is selected for funding. Confirm that the EIN/TIN and DUNS number are consistent with the information on the SAM and ASAP. Per 2 C.F.R. Part 25, each applicant must:

- (1) Be registered in the Central Contractor Registration (CCR) before submitting an application noting the CCR now resides in SAM;
- (2) Maintain an active CCR registration, noting the CCR now resides in SAM, with current information at all times during which it has an active Federal award or an application under consideration by an agency; and
- (3) Provide its DUNS number in each application it submits to the agency.

The applicant can obtain a DUNS number from Dun and Bradstreet. A DUNS number can be created within one business day. The CCR or SAM registration process may take five or more business days to complete. If you are currently registered with the CCR, you may not need to make any changes. However, please make certain that the EIN/ TIN associated with your DUNS number is correct. Also note that you will need to update your CCR registration annually. This may take three or more business days to complete. Information about SAM is available at SAM.gov (<http://www.sam.gov>). See also 2 C.F.R. Part 25 and the Federal

Register notice published on September 14, 2010, at 75 FR 55671.

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.

Applicants are advised to check the public Question and Answer website located at <http://www.nist.gov/sbir> for up-to-date information concerning specific subtopics that may be posted during the FFO open period.

9.0 RESEARCH TOPIC AREAS

The research topic areas are 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 Cyber-Physical Systems

9.01.01.73-R Residential Heat Pump Fault Detection and Diagnostic Datalogger

A low cost, modular system for monitoring and controlling a process or environment is applicable to a wide variety of commercial and consumer-based endeavors. The ability to measure a quantity and then affect a change to control that quantity, or a related quantity, is highly desirable in an innumerable number of scenarios whether it be on the manufacturing plant floor or even within the home. This type of monitoring and control functionality is being popularized by smart phone based hardware such as the Nest Thermostat (<http://www.nest.com/>) and other home automation technology (www.Wigwag.com). Sophisticated monitoring tools integrated with process control are already applied in the manufacturing environment, but for some purposes, a commercial-type system is overkill. The refinement of home automation technology into a hardware and software tool that focuses on monitoring a residential heat pump is one such system that would have broad application for the millions of heat pumps already installed in the United States, and would advance the development of more refined measurement tools for similarly complicated home appliances.

A primary objective of this research topic area is to develop fault detection and diagnosis (FDD) methods for residential heat pumps. In particular, the development of tools which make use of artificial intelligence, deductive modeling, and statistical methods to automatically detect and diagnose deviations between actual and optimal system performance is necessary to accelerate market penetration of heat pump FDD technology. Historical work has focused on vapor compression heat pump and rooftop/package systems [1-3], however, the ability to detect and diagnose the cause of faults remains poorly understood. In particular, the following two questions must be answered to advance the FDD state-of-the science:

- 1) What is the true economic and energetic cost of a particular fault? and
- 2) What is the statistical prevalence of important faults?

A recent NIST project to examine correlations of the effects of different faults in a yearly simulation for two different home types in 5 climate zones has provided insight to this topical area, however, additional research to fully understand the economic and energetic cost of faults is necessary

With respect to the second question previous studies in California and other Western States are reported for various faults such as refrigerant charge and indoor airflow [4]. However, a larger sampling of data from different climate zones with some degree of statistical certainty is necessary. In particular, the development of a measurement tool to gather data from a large portfolio of residential systems, e.g., a datalogging tool, will advance FDD methods. An optimum tool should be easy to install with minimum invasiveness; economical and scalable; and able to communicate its data over wireless and wired communication networks. Moreover, an optimum tool should leverage existing home automation technologies, be a modular design to allow for the expansion of measurement inputs, and be applicable to a broad range of applications monitoring varied pieces of equipment, processes, and/or environments.

An optimum tool is envisioned as being installable on indoor units and outdoor units, and should be able to handle the appropriate environmental condition associated with these environments. Minimum functionality of such a device comprises: 1) a plurality of measurement nodes for temperature distributed inside and outside of a building/residence that is using a heat pump; 2) a plurality of pressure transducers suitable for heat pump operations; 3) a plurality of suitable electrical measurement devices for both voltage and current deployable at suitable locations relative to fault occurrence; 4) appropriate analog to digital conversion; 5) suitable communications capabilities (e.g., wireless 3G/4G cellular; 802.11g; and hardwired TCP/IP). The optimum tool should be able to store data for long periods of operation; provide adequate data security; and preserve data in the event of power failure.

The product of this SBIR project will be a FDD datalogger tool which will allow detailed performance data collection on residential heating and air conditioning equipment. This tool should be applicable to a broad set of residential heat pumps in order to maximum the tool's applicability to collecting a wide range of field performance data. Data collection efforts will be designed with the aid of NIST statisticians to ensure that the goal of determining fault prevalence is met with a known degree of uncertainty.

Applicants should have access to a broad range of technical experts in the fields of consumer electronics, air conditioning, and related fields, experts expected to provide input toward the development of a practical FDD data logging tool. This input should produce an effective device design at a cost deemed reasonable to the cost of the development of the tool.

Phase I activities and expected results:

The awardee shall create a design that performs all of the necessary functions described

above. If all functions cannot be directly incorporated, the awardee shall re-define the criteria to something buildable while meeting most of the previously listed requirements.

Phase II activities and expected results:

In Phase II of the SBIR project, the awardee shall construct three prototypes of the Phase I design for evaluation in the field, and conduct field testing. NIST personnel will be involved with field testing. During these prototype tests, the awardee shall work to refine its interfaces, perfect communication protocols/software tools, and refine the design to remove any flaws.

On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees for consultations and discussions to answer design questions and clarify any other technical aspects within the field of expertise.

References:

1. Breuker, M.S. and Braun, J.E., 1998a, "Common faults and their impacts for rooftop air conditioners," *International Journal of Heating, Ventilating, Air-Conditioning and Refrigerating Research*, Vol. 4, No. 3, pp. 303-318.
2. Li H. A decoupling-based unified fault detection and diagnosis approach for packaged air conditioners. Ph.D. Thesis, West Lafayette, IN: Purdue University, 2004.
3. Rossi, T.M. and Braun, J.E., 1997, "A statistical, rule-based fault detection and diagnostic method for vapor compression air conditioners, *International Journal of Heating, Ventilating, Air-Conditioning and Refrigerating Research*," Vol. 3, No. 1, pp. 19-37.
4. Proctor, J., 2004, "Residential and Small Commercial Central Air Conditioning; Rated Efficiency isn't Automatic," Presentation at the Public Session. ASHRAE Winter Meeting, January 26, Anaheim, CA.

