February 28, 2017

AMENDED NOTICE OF FUNDING OPPORTUNITY (NOFO) FOR

NIST FY 2017 SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

2017-NIST-SBIR-01

AMENDMENT 1

The National Institute of Standards and Technology (NIST) is amending its January 10, 2017 Notice of Funding Opportunity (NOFO) (2017-NIST-SBIR-01) posted on Grants.gov and on the NIST Web site (https://www.nist.gov/sites/default/files/documents/2017/01/10/fy2017_sbir_nofo_phase_i_final.pdf) that solicits applications for the NIST FY 2017 Small business Innovation Research (SBIR) Program.[1]

NIST is issuing this amendment (2017-NIST SBIR-01 Amendment 1) to the NOFO to notify the public that NIST is withdrawing Subtopic 9.03.07.63 (Steel Corrosion Detection Technology Using THz Waves: A Field-operable Unit Based on NIST Spectroscopic Technology) due to the NIST-specific nature of the spectroscopic technology. A version of the 0.1 to 1 THz wave technology pertinent to the Subtopic has been exclusively licensed by NIST, on behalf of the U.S. Government, to a third party for commercial use. Although other approaches may be feasible as envisioned in this subtopic, the field of use of the existing exclusive license poses a conflict with the technology referenced in this Subtopic. As such, Subtopic 9.03.07.63 is withdrawn from the listing of available SBIR Phase I Subtopics for the NIST FY 2017 SBIR Program. **Any applications received in response to this Subtopic, either prior to the issue of this amendment in response to the NOFO or after the issue of this amendment, will be eliminated from further review.[2]**

This change is detailed below.

[1] All page number references are to the full text of the Amended NOFO, including the revisions being made with this amendment.

[2] No applications will be returned to applicants.

#	Page Number	Section	What does the revision do?	How does the new paragraph now read?
1	66	Section 9.03 Precision Measurements	The amendment removes Subtopic 9.03.07.063 Steel Corrosion Detection Technology Using THz Waves: A Field-operable Unit Based on NIST Spectroscopic Technology.	***The following text is deleted from 2017-NIST-SBIR-01 NOFO:*** *9.03.07.63 Steel Corrosion Detection Technology Using THz Waves: A Field-operable Unit Based on NIST Spectroscopic Technology* *Corrosion of steel cost the U.S. several $100B per year. Early detection of this corrosion, most of which is buried under some kind of protective coating like concrete or polymers, would reduce this remediation cost and improve the safety of infrastructure and factories. Current detection methods cannot sense a particular corrosion product, only the presence of something, and especially at early stages when not much corrosion is present. NIST had a Corrosion Detection Innovative Measurement Science project from 2010-2014, in which a 0.1-1 Thz wave technology based on antiferromagnetic resonance (AFMR) detection was successfully developed. Two of the most common iron corrosion products, hematite and goethite, are antiferromagnetic, and thus can be detected by this method: hematite through several centimeters of concrete and goethite through similar or greater thickness polymer layers. This laboratory-based technology needs to be taken to the field in order to have practical commercial use. From talking to government and industry, there is certainly a large need for this technology and apparently a large commercial market exists, too. NIST desires to see this technology commercialized, which involves*

#	Page Number	Section	What does the revision do?	How does the new paragraph now read?
				some technical challenges in translating the laboratory technology into the field. The main technical challenges are probably using real corrosion products, getting enough power through the barrier, especially concrete layers, to see the AFMR, and locally controlling the temperature of the specific material site of interest (where the beam is impacting). *The goal of this subtopic is to demonstrate a field-operable measurement system, using 0.1 - 1 THz waves, using NIST technology, that identifies the presence of the iron corrosion compounds hematite and goethite under a variety of protective coverings, including concrete (hematite) and polymers (hematite and goethite). NIST has demonstrated this technology in the laboratory – the goal is to be able to move this technology into the field for application to corrosion detection problems in factories and physical infrastructure. To be able to detect specific iron corrosion products through protective barriers is an unmet need in the U.S.* *Phase I expected results: Demonstration of the feasibility of taking the laboratory-based technology to the field, with identification of the technical problems that need to be solved and the current equipment that is available for doing so. A plan for how the field equipment would be operated and a list of successful sample applications in the laboratory is part of the Phase I expected results.*

#	Page Number	Section	What does the revision do?	How does the new paragraph now read?
				Phase II expected results: Demonstration, in the field and on an important application, of a portable antiferromagnetic resonance –based THz system for corrosion detection of hematite and goethite. This system should be capable of being commercialized. *NIST may be available to provide technical guidance, comments and advice on design concepts, discussion of technical problems, and previous lab data.* *References: [1] R.M. Cornell and U. Schwertmann, The Iron Oxides: Structure, Properties, Reactions, Occurrences, and Uses, 2nd ed., Wiley-VCH GmbH and Co. KGaA (2000). Wiley On-line library.* *[2] S. Kim, J. Surek, and J. Baker-Jarvis, Electromagnetic Metrology on Concrete and Corrosion, Journal of Research of the National Institute of Standards and Technology 116, 655-669 (2011).* *[3] S. G. Chou, P. E. Stutzman, S. Wang, E. J. Garboczi, W. F. Engelhoff, David F. Plusquellic, High Resolution THz Optical Absorption Study of Antiferromagnetic Transitions in Hematite (α−Fe2O3), Journal of Physical Chemistry C 116, 16161-16166 (2012). DOI: 10.1021/jp3036567.* *[4] S. G. Chou, P. E. Stutzman, V. Provenzano, R. D. McMichael, J. Surek, S. Wang, S. Kim, D. F. Plusquellic, and E. J. Garboczi, Detection of the Presence of Goethite via Antiferromagnetic Resonance Using Terahertz Waves, in internal NIST*

#	Page Number	Section	What does the revision do?	How does the new paragraph now read?
				review, intended for a corrosion science journal. Preprint available upon request. *[5] E.J. Garboczi et al., "Corrosion Detection in Steel-Reinforced Concrete Using a Spectroscopic Technique," in proceedings of Quantitative Non-destructive Evaluation (QNDE 2013), Baltimore, MD.* *[6] E.J. Garboczi et al., "Measurement and Simulation of Millimeter Wave Scattering Cross-sections from Steel-Reinforced Concrete," in proceedings of Quantitative Non-destructive Evaluation (QNDE 2013), Baltimore, MD.*

FY 2017

Small Business Innovation Research (SBIR) Program

Notice of Funding Opportunity (NOFO)

ANNOUNCEMENT

FUNDING OPPORTUNITY NUMBER: 2017-NIST-SBIR-01
Amendment 1

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 of NOFO: January 10, 2017
Amendment 1 Date: February 28, 2017

Closing Date: March 30, 2017

http://www.nist.gov/sbir

Table of Contents

US DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
FY 2017 SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
NOTICE OF FUNDING OPPORTUNITY (NOFO)

1.0 PROGRAM DESCRIPTION AND FEDERAL AWARD INFORMATION

1.01 Introduction

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

Only FY 2017 Phase I applications may be submitted in response to this NOFO. **Phase II applications are not being accepted at this time**. NIST publishes a Phase II NOFO approximately 30 days prior to the end of the previous year's Phase I period of performance to request Phase II applications. That NOFO provides instructions for Phase I awardees to prepare a Phase II application and the closing date for submission of applications; only the previous year's Phase I awardees are eligible to submit a Phase II application.

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

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

The NIST FY 2017 SBIR program identifies and solicits applications in topics that fall within NIST's mission and allow collaboration between NIST scientists and the SBIR awardees whenever possible. In order to ensure a greater strategic alignment between the SBIR program and NIST's laboratory research programs, the SBIR topics are the priority areas identified in the NIST Programmatic Plan FY 2017-2019 available at: http://www.nist.gov/director/planning/planning.cfm.