9.02 Cybersecurity

9.02.01.77-R Cryptographic Acceleration for Border Gateway Protocol Security (BGPSEC)

The Border Gateway Protocol (BGP) was initially developed in 1989 (RFC 1105 [1]) and last refined in 2006 to its current version BGP-4 (RFC 4271 [2]). Because the protocol itself does not provide any notion of security, more and more successful attacks against the protocol have been witnessed in recent years [3][4]. The Internet Engineering Taskforce (IETF) is currently developing two mechanisms with the intent to strengthen BGP to be protected against attacks (malicious or due to misconfiguration) such as route hijacks and redirects (i.e., AS-path modifications). These security mechanisms being developed in the IETF, based on a Resource Public Key Infrastructure (RPKI), are called route-origin validation [5] [6] and path validation [7]. The new security enhanced BGP together with these two mechanisms is known as BGPSEC (BGP with Security) [7].

BGPSEC relies heavily on cryptographic processing because it involves cryptographically signing and verifying the BGP update messages. In essence, BGPSEC requires real-time line-speed cryptographic operations on BGP path announcements, and hence poses many challenges in today's routing landscape. The router control plane hardware currently deployed in the field is not up to the task due to lack of adequate processing power, especially for the cryptographic-intensive computations in BGPSEC. The global Internet BGP routing tables consists of approximately 500,000 routes (i.e., unique announced prefixes) with re-convergence requirement of approximately 15 to 20 minutes following router reboots. The current lack of any special purpose hardware for cryptographic processing in routers poses a challenge for the hardware vendors.

NIST is heavily involved in the design of the new BGPSEC protocol (i.e., route-origin and AS-path validation), and has developed a prototype validation software reference implementation [8]. There is a critical need to research and develop mechanisms to use embedded or off-board specialized cryptographic processors (e.g., any that may be available off-the-shelf from vendors such as Intel, AMD, Cavium, etc.) in routers so that future BGPSEC-enabled routers will be well equipped to handle the required cryptographic-processing loads. Special consideration needs to be given to router failure-recovery scenarios when speed of convergence would be most critical. Cryptographic-hardware can be combined with innovative BGPSEC processing optimization algorithms to further improve performance. It is important that cryptographic acceleration can be added to secure routers in a cost effective matter. Additional problems that also need to be addressed are minimization of power consumption, and efficient use of available memory since there may be some limitation in increasing memory size in routers.

The goal of the project is to research and develop an efficient router platform that is capable of performing the cryptographic operations associated with the evolving BGPSEC protocol. The resulting router would perform said cryptographic processing at nearly line speed even under router failure-recovery scenarios so that the speed of BGP convergence can meet operators' stringent requirements while still maintaining security. The resulting router should be economically viable and commercially deployable in the near future.

Phase I activities and expected results:

Phase I consists of incorporating an embedded or off-board cryptographic accelerator onto a PC-router platform using the NIST BGP-SRx [8] reference implementation. An optimum design would enable the addition of cryptographic hardware accelerators to a PC platform to completely off-load all cryptographic operations from the BGP-SRx software prototype. The selection of cryptographic accelerator hardware and software interfaces to BGP-SRx should be included in Phase I.

Phase II activities and expected results:

Phase II consists of developing and testing a prototype for the PC-router mentioned above in Phase I activities. The prototyped router should open the doors for commercial deployment of BGPSEC, including route-origin validation and AS-path validation.

NIST will be available for providing BGPSEC validation algorithms to be used in the router implementation as well as to assist in designing the prototype framework. The BGPSEC protocol standard has been only partially developed in the IETF; the route-origin validation is specified while the AS-path validation is still work-in-progress.

On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees to provide assistance in keeping the awardee abreast of the latest developments in the IETF and network operator community regarding the BGPSEC protocol. NIST may also provide expertise to assist with the design of the integration into today's routing systems.

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9.02.02.77-R Privacy Preserving Tools for Federated Authentication Models

Legacy Internet communication protocols were designed for secure communication in the Dolev-Yao model. This model consists of two communicating parties and an adversary who can overhear, intercept, and synthesize any message. In this paradigm, the legitimate communicating parties only send messages to each other. No messages are sent to the third party, who is an adversary intent on preventing the legitimate parties from achieving its

goal.

In the last few decades, software and standards have been developed which satisfactorily solve the above problem. Current digital transactions, however, occur in a model that is very different from Dolev-Yao. Specifically, third parties are not necessarily malicious and, in fact, often are an important part of a multi-party communication protocol. These protocols seek to enhance the digital world. In particular, they aim at facilitating electronic commerce and other transactions in a cooperative, rather than adversarial, model. Of course, we cannot simply assume bad actors away. The next generation of protocols needs to replace “distrust” by “trust but verify.” It seeks to use novel Internet technologies (see, for example, the NIST Beacon at http://www.nist.gov/itl/csd/ct/nist_beacon.cfm).

In the modern internet world, with its myriad players - customers, standards bodies, industry, governments, privacy advocates, and many more - it will be hard to effect this transition. But transition we must if we are to realize the potential of the Internet for improving our quality of life and, from the United States perspective, our competitiveness. However, industry and other actors often resist modification to its deployed technologies. This subtopic is about overcoming this critical barrier by focusing on test cases that are representative of many scenarios and specific enough to allow engineering of working solutions. So as to maximize the probability of successful commercialization and adoption by industry, these solutions should leverage existing Dolev-Yao protocols and standards by either using them as black-box primitives or implementing minimal changes to them.

A primary objective is to develop tools that solve remote authentication, identification, and attribute disclosure problems (e.g., JSON, SAML, OpenID Connect, OAuth). A representative problem is the “brokered identity problem,” in which there are identity and attribute providers that, due to privacy considerations, must issue assertions without knowing who the consumer of the assertion is. For example, an attribute verifier does not need to know what application the user is attempting to access. Signed assertions are issued and sent to a broker, who in turn forwards them to the assertion consumer, typically a service provider. It is fairly straightforward to use two-party protocols such as SAML to solve this problem if we are willing to allow the broker to read the assertions. However, it is more complicated to solve this problem under the so-called “honest but curious model” in which the broker follows the protocols but anything that it learns becomes public knowledge. The recipient will specifically develop and test working technologies that solve attribute disclosure problems in a multi-party authentication architecture for privacy preserving protocols outside the Dolev-Yao model.

Phase I activities and expected results:

Pick one or more representative problems;

1. Research solutions from the cryptographic literature; and/or
2. Choose candidate techniques and carry a preliminary assessment of how these choices impact feasibility vis-à-vis compatibility with existing standards and industry practice.

Phase II activities and expected results:

Develop working prototypes and work with NIST, the NSTIC NPO [1], and industry to carry out feasibility tests and evaluations, with an eye toward downstream commercialization.

On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees for consultations and discussions to answer design questions and clarify any other technical aspects within the field of expertise.