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

In developing topics and subtopics and when reviewing applications, NIST gives high priority to small business concerns that participate in or conduct energy efficiency or renewable energy system R&D projects, consistent with Executive Order (EO) 13329 (http://www.gpo.gov/fdsys/pkg/FR-2004-02-26/pdf/04-4436.pdf) "Encouraging Innovation in Manufacturing," the Energy Independence and Security Act of 2007 (P.L. 110-140 § 1203(e), codified at 15 U.S.C. § 638(z)), and the Small Business Administration (SBA) SBIR Policy Directive, § 9, found at http://www.sbir.gov/sites/default/files/sbir_pd_with_1-8-14_amendments_2-24-14.pdf.

For any SBIR award for a subtopic that requires a license to use a NIST-owned invention covered by a patent or patent application, the SBIR awardee will need to contact NIST's Technology Partnerships Office for a license to use the NIST-owned invention. Such awardees will be granted a non-exclusive research license and will be given the opportunity to negotiate a non-exclusive or an exclusive commercialization license to the NIST-owned invention, in accordance with the Federal patent licensing regulations, set forth in 37 C.F.R. Part 404, and to the extent that such NIST-owned invention is available for licensing and has not otherwise been exclusively licensed to another party. It is the goal of this program to position the SBIR awardee to use and build upon such licensed NIST-owned invention with the awardee's own innovation to develop a commercially viable product based on the NIST-owned invention.

1.02 Three-Phase Program

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

The funding vehicles for NIST's SBIR program 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)(4). NIST programmatic authorities for the subtopics listed in this NOFO are found at 15 U.S.C. § 272(b) and (c). The nature of NIST's "substantial involvement" will generally be collaboration with the awardees in carrying out the scope of work. Grants and agreements administrative requirements set forth at 2 C.F.R. Part 200 will apply to NIST SBIR awards.

1.02.01 Phase I - Feasibility Research

The purpose of Phase I 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 Phase II research, a prerequisite to receiving further support in Phase II.

1.02.02 Phase II - Research and Development

All Phase I awardees under this NOFO 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 published in an NOFO approximately 30 days prior to the end of the FY 2017 Phase I performance period to request FY 2018 Phase II applications.

In Phase II, work from Phase I that exhibits potential for commercial application is further developed. Phase II is the R&D or prototype development phase. To apply for a Phase II award, each Phase I awardee 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

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

1.02.04 Commercialization Readiness Pilot Program

As allowed in Section 5123 of the SBIR/STTR Reauthorization Act of 2011, Division E of Pub. L. 112-81, codified in 15 U.S.C. § 638(gg), NIST has received authorization to establish a Commercialization Readiness Pilot Program (CRPP). NIST may provide supplemental funding (up to an additional ten percent of the Phase II award) to selected awardees after

completion of Phase II. The funding would be used to further develop Phase II technologies, to support advancement toward Phase III, and to increase the likelihood of commercialization. NIST is under no obligation to make any CRPP awards.

1.03 SBIR Applicant Eligibility and Limitations

1.03.01 Applicant Qualifications

Each applicant must qualify as a small business concern for R/R&D purposes, as defined in Section 1.05 of this NOFO, at the time of award. In addition, the primary employment of the principal investigator must be with the small business at the time of the award and during the conduct of the proposed research. Primary employment means that more than one-half of the principal investigator's time is spent working with the small business. Primary employment with a small business precludes full-time employment with another organization. Occasionally, deviations from this requirement may occur, which must be approved in writing by the NIST Grants Officer after consultation with the SBIR Program Manager. Further, a small business may only replace the principal investigator on an SBIR Phase I award if the NIST Grants Officer provides prior written approval. Personnel obtained through a Professional Employer Organization or other similar personnel leasing company may be considered employees of the awardee.