References:

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9.02.03.77-R Secure Email Agent Using the Domain Name System (DNS) as a Trust Infrastructure

Email is widely used for Internet communication both in dialogs between people and one-way messaging and notification systems (e.g., Email from your bank noting a deposit). However, email is inherently insecure and often spoofed by attackers looking to impersonate another user, or institution, in order to trick a victim to download malware or view a malicious site. This type of attack (often called "phishing") has been used to successfully infiltrate enterprises to steal sensitive data or leverage other attacks [1]. The current state of Email security is considered so poor that many financial institutions and government agencies tell their customers they will never send them unsolicited email and to distrust all email purporting to come from their domain [2].

There are standards developed by the IETF to provide authentication (via digital signatures) and confidentiality (via encryption) to email through the Secure/Multipurpose Internet Mail Extensions (S/MIME) [3]. S/MIME encryption uses asymmetric cryptography. A user's public key is usually stored in a digital certificate signed by its enterprise or a provider's Certificate Authority (CA). However, S/MIME lacks the ability to easily establish cross-domain trust. Users within an enterprise can all configure a central trust anchor (to validate S/MIME digital certificates), but may not be able to obtain and validate the S/MIME digital certificates of users in a different domain. For example, employees of "agency.gov" would like to send a digitally signed email to users in "example.com". However, end users of example.com are not able to obtain (or validate) the S/MIME digital certificates of the agency.gov senders so they cannot validate the signed messages. One way to make obtaining (or validating) S/MIME digital certificates possible is to use the Domain Name System (DNS) as a public key distribution infrastructure.

The DNS [4] [5] is a globally distributed, hierarchical naming infrastructure that supports almost every other form of Internet communication. A DNS query is usually the first step in

communication and is already currently used by the email protocol to find the proper destination for email messages. The DNS Security Extensions (DNSSEC) [6] provides a means to protect the integrity of DNS data and provide data authentication (i.e. that it comes from the authoritative domain holder). This means DNS can be used as a lightweight distribution channel for security information such as public keys or digital certificates.

New DNS data types have been developed to store digital certificates to support Transport Layer Security (TLS) for web traffic (e.g., https) and other uses [7]. This new data type can be used as the model for another new data type [8] to store email digital certificates. Email certificates require different features than simple TLS certificates. Email security often involves two different certificates: one for generating digital signatures and one for encryption of email contents. The new DNS data type for email digital certificates takes these differences into account, but otherwise it is treated like any other DNS data.

The goal of the project is to design, develop and test an extension to open source Mail User Agents (MUA) to use the DNS to obtain and verify email digital certificates. This extension could be a downloadable plug-in or a modified open source implementation that users can download and install on their own. This modified MUA would have two new functions related to secure email: First, the MUA, upon receiving a digitally signed email, would issue DNS queries to obtain additional information in order to validate the certificate before using the certificate to validate the message signature. Second, the MUA would have the ability to query the DNS to obtain a receivers email encryption certificate (or public key) in order to send an encrypted email.

Provisioning tools to format and store email digital certificates in the DNS are not part of this project, but may be developed to aid in the testing portion of the project.

Phase I activities and expected results:

Phase I consists of identifying possible candidates to use as the base code and designing the algorithms to query the DNS for digital certificates and how to interpret the response. MUA candidates are ideally open source and either easily extendable via plug-ins (for example Mozilla Thunderbird), or proprietary MUA software that has API's available to develop plug-ins that users can download and install independently (for example, Apple Mail).

Phase II activities and expected results:

Phase II consists of developing and testing a prototype of the MUA plug-in to send and receive encrypted and/or digitally signed email. The MUA will use the DNS to obtain digital certificates (or additional information to validate digital certificates) used to sign email. The MUA will also use the DNS to obtain the public encryption key of an email receiver and use it to encrypt and send a confidential email message.

On a case-by-case basis for Phase I and Phase II awards, NIST may provide technical experts to act as subject matter experts in DNS, DNSSEC and email as needed. NIST may also be available to establish the network and DNS infrastructure that would be needed to conduct

testing of the resulting modified MUA. NIST has experience from previous DNS projects in setting up test domains using newly specified data types.

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<http://datatracker.ietf.org/doc/rfc6698/>.
8. P. Hoffman, J. Schlyter. "Using Secure DNS to Associate Certificates with Domain Names For S/MIME". Work in Progress. <http://datatracker.ietf.org/doc/draft-ietf-dane-smime-02/>.

9.02.04.68-R Silicon Single-Photon Avalanche Diodes with Detection Efficiency that Exceeds 95 %

Recent advances in quantum communications and quantum random number generation have identified the critical need for detectors with single-photon detection efficiency above bounds that are determined by information theory. Additional losses in any preceding optical components require that the efficiency of the subsequent detectors be even higher. Devices of this type may be used in verifiable random number generation, a critical need for cryptography and cyber security [1]. Detectors with single-photon detection efficiency above 95 % are generally considered suitable for these applications, though higher efficiency is better. To date the only candidates that meet this requirement operate at cryogenic temperatures, which significantly increases the complexity and cost of any cryptographic apparatus based on such processes. Devices of this type are also critical to

advance communications systems based on generalized quantum measurements [2], which can discriminate low-photon-number states at error rates lower than those determined by the standard quantum limit.

While there are a wide variety of single-photon detectors, it has been demonstrated recently that silicon single-photon avalanche diodes can achieve detection efficiencies exceeding 80 % at some wavelengths, while maintaining relatively low noise (less than 100 Hz dark count rate) [2]. These advances are promising, and suggest that it may be possible to achieve near unity single-photon detection efficiency in a compact, low-cost device that requires only thermoelectric temperature control. Such a device could be a critical component in the development of a small-form-factor quantum-random-number-generation equipment. A primary objective is the development of quantum random number generation for cyber-security and selective disclosure protocols, as well as an ongoing commitment to quantum optics research and devices that enable quantum information processing. More generally, high-efficiency low-noise single-photon detectors play a critical role in applications ranging from quantum cryptography and DNA sequencing, to 3D imaging based on time-of flight ranging; technological advances in sensors that operate at the fundamental limit to electromagnetic signal strength are likely to have an impact in a variety of fields.

The award should ultimately result in the development and demonstration of single-photon avalanche diodes with single-photon detection efficiency somewhere in the silicon region (roughly between 350 nm and 1100 nm) that exceeds 98 %, with an intermediate Phase I goal of 95 %. In addition, noise is an important concern for detectors for cyber-security applications. To this end, the intrinsic dark count rate of the devices must be below 10 kHz, while the timing resolution must be better than 1 ns (full-width at half maximum), or, equivalently, the per-gate dark count rate should not exceed 10^{-5} . Otherwise, there are no requirements on the wavelength at which the devices should operate, their maximum count rate, or their recovery time, though a recovery time below 10 microseconds is preferable.

To allow efficient optical coupling, the device's active area should have a diameter larger than 50 micrometers. Devices that meet all these requirements would represent a significant advance in single-photon detection technology, and would benefit not only cyber-security and quantum information applications, but also the more conventional applications of high-efficiency single-photon detectors such as fluorescence spectroscopy and LIDAR.

Phase I activities and expected results:

Design, fabrication packaging, and testing and characterization of silicon single-photon avalanche diodes with >95 % single-photon detection efficiency

Phase II activities and expected results:

As in Phase I, improving efficiency from > 95 % to the ultimate goal of > 98 %.

On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees to work collaboratively to help test and characterize the devices fabricated and packaged under this project.

References:

1. S. Pironio, A. Acin, S. Massar, A. Boyer de la Giroday, D. N. Matsukevich, P. Maunz, S. Olmschenk, D. Hayes, L. Luo, T. A. Manning, and C. Monroe, "Random Numbers Certified by Bell's Theorem," *Nature* 464, 1021 (2010).
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9.03 Health Care

9.03.01.63-R Instrument to Detect Aerosolized-Droplet Dose Delivery of Vaccines

Delivery of aerosolized drugs through the pulmonary system has received much attention in recent years for addressing a variety of health issues – in particular the delivery of vaccines. Higher costs and increased chemical toxicity of drugs under consideration are requiring more stringent dose delivery criteria, and thus has affected inhaler design and development. Little quantitative information on spatially or temporally resolved concentration of a drug throughout the aerosol (i.e., presence of the active pharmaceutical ingredient (API) within a particular liquid droplet or solid particle) is available; concentration along with size is critical for proper dosage and transport efficiency to the site of action within the lungs.

NIST has developed a measurement approach to measure inhaler dose concentration of pharmaceutical-laden, multiphase aerosols [1]. Since many biological molecules either are naturally fluorescent or can be chemically modified with fluorophores, one can relate fluorescence intensity to concentration (or mass) of these inclusions within the droplet volume. The approach used distinguishes between aerosol droplets that may or may not contain fluorescing agent (i.e., to identify droplet-to-droplet variations in agent concentration). Development of a functioning prototype instrument is needed that integrates the measurement of particle/droplet fluorescence intensity with image splitting technology and magnification optics, as well as provides software algorithms to identify API-laden droplets/particles and statistically evaluates the overall API concentration.

Foundational capabilities to conduct this research include: 1) image and record fluorescence and scattering intensity of individual droplets; 2) determine API drug fluorescence by fluorescence spectrophotometry; 3) prepare solutions with API to prove that natural fluorescence can be used to identify API in a solution or mixture; 4) image and distinguish fluorescent and non-fluorescent microspheres (of comparable size to droplets in metered-dose or dry-powder inhalers) using fluorescence microscopy; 5) extract and identify particle size, scattering and fluorescence intensity from recorded images using an already existing

mathematical algorithm; and 6) form composite images of the combined scattering and fluorescence images.

Phase I activities and expected results:

During Phase I, commercially available equipment will be identified and a prototype design will be developed that will accommodate different types of manufactured inhalers. Expected instrument operating parameters are droplet range of interest is between 1 μm and 10 μm , API concentration of 0.2 g/L – 1.0 g/L, total test time < 1 min, instrument response time < 1 s, maximum flow rate of 15 L/min, volume/dose of 50 μL – 100 μL , and droplet flow speed of 1 m/s – 10 m/s. The awardee will also address experimentally other potential issues that need to be considered for developing a functioning prototype instrument.

Phase II activities and expected results:

The objective of Phase II is the delivery of a functioning prototype device applicable to a wide range of healthcare technologies.

On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees during both phases of the research, including coauthoring manuscripts to be submitted for archival publication.

Reference:

1. Presser, C., "Detection of Dose Concentration in Droplets Generated by Pulmonary Drug Delivery Devices," 21st Annual Conf. on Liquid Atomization and Spray Systems (ILASS Americas 2008), on CD, Orlando, FL, 2008.

9.03.02.68-R Production of NIST/UCSF Breast Phantom for Magnetic Resonance Imaging (MRI)

NIST, in conjunction with University of California San Francisco (UCSF), has designed a breast phantom for quantitative magnetic resonance imaging (MRI), specific to American College of Radiology Imaging Network (ACRIN) trial 6698. A phantom is an inanimate structure used to calibrate and test MRI scanners, coils, and their operating protocols. The initial design has received interest from researchers conducting clinical trials in breast cancer research and major MRI vendors and from major research institutions that design breast imaging coils and pulse sequences. The breast phantom consists of two independent phantoms, one focused on diffusion MRI measurements and the other focused on accurate measurements of fat and fibroglandular tissue properties; additional details are provided in the References. The objective is to develop and commercialize the NIST/UCSF breast phantom based on this design. Development needs include: lowering cost through advanced manufacturing techniques, creating sterilization techniques to ensure stability for a minimum of five years, incorporating quantitative traceability into dimensional and magnetic resonance properties, and writing software that overlays the phantom structure with magnetic resonance images.

Project Goals:

- a. **Cost reduction:** Current prototype phantoms cost approximately \$12,000 to construct. For successful commercialization we require that the cost to the end-user be brought down to less than \$5,000. Cost reduction can be achieved by simplifying the phantom design (while retaining the prescribed functionality), reducing the number of machined parts, integrating components, incorporated cost efficient production techniques, or other methods.
- b. **Improve phantom stability:** The phantom should be stable for at least five years. Five-year stability requires all components to be sterilized so there will be no bacterial or fungal growth within the phantom. Current designs utilize corn syrup and other materials that are potential growth media for bacteria. The diffusion and T1 inserts must be well sealed and their properties and concentrations must be stable for at least five years. The phantom should be robust enough to withstand shipment and at least five years of normal use.
- c. **Incorporation of quantitative traceability:** A plan must be developed to insure quantitative traceability for critical components of the phantom. This includes traceable dimensional measurement of the resolution insets, traceability of the chemical composition of the T1 and diffusion components, and traceability of the T1 and T2 relaxation properties to gold standard NMR measurements. NIST may provide assistance and guidance on best methods to insure traceability.
- d. **Analysis software:** When imaging these phantoms an overlay is required to identify the exact position of the phantom components. Software is required to take the output of the three-dimensional models used for phantom construction and provide an output suitable for overlays in standard DICOM viewers. For the commercial phantom (Phase II), a complete analysis package is required to be disseminated with the phantom that can input DICOM images, overlay the designated regions of interest, process the data, and compare measured parameters with prescribed parameters.

Phase I activities and expected results:

Revise initial designs and develop manufacturing process to lower cost to end-user:

The goal is a total cost of \$5000 or less per phantom. Prototype phantoms should be constructed using low cost manufacturing techniques. A plan is required to ensure measurement traceability of all key parameters. Traceable measurements should be made on key components going into prototype phantoms.

Develop sterilization plan and methods such that the fabricated phantoms have at least five-year stability.