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

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

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

Each applicant will be required to provide certain information via www.SBIR.gov as well

as other information required by the SBIR Policy Directive (see Appendices V-VI). Each SBC applying for an award is required to update the appropriate information in the SBA Tech-Net database on SBIR.gov for any of its existing and prior Phase II awards.

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

The statement of work of an SBIR award awarded under this NOFO cannot overlap with the statement of work of an existing NIST Cooperative Research and Development Agreement (CRADA) with the awardee. NIST will consider the issue of any potential overlap on a case-by-case basis.

1.03.02 Company Registry Requirements

SBA maintains and manages a Company Registry at http://www.sbir.gov/registration to track ownership and affiliation requirements for all companies applying to the SBIR Program. **Each Phase I applicant must register in the Company Registry prior to submitting an application. The applicant must save its information from the registration in a .pdf document and append this document to SF-424 form as described in Section 8.01.9 of this NOFO.** All applicants are required to report and/or update their registration information in the SBA Company Registry prior to each SBIR application submission or if any information changes prior to an award.

1.03.03 Performance Benchmark Ratings Requirements

All Phase I applicants with a current Small Business Administration (SBA) assessment of their *Phase I to Phase II Transition Rate* must at the time of the award have satisfied the requirements of that Performance Benchmark to be eligible for a new Phase I award. NIST will not consider proposals from firms that are currently ineligible for Phase I awards as a result of failing to meet the benchmark rate at the last assessment.

The *Phase I to Phase II* ***Transition Rate*** requirement applies only to SBIR Phase I applicants that have received more than 20 (21 or more) Phase I awards over the past 5 fiscal years (excluding the most recent year). For these applicants, the ratio of the number of Phase II awards (awarded during the past 5 fiscal years) to the number of Phase I awards (awarded during the past 5 years excluding the most recent year) must be at least 0.25. For the purposes of this NOFO, the applicable five fiscal year period is fiscal year 2011 to fiscal year 2015. On June 1st of each year, the SBA) assesses the Performance Benchmark rates for all applicable SBIR and Small Business Technology Transfer (STTR) awardees in the Company Registry. STTR is another program that expands funding opportunities in the federal innovation research and development arena. See https://www.sbir.gov/about/about-sttr.

Performance Benchmark rates are based on a company's total SBIR/STTR awards, across all the participating agencies. Companies that fail to meet the Performance Benchmark requirements are not eligible to receive a Phase I award for a period of one year from the assessment: from June 1st through May 31st. Note that this does not affect a company's eligibility for Phase II or Phase III awards.

The ***Commercialization Rate*** is not applicable for FY 2017. When in effect, the ***Commercialization Rate*** requirement applies to SBIR and STTR Phase I applicants that have received more than 15 (16 or more) Phase II awards over the past 10 fiscal years, excluding the last two years. These companies must have realized, to date, an average of at least $100,000 of sales and/or investments per Phase II award (awarded during this period), 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.

SBA sends three notifications each year to companies affected by the benchmark performance requirements:
February 1st – SBA identifies and notifies via email all companies that, on that date, have won enough past awards to be subject to the benchmark requirements.
April 1st – SBA runs a preliminary assessment to determine which companies appear to be failing a benchmark given the data in the system on that date. SBA sends a Warning Notice to these companies so that they can review the award in the Company Registry (SBIR.gov) and update as needed.
June 1st – SBA identifies companies that fail a benchmark and notifies them that they may not be eligible to receive a new Phase I award for a period of one year.

NOTE: Before responding to this NOFO, all applicants should verify their *Transition Rate* eligibility for Phase I awards. When logged in to the Company Registry at https://www.sbir.gov/registration, awardees can view their last assessed *Transition Rate* by clicking on the "Performance Benchmark" side-bar. These company-specific rates appear under the heading "At Last Assessment." A thumbs-up/thumbs-down indicator shows whether or not the company passed the benchmark rates at the last assessment. If at any time, a company believes the award information on SBIR.gov is not correct, it should notify SBA using the *dispute* link provided. If a company's dispute of the data used for the rates is under review, it will see "TBD" under the "At Last Assessment" heading. Companies with less than the threshold number of awards (21 Phase I awards for the Transition Rate a) will see "N/A" displayed because the requirement did not apply to them.