Phase II activities and expected results:

Move toward manufacture of commercial breast phantoms: test performance of lower cost

prototype, make final revisions with input from the breast MRI community, and produce breast phantoms for distribution. It is expected that at least six phantoms will be distributed to the user community in exchange for testing and feedback. A compact software analysis package will be developed to be distributed with the phantom to allow users quick feedback on their imaging protocols and image quality. A full distribution package will be designed that will include the phantom, analysis software, environmental site monitoring (e.g., temperature of the phantom during imaging), and any infrastructure required to ship the phantom and precisely load the phantom into various scanners and RF coil assemblies.

On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees for consultation, input, testing of prototype phantoms and solutions, and analysis of data collected from the user community. NIST may provide any needed clarification to the phantom specifications currently posted on the public TWIKI listed below, and NIST may be available for consultation and input.

Reference:

1. The initial designs of the phantom and prototype testing are documented at the publically accessible NIST TWIKI site:
<http://collaborate.nist.gov/mriphantoms/bin/view/MriPhantoms/BreastPhantom>.

9.04 Manufacturing

9.04.01.68-R Compact, Rapid Electro-Optic Laser Scanner for Absolute 3D Imaging

Real time, three-dimensional (3D) imaging is needed by industry for both machine vision and monitoring of manufacturing processes. Today's 3D imaging equipment have significant technical limitations: poor image resolution, low refresh rate, as well as a lack of rigorous, calibrated distance measurements, which render the equipment inadequate for high-quality measurements in today's challenging manufacturing environments.

NIST has demonstrated a novel, prototype 3D self-calibrated laser radar (LADAR) imager. The NIST 3D LADAR imager is capable of non-contact, absolute dimensional measurements from distances as far as 5 m away. Measurement of complicated 3D objects, such as parts and assemblies on a manufacturing line, or footprints and other unstable trace evidence in forensics investigations are expected potential uses for this technology. The NIST prototype can be improved upon further, and can potentially be used with a number of different potential LADAR techniques.

An optimum LADAR instrument would be cheaper, easier to build, and easier to use, and also be more compact and have a faster refresh rate. A significant technical barrier to such an instrument is the lack of an appropriate, compact laser scanner. In existing LADAR systems, the laser beam is scanned across the target surface through mechanically actuated mirrors that are based on bulk optics packaged within a much larger device. A compact LADAR would be possible if this conventional scanner could be replaced by a compact electro-optic scanner.

The combination of a compact, electro-optic scanner with a LADAR approach that exploits modern laser technology, including frequency combs, would result in a compact 3D LADAR imager with extremely high performance. This imager could be used to qualify physical parts on manufacturing lines, enabling absolute multiscale dimensional measurements of parts and assemblies up to one meter in size at resolution of one micrometer or better. These methods, and the knowledge gained by using them, will reduce manufacturing costs, and accelerate the adoption of metal additive technologies, by enabling real-time qualification of additive manufacturing parts for mission-critical uses.

The twin goals of a cooperative project are to transfer NIST 3D LADAR technology to the private sector, which, in turn, requires a party to develop a compact, rapid electro-optic (EO) laser scanner that would make this technology more commercially viable. The EO laser scanner will be used to steer a swept laser across an object of interest. A commercial feasibility EO laser scanner must steer a swept laser with at least 5 THz of laser bandwidth, and it must be capable of sweep transit times of 0.5 ms or less. The center wavelength of the EO laser scanner should be 1550 nm, and it must have a clear aperture of 1 cm or greater. The EO laser scanner must be able to operate with bidirectional light to support a monostatic LADAR configuration. Most importantly, the EO laser scanner must contain no mechanical parts, thus enabling robust operation within manufacturing environments that may involve exposure to large temperature swings, mechanical vibration, or other environmental changes that could cause misalignment of mechanical parts.

Through this subtopic, the development and demonstration of a commercial sale 3D LADAR system (or systems) based on NIST's technology, which includes several proof-of-concept LADAR technologies, will be developed. For additional information please see the NIST Fiber Sources and Applications website

http://www.nist.gov/pml/div686/sources_detectors/fiber.cfm.

Phase I activities and expected results:

1. Design a two-dimensional electro-optic scanner that can enable near-diffraction-limited scanning over an instantaneous bandwidth of > 1 THz (defined as an excess beam spread of less than 20 % diffraction limit), in a 1 cm FWHM beam, over 10 mrad of angular range, at sweep transit times of less than 0.5 msec, and with insertion loss of less than 6 dB. The design for the overall dimensions of the instrument should be 50 cm³ or less.
2. Conduct necessary laboratory tests to verify the design with a particular emphasis on the instantaneous bandwidth, beam size, number of "spots" (defined as the angular range divided by the diffraction limited angular spread), and insertion loss.
3. Conduct preliminary measurements and become familiar with the NIST technology available for use in a complete LADAR system, which would be a significant component of a Phase II application.

4. Conclude Phase I with a report that describes, in detail, the approach to laser electro-optic scanner, including calculations and data on how the electro-optic approach will meet specifications on sweep times, angular deviation, output beam diameter, beam divergence, insertion loss, and instantaneous optical bandwidth.

Phase II activities and expected results:

1. Build an electro-optic two-dimensional scanner.
2. Test and validate the scanner within existing NIST LADAR hardware prototypes.
3. Create design concepts and develop a rapid 3D LADAR imager for commercial deployment.

On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees to work collaboratively and to provide existing information regarding tradeoffs in EO scanner performance to optimize its capabilities for 3D imaging. NIST expects to provide limited testing by incorporating any prototype EO scanners into an existing NIST LADAR imager. NIST may provide expertise in 3D LADAR imaging data acquisition and analysis.

References:

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

The design and development of standards is a long and tedious process. This process is often hampered by requirements to keep complex terminology consistent and keeping its associated information content current. The implementation and adoption of standards is slowed by the gap between the technical requirements in a standard and the technology required to implement those requirements. This SBIR subtopic seeks a software tool that will make the design and development process faster, more robust, and more integrated. The tool will be similar to a Computer Aided Software Engineering (CASE) tool, but applied to standards development and deployment. The tool will provide the following facilities 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.

The life-cycle of a standard may involve the following three broad stages [1]. First is the *development stage* where stakeholders gather within committees, prepare a draft, and come to a consensus on a final standard. The second stage is the *deployment* stage where a pilot implementation is undertaken by some consortia followed by industry wide implementation. The third stage is the *maintenance* stage where the standard is revised and maintained. A well-defined underlying information structure/model will also 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. One area in which such advancements can help is in managing the terminology contained in standards. To address this issue, we need a framework for developing a taxonomy for the terminology and concepts contained in a standard. Another way is in capturing the requirements of a standard in a formal model. A third way is to produce a standard as a structured information model, instead of a simple text document. This can be supported by additional tools to automatically verify these models for consistency, and generate other artifacts such as documents and software implementation modules. All of these will be supported by tools 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) together under a single framework, and allow them to exchange standards information in an unambiguous and efficient manner. While the focus of this project 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 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 FACTS work [4].
- Develop an export/import mechanism for the information content of a standard and associated document formats.

Phase II activities and expected results:

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

On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees to consult and provide inputs and work closely with awardees to assess their progress.

References:

1. Cargill, C.F., (2011): Why Standardization Efforts Fail, in: The Journal of Electronic Publishing.
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.

9.04.03.68-R Erbium-Based DPSS Lasers for Remote Sensing

The primary objective is to develop a narrow-band, tunable, diode-pumped solid-state (DPSS) pulsed laser system operating in the eye-safe infrared region around 1.6 micrometers in wavelength. Such laser systems are in demand for remote sensing of fugitive emissions, which can cost millions of dollars to industry, as well as for sensing and mitigation of pollutants for regulatory requirements and research. These applications demand high repetition rates (1 kHz – 10 kHz) and high-energy (>1 mJ) pulses.

Currently available commercial technologies for generating laser light in this region include telecommunications lasers using erbium-doped fibers, and optical parametric oscillators pumped by two additional laser systems. The former are limited in pulsed power output by nonlinear processes within the fiber, and the latter are complex and limit the field-portability of remote sensing instruments. The development of a system with orders of magnitude higher pulse energy than telecommunications lasers and lower complexity than optical parametric oscillator-based systems is necessary to advance these limitations.

Diode-pumped solid-state lasers using erbium ions embedded in a crystal matrix (such as YAG or YVO₄), which have emission lines in the appropriate spectral region, have been developed and demonstrated to be suitable for both high-energy and high-repetition rate pulse production[1-6]. The grantee will develop and commercialize a system, or set of systems, optimized for remote sensing applications.

The project outcome should be a turnkey, environmentally robust DPSS Er-ion based laser system with high mode quality, high pulse energy, and high repetition frequency. The pulse duration should be in the tens of nanoseconds and the linewidth should be as close to transform limited as is practical. A state-of-the-art optical parametric oscillator based system can generate pulses of several tens of mJ at a 100 Hz repetition rate when pumped with a high-power Nd:YAG [7]. The project outcome should have comparable pulse energies and have a variable repetition rate exceeding 1 kHz and not exceeding 20 kHz. The laser should be capable of being reconfigured for a variety of spectroscopic lines and targets (for example, the 1570 nm CO₂ absorption range as well as the 1645 nm CH₄ range). There should also be fine tunability of the laser to densely sample points across a typical absorption feature. This tuning could be achieved, for example, by seeding with a tunable diode laser.

Phase I activities and expected results:

- 1) Design of laser platform including material selection
- 2) Performance modeling of laser platform
- 3) Feasibility study of use of laser design for detection of CH₄ and CO₂.

Phase II activities and expected results:

- 1) Construction of laser system
- 2) Performance characterization of laser system
- 3) Environmental testing of laser system

4) Demonstration of absorption spectroscopy on at least one spectroscopic target using the laser

On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees and may consult and provide input through discussions.

References:

1. Wang, X. *et al.* Dual-wavelength Q-switched Er:YAG laser around 1.6 μm for methane differential absorption lidar. *Laser Phys. Lett.* **10**, 115804 (2013).
2. Wang, R. *et al.* Continuous-wave and Q-switched operation of a resonantly pumped U-shaped Er:YAG laser at 1617 and 1645 nm. *Laser Phys. Lett.* **10**, 025802 (2013).
3. Zhu, L., Wang, M., Zhou, J. & Chen, W. Efficient 1645 nm continuous-wave and Q-switched Er:YAG laser pumped by 1532 nm narrow-band laser diode. *Opt. Express* **19**, 26810–26815 (2011).
4. Kim, J. W., Sahu, J. K. & Clarkson, W. A. High-energy Q-switched operation of a fiber-laser-pumped Er:YAG laser. *Appl. Phys. B* **105**, 263–267 (2011).
5. Bigotta, S. & Eichhorn, M. Q-switched resonantly diode-pumped Er³⁺:YAG laser with fiberlike geometry. *Opt. Lett.* **35**, 2970–2972 (2010).
6. Chen, D.-W., Birnbaum, M., Belden, P. M., Rose, T. S. & Beck, S. M. Multiwatt continuous-wave and Q-switched Er:YAG lasers at 1645 nm: performance issues. *Opt. Lett.* **34**, 1501–1503 (2009).
7. Douglass, K. O. *et al.* Construction of a high power OPO laser system for differential absorption LIDAR. in *Lidar Remote Sens. Environ. Monit. XII SPIE* **8159**, 81590D–81590D–9 (2011).

9.04.04.63-R Precision Specimen Control for Transmission Scanning Electron Microscopy

The primary objective is to significantly extend the capabilities of the scanning electron microscope (SEM), a tool considered invaluable for characterizing materials and products in numerous forms of manufacturing. Examples range from extremely fine-scale structures found in nanoparticle production and semiconductor processing to large-scale structures used for transportation and infrastructural applications. The efficiency and quality of all manufactured products depends intimately on the ability of engineering materials to perform their intended function. Those functions are a direct result of the properties imparted upon each material due to the arrangement of its atoms over dimensional scales from sub-nanometer to several hundreds of micrometers. It is therefore critical to product manufacturing and reliability that the microscopic structure of materials be precisely measurable over those size scales.

A rapidly emerging area of material characterization makes use of the detection of electrons that have transmitted through specimens within an SEM, in order to significantly improve spatial resolution and image contrast over many conventional SEM and transmission electron microscope (TEM) methods. This approach makes use of some operational principles analogous to those used in scanning transmission electron microscopy (STEM), and is therefore sometimes termed “STEM-in-SEM”. NIST is developing SEM-based technologies that make use of transmitted electrons in ways different from TEM-based STEM imaging, resulting in a broader characterization approach we call transmission SEM, or t-SEM.

Critical to the success of developing reliable quantitative material analysis methods based on detection of transmitted electrons in the SEM is the precise control of specimen position inside the SEM chamber. Quantitative analysis requires the microscope operator to position a specimen under very precise, well-defined (in terms of crystal directions as determined by electron diffraction) incident electron beam conditions, independent of that detector’s location. Existing SEM positioning systems are insufficient for the required level of control because (i) the detector itself mounts onto the stage, precluding independent movement of the specimen, (ii) the specimen cannot be tilted eucentrically, i.e., the transmitted electron image translates unacceptably during tilting, and/or (iii) the SEM stage itself gets in the way of detectors for STEM imaging and electron backscatter diffraction (EBSD).