Under the heading "Current (On-Going)", the page displays a running calculation of the benchmark rates using the next years' time periods (each period moved up by one year) and current data in the system. Companies should monitor these rates to anticipate their standing for each upcoming June 1 Assessment. Prior to proposal preparation, all applicants

to this NOFO that have received more than 20 Phase I awards across all federal SBIR/STTR agencies over the past five (5) years should verify that their company will not have a failing status on the *Transition Rate* Benchmark at the time of award.

Performance Benchmarks: (General information on the Performance Benchmark requirements is available at https://www.sbir.gov/performance-benchmarks.)

1.04 Contact with NIST

In the interest of competitive fairness, all oral or written communication with NIST regarding Section 9.0 Research Topics during the Phase I open NOFO period - with the exception of the public Question and Answer site located at http://www.nist.gov/sbir, is prohibited. Questions may be submitted through the NIST SBIR website, and all responses will be publicly, though anonymously, posted on the web site. Questions and answers will not be accepted through nor posted on Grants.gov.

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 NOFO.

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

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

Subject Area	Point of Contact
	Grants.gov Phone: 800-518-4726 E-mail: support@grants.gov
Grant Rules and Regulations	Nuria Martinez Phone: (301) 975-6215 Fax: (301) 975-8884 E-mail: nuria.martinez@nist.gov

1.05 Definitions

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

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

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

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

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

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

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

or award, regardless of the funding source.

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

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

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

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

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

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

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

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

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

Subaward – See 2 C.F.R. § 200.92.

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

1.06 Fraud, Waste and Abuse

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

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

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

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

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

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

(vi) extravagant, careless, or needless spending;

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

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

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

Report any allegations of fraud, waste and abuse using the online Complaint Form to:

E-mail:
Hotline@oig.doc.gov
Note: Because the Internet is not secure, it is possible, though unlikely, that e-mail complaints may be read by persons other than your intended source. If you are concerned about this, you may choose to mail or call. Please do not include Personally Identifiable Information (PII) through the website or via e-mail. PII is considered to be items containing Social Security numbers, dates of birth, credit card and passport numbers, or other personally identifying information that could adversely affect an individual. E-mails and web submissions containing such information will be blocked by our system administrator and will not be processed by our Complaint Department. Should you desire to provide this information, please contact the Hotline by telephone at the numbers listed below.

Phone:
Toll Free 800-424-5197
In the DC metro area 202-482-2495
TTD Toll Free 855-860-6950
TTD in the DC metro area 202-482-5923

Mail:
Office of Inspector General
Complaint Intake Unit, Mail Stop 7886
1401 Constitution Avenue, N.W.
Washington, DC 20230

Fax:
855-569-9235

2.0 CERTIFICATIONS

2.01 Funding Agreement Certification

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

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

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

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

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

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

(1) Intervention includes both physical procedures by which data are gathered and manipulations of the subject or the subject's environment that are performed for research purposes.

(2) *Interaction* includes communication or interpersonal contact between investigator and subject.

(3) *Private information* includes information about behavior that occurs in a context in which an individual can reasonably expect that no observation or recording is taking place, and information which has been provided for specific purposes by an individual and which the individual can reasonably expect will not be made public (for example, a medical record). Private information must be individually identifiable (i.e., the identity of the subject is or may readily be ascertained by the investigator associated with the

information) in order for obtaining the information to constitute research involving human subjects.

See 15 C.F.R. § 27.102 (Definitions).

1) **Requirement for Federalwide Assurance.** If the application is accepted for [or awarded] funding, organizations that have an Institutional Review Board (IRB) are required to follow the procedures of their organization for approval of exempt and non-exempt research activities that involve human subjects. Both domestic and foreign organizations performing non-exempt research activities involving human subjects will be required to have protocols approved by a cognizant, active IRB currently registered with the Office for Human Research Protections (OHRP) within the DHHS that is linked to the engaged organizations. All engaged organizations must possess a currently valid Federalwide Assurance (FWA) on file from OHRP. Information regarding how to apply for an FWA and register an IRB with OHRP can be found at http://www.hhs.gov/ohrp/assurances/index.html. NIST relies only on OHRP-issued FWAs and IRB Registrations for both domestic and foreign organizations for NIST supported research involving human subjects. NIST will not issue its own FWAs or IRB Registrations for domestic or foreign organizations.

2) **Administrative Review.** The NIST Human Subjects Protection Office (HSPO) reserves the right to conduct an administrative review[3] of all applications that potentially include research involving human subjects and were approved by an authorized non-NIST institutional entity (an IRB or entity analogous to the NIST HSPO) under 15 C.F.R. § 27.112 (Review by Institution). If the NIST HSPO determines that an application includes research activities that potentially involve human subjects, the applicant will be required to provide additional information to NIST for review and approval. The documents required for funded proposals are listed in each section below. Most documents will need to be produced during the proposal review process; however, the Grants Officer may allow final versions of certain required documents to be produced at an appropriate designated time post-award.

[3] Conducting an "administrative review" means that the NIST HSPO will review and verify the performing institution's determination for research not involving human subjects or exempt human subjects research. In addition, for non-exempt human subjects research, the NIST HSPO will review and confirm that the research and performing institution(s) are in compliance with 15 C.F.R. Part 27, which means HSPO will 1) confirm the engaged institution(s) possess, or are covered under a Federalwide Assurance, 2) review the research study documentation submitted to the IRB and verify the IRB's determination of level of risk and approval of the study for compliance with 15 C.F.R. Part 27, 3) review and verify IRB-approved substantive changes to an approved research study before the changes are implemented, and 4) review and verify that the IRB conducts an appropriate continuing review at least annually.

Research involving human subjects may not start until the NIST Grants Officer issues an award explicitly authorizing such research. In addition, all amendments, modifications, or changes to approved research and requests for continuing review and closure will be reviewed by the NIST HSPO.

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

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

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

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

Research not involving human subjects. If an activity/task is determined to be research and involves human subjects, but is determined to be *not human subjects research* (or *research not involving human subjects*) under the Common Rule, the following information may be requested for that activity/task:

(1) Justification, including the rationale for the determination and such additional documentation as may be deemed necessary by NIST to review and/or support a determination that the activity/task in the application is not research as defined in the Common Rule.
(2) If the applicant participant(s) used a cognizant IRB that provided a determination

that the activity/task is research not involving human subjects, a copy of that determination documentation must be provided to NIST. The applicant participant(s) is not required to establish a relationship with a cognizant IRB if they do not have one.

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

(1) The name(s) of the institution(s) where the exempt research will be conducted.
(2) The name(s) of the institution(s) providing the biological materials or data from human subjects.
(3) A copy of the protocol for the research to be conducted; and/or the biological materials or data from human subjects to be collected/provided, not pre-existing samples (*i.e.,* will proposed research collect only information without personal identifiable information, will biological materials or data be de-identified and when and by whom was the de-identification performed, how were the materials or data originally collected).
(4) For pre-existing biological materials or data from human subjects, provide copies of the consent forms used for collection and a description of how the materials or data were originally collected and stripped of personal identifiers. If copies of consent forms are not available, explain.
(5) Any additional clarifying documentation that NIST may deem necessary in order to make a determination whether the activity/task or use of biological materials or data from human subjects is exempt under the Common Rule.