Successful development of the required type of specimen control in the SEM would represent a major leap forward in advancing STEM-in-SEM (t-SEM) capabilities for quantitative analysis of materials. Two major benefits to manufacturing could result: (1) a host of powerful analytical material characterization methods would be brought within reach for those presently without access to TEMs, due to budgetary or personnel constraints, and (2) a new, broader spectrum of measurements will be achievable with relatively inexpensive modifications or add-ons to existing SEM investments, as compared to state of the art TEM purchases. As a result, manufacturers may perform detailed measurements for product optimization, as well as meaningful root-cause failure analyses, both from the key perspective of structure of engineering materials.

The following five goals must be met in order to consider this project successful:

1. A method to hold a thin, fragile specimen, in the form of a circular, 3 millimeter diameter TEM grid, within an SEM, centered on the microscope’s optic axis.
2. Precise operator control over specimen x and y translation (where z coincides with the optic axis of the microscope), as well as control over the incident beam direction (i.e., specimen orientation) within the specimen coordinate system (see activity number 2 for more detail).
3. The positional control method must allow for the insertion of a STEM detector within the microscope, i.e., the specimen must reside and its position must be controllable within the available space between the bottom of the SEM pole piece and the top of the

STEM detector.

4. The positional control method must allow for the insertion of an existing EBSD camera on the microscope.
5. The positional control method, when not in use, must allow for conventional SEM studies.

Phase I activities and expected results:

NOTE: any hardware design to enable control of specimen position for transmission imaging must also allow for conventional SEM operation. In other words, since NIST's instrument is not dedicated solely to transmission SEM mode, the hardware must either: (i) be removable from the SEM, or (ii) be "placed aside" within the chamber to accommodate normal operations.

1. Specimen translation. Choose or develop a method for positioning a TEM specimen within the (x, y) plane beneath the SEM pole piece with a minimum step size of 250 nm or better. Specimen translation may be controlled either manually or in a motorized manner.
2. Specimen orientation. Choose or develop a method compatible with that in activity number 1 that allows for control of the incident electron beam direction (i.e., specimen orientation) within the specimen coordinate system via specimen manipulation; typically this is done in the field of TEM specimen control via either: (i) two orthogonal tilt axes ("double-tilt") OR (ii) one tilt axis plus one rotation axis ("tilt-rotate"). The primary tilt axis must both: (a) have a tilt sensitivity of 0.5 degree or better, and (b) lie within the thin specimen plane to maintain a practically manageable degree of eucentricity. Specimen orientation may be controlled either manually or in a motorized manner.
3. Compact design. Design the method combining control of specimen translation and incident beam direction (via e.g., double-tilt or tilt-rotate) to fit within the space between the bottom of the pole piece and the top of the inserted STEM detector. For our particular microscope and STEM detector combination (a LEO 1525 with a KE Developments 3-channel dark-field/bright-field detector), the distance between the bottom of the pole piece and top of the detector is 15 mm. From a broader commercial perspective, this distance will vary somewhat depending on the microscope manufacturer and STEM detector technology available.
4. Interface to operator. Design a port adapter and/or feed-through system that can accommodate any necessary connections external to the microscope chamber. The port adapter and/or feed-through must allow for concurrent use of an existing EBSD camera mounted beneath the EDS and WDS ports on our microscope. We have unused ports available that should allow this.

Expected results: by the end of Phase I, a design should be submitted for review by NIST. The design should be complete except for exact machining dimensions. It should describe the translation mechanism and minimum translation step size, and the mechanism for controlling incident beam direction while maintaining a manageable degree of eucentricity. The design must be feasible for incorporation into our SEM. Approximate dimensions may be provided at the end of Phase I, and refined dimensions can be addressed during Phase II.

Phase II activities and expected results:

1. Refinement of the design and construction of a prototype specimen holder/control system with port adapter and/or feed-through that fits our microscope.
2. If the Phase I design results in a novel specimen holder that is to be introduced each time transmission SEM is to be performed, determine feasibility of introducing an airlock to accommodate the holder.

Expected results: by the end of Phase II, a NIST t-SEM operator should be able to mount a TEM specimen into the new system, translate it to a desired position with 250 nm or better accuracy, observe a transmission Kikuchi electron diffraction pattern with the EBSD camera, and tilt and/or rotate the specimen to a desired crystallographic orientation. Finally, the operator must be able to observe the transmitted image with the existing STEM detector.

On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees for consultations and discussions to answer design questions and clarify any other technical aspects within the field of expertise.

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

The primary objective is to develop tools that rely on a suite of physics-based models to support accurate predictive analyses of metal-based additive manufacturing processes and products. Physics-based models must be developed in such a way to ensure reusability in a predictive environment, irrespective of product geometry. The tool will allow for accurate and reliable microstructure predictions for various geometries for a given process and material, reducing the need for empirical testing and allowing for part qualification based solely on analysis. This tool will allow industry to begin moving away from empirical testing and instead rely more on modeling and simulation, enabled primarily by measurement science underpinnings. Such a tool should:

- Provide a set of physics-based models for metal powder-bed fusion manufacturing processes.
- Demonstrate composability¹ of such models to support geometry-independent reusability. Provide ranges of parameter values for which composed models can be assumed reliable and accurate.

¹ Composability is a system design principle that deals with the interrelationships of components. A highly composable system provides recombinant components that can be selected and assembled in various combinations to satisfy specific user requirements. The essential attributes that make a component composable are: 1) it is self-

- Provide an automated or semi-automated means for composing models.
- Provide support for in situ feedback to allow for real-time adjustments during manufacture.

Industry currently relies heavily on the manufacturing of coupons to qualify metal parts created using additive manufacturing processes. Physics-based models promise to provide the ability for industry to move away from relying solely 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 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 irrespective of geometry. This tool will be an early step in allowing industry to move away from 100% testing and towards part qualification that is able to rely more on modeling and simulation.

As additive manufacturing becomes increasingly popular, 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.

The awardee(s) will 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.

Phase I activities and expected results:

contained (i.e. it can be deployed independently- note that it may cooperate with other components, but dependent components are replaceable). 2) it is stateless (i.e. it treats each request as an independent transaction, unrelated to any previous request) (see Reference [1] in Section 9.04.05.73R of this FFO.

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

Phase II activities and expected results:

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

On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees to consult, provide inputs, and work closely with awardees to assess their progress.

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. Roadmap for Additive Manufacturing: Identifying the Future of Freeform Processing, (<http://wohlersassociates.com/roadmap2009.pdf>) 2009
3. Measure Science Roadmap for Metal-based Additive Manufacturing, (http://events.energetics.com/NIST-AdditiveMfgWorkshop/pdfs/NISTAdd_Mfg_Report_FINAL.pdf), May 2013.

9.04.06.63-R Technology for Separation of Carbon Nanotubes

As an advanced material, carbon nanotubes (CNTs) hold great promise for a number of technological applications of strategic importance, including future digital electronics beyond current CMOS technology. A fundamental problem in CNT applications is the lack of purity of CNTs with well-defined electronic and optical properties. A recent NIST advancement in CNT separation has demonstrated that aqueous two-phase (ATP) extraction is a scalable and cost-effective solution to this long standing problem.

Automation of the process to enable high-resolution, multistage extraction is the key to turn the NIST finding into an industrial manufacturing process. This project calls for technology to improve resolution and speed to for CNT separations. The goal is to develop an automated technique to enable the total fractionation of a synthetic CNT mixture in a single run to allow manufactures to monitor CNT chirality distribution in their production process, and for application developers to obtain high purity CNTs in an automated and continuous way.

Phase I activities and expected results:

Feasibility study regarding the design and fabrication for small-scale (1 mg) CNT separation defined by the two specific goals listed below:

1. Single-chirality CNT separation of a synthetic mixture in a single run within 8 hrs;
2. Separating semiconducting and metallic tubes and obtaining 99.9999% semiconducting tube purity.

Phase II activities and expected results:

Fabrication and testing of a new instrument including instrument optimization, integration, and increase of throughput to achieve separation of 100 mg or higher CNT materials in a single run.

On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees to work collaboratively in providing input, discussion, evaluation of instrument performance in CNT separation and benchmarking with other CNT separation methods.

Reference:

1. C. Y. Khripin, J. A. Fagan, M. Zheng, "*Spontaneous Partition of Carbon Nanotubes in Polymer Modified Aqueous Phases*" *Journal of the American Chemical Society*, 135, 6822, (2013).

9.04.07.63-R Ultra-sensitive and Wide Dynamic Range, Cavity Ring-down Spectroscopy System for Detection of Ozone

The Standard Reference Photometer for Ozone (SRP) has met the need for an ozone standard for National Metrology Institutes (NMI) and the Environmental Protection Agency (EPA) since 1980. The instrument is based on UV optical spectroscopy and 1980's electronics. The inherent problems with this technology are long term stability, sensitivity, and noise. As we go forward, there is an unmet need for an instrument that would provide the stability, sensitivity and accuracy to become an intrinsic standard for ozone, the Primary Standard. The technology could also be somewhat downgraded to be mass produced into instruments for field use to monitor ozone in the environment, the secondary standard. NIST is interested in the development of this new instrument to replace the 1980's technology SRP with one that has better sensitivity, stability and low noise. This would produce results that are accurate and precise for the world's NMIs, and support the

regulatory and measurement needs for ozone. From this molecule, other environmentally important chemicals could also be in reach.

The project goal is to develop an ozone sensitive measurement tool with the ability to measure in the range of 0.1 micromole per mole (ppm) to 5000 micromole per mole (ppm) with an uncertainty of less than 0.5 % relative. The instrument should be stable in reading ozone from a stable source to within 0.5% over one year.

The NIST SRP is not capable of measuring ozone below 1 ppm, and thus cannot calibrate field instruments in this range. In order for NIST and other NMIs to support these measurements, a stable and reliable instrument is needed that can measure down to 0.1 ppm or lower. The uncertainty of these measurements must be low enough to accommodate the natural uncertainty expansion of secondary instruments. Thus the uncertainty must be 0.5 % relative or better.

Other industries also require ozone traceability. Emissions from process streams can be very high, and must be monitored. The upper concentration limit of the instruments must accommodate these needs as well. The upper limit of 5000 ppm was chosen to reach a majority of these applications. However, some processes go beyond even this limit, e.g. when ozone is used to sterilize components. Some needs for traceability exists for these applications as well, however they may need to be covered by a different instrument. Long term stability is required in order to demonstrate that this instrument can meet the stringent requirements of an intrinsic standard. An intrinsic standard is one that can be defined as a Primary Standard in its own right, due to the traceability of its signal to known principles that have defined uncertainties and no known biases. Therefore the concentration derived from the signal can be derived without reference to an external standard. The cavity ring-down design is one where an intrinsic standard is possible, however long term stability must be measured, and be as low as possible. The 0.5 % relative drift over one year is a maximum allowed drift for the instrument to be useful as an intrinsic standard. The instrument must also remain accurate, so that drift must be random about the true concentration of ozone.

The primary objective is to design, construct and test a cavity ring-down spectrometer suitable for measuring 1 – 5000 ppm of O₃ in air. Because of the need to span these O₃ concentrations, the spectrometer must have a wide dynamic range. This can be achieved either by probing different spectral regions of O₃ to access both relatively weak and strong absorption cross sections, through gas dilution methods, or by realizing a dynamic range of 50,000:1 or more at a given wavelength. The spectrometer should use robust, commercial single-frequency laser technology; for example distributed feedback diode lasers (DFBs) or external cavity diode lasers in the visible and/or near-infrared regions. Measurements near 600 nm could access the Chappuis-band (peak cross section of $5 \times 10^{-21} \text{ cm}^2$) yielding an absorbance of $\sim 10^{-6}$ for a 75-cm long cavity given 0.1 ppm of O₃ in air. This absorbance level would be ~ 750 times greater than the estimated detection limit assuming standard low-loss mirrors (20 ppm) and 0.02% relative uncertainty in the measured time constant. However,

at this wavelength, measurements on 5000 ppm of O₃, would require that the sample be diluted by a factor of ~500 to ensure that the sample is not optically thick. Alternatively, or in parallel the spectrometer could be operated near a wavelength of 1.8 μm, which would give a peak absorbance of $\sim 1.5 \times 10^{-5}$ for 5000 ppm and $\sim 3 \times 10^{-10}$ at 0.1 ppm. The small absorption value corresponding to 0.1 ppm would be challenging to measure, but it is within demonstrated cavity ring-down detection limits and would mean that dilution would not be required.

Phase I activities and expected results:

Phase I involves the design and construction of a laboratory table-top instrument. The principal Phase I deliverable should demonstrate O₃ detection over 0.1 – 5000 ppm range with one integrated instrument.

Phase II activities and expected results:

Phase II involves the development of a fully integrated prototype spectrometer. This system should be rack-mountable, incorporate fiber-based components when possible and be temperature-regulated (0.01 K maximum variation) to ensure long-term stability. The final prototype will include all necessary optical, gas-handling, instrument control and data acquisition systems.

NIST has extensive experience in the development and application of cavity ring-down spectroscopy for quantitative measurements of gaseous species. On a case-by-case basis, NIST may provide technical experts to work with Phase I and Phase II awardees to work collaboratively with awardees through on-site training and by using our resources to provide critical data and implement experiments to support the effort. NIST may also provide extensive consultation to ensure that the awardee is knowledgeable about the existing technology, and to make the awardee aware of the most advanced techniques in cavity ring-down spectroscopy.

Reference:

1. Potentially relevant NIST IP: U.S. Patent # 6,727,492 issued 04-27-2004.

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 Partnership 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

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 boxes must be checked):

(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 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: _____ %

(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