Research review with an IRB. If the application appears to NIST to include research activities (exempt or non-exempt) involving human subjects, and the proposed performer of the activity has a cognizant IRB registered with OHRP, and linked to their Federalwide Assurance, the following information may be requested during the review process:

(1) The name(s) of the institution(s) where the research will be conducted.
(2) The name(s) and institution(s) of the cognizant IRB(s), and the IRB registration number(s).
(3) The FWA number of the applicant linked to the cognizant IRB(s);

(4) The FWAs associated with all organizations engaged in the planned research activity/task, linked to the cognizant IRB.
(5) If the IRB review(s) is pending, the estimated start date for research involving human subjects.
(6) The IRB approval date (if currently approved for exempt or non-exempt research).
(7) If any of the engaged organizations has applied for or will apply for an FWA or IRB registration, those details should be clearly provided for each engaged organization.

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

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

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

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

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

2.03 Research Applications Involving Live Vertebrate Animals or Pre-Existing Cell Lines/Tissues From Vertebrate Animals

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

1) **Administrative Review.** NIST reserves the right to conduct an administrative review[4] of all applications that potentially include research activities that involve live vertebrate animals, or custom samples from, or field studies with live vertebrate animals. If the application includes research activities, field studies, or custom samples involving live vertebrate animals, the applicant will be required to provide additional information for review and approval. In addition, NIST will verify the applicant's determination(s) of excluded samples from vertebrate animals. The documents required for funded proposals are listed in each section below. Some may be requested for a pre-review

[4] Conducting an "administrative review" means that the NIST HSPO will review and verify the performing institution's IACUC's approval of research with live vertebrate animals, and confirm that the research and performing institution(s) have an appropriate assurance and are in compliance with applicable regulations. HSPO will 1) confirm the engaged institution(s) possess, or are covered under an applicable assurance, 2) review the research study documentation submitted to the IACUC and verify the IACUC's determination of level of risk and approval of the study for compliance with applicable regulations, 3) review and verify IACUC-approved substantive changes to an approved research study before the changes are implemented, and 4) review and verify that the IACUC receives an annual report for the study and conducts an appropriate continuing review at least every three years.

during the proposal review process; however, the Grants Officer may allow final versions of certain required documents to be produced at an appropriate designated time post-award. If an award is issued, no research activities involving live vertebrate animals shall be initiated or costs incurred for those activities under the award until the NIST Grants Officer issues written approval. In addition, all re-approvals, amendments, modifications, changes, annual reports and closure will be reviewed by NIST.

2) Required documents for NIST proposal review. ***The applicant should clearly indicate in the application, by separable task, all research activities believed to include research involving live vertebrate animals and the institution(s) where the research activities involving live vertebrate animals may be conducted. In addition, the applicant should indicate any activity/task that involves an excluded or custom collection from vertebrate animals, or a field study with animals.***

a) **Excluded Collections from Vertebrate Animals:** The requirements for review and approval by an Institutional Animal Care and Use Committee (IACUC) 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 or pre-existing items from animal material suppliers (*e.g.,* tissue banks), such as pre-existing cell lines and tissue samples, or from commercial food processors, where the vertebrate animal was euthanized for food purposes and not for the purpose of sample collection.

For pre-existing cell lines and tissue samples originating from vertebrate animals, NIST requires that the proposer provide documentation or the rationale for the determination that the cell line or tissue is pre-existing and not a custom collection from live vertebrate animals for an activity/task within the proposal. NIST may require additional documentation to review and/or support the determination that the cells and/or tissues from vertebrate animals are excluded from IACUC review.

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

c) **Field Studies of Animals:** Some field studies of animals may be exempt under the Animal Welfare Act from full review and approval by an animal care and use committee, as determined by each institution. Field study is defined as "*… a study*

conducted on free-living wild animals in their natural habitat...". 9 C.F.R. § 1.1. However, this term excludes any study that involves an invasive procedure or that harms or materially alters the behavior of an animal under study. Field studies, with or without invasive procedures, may also require obtaining appropriate federal or local government permits (marine mammals, endangered species, etc.). If the applicant's institution requires review and approval by an animal care and use committee, NIST will require that documentation to be provided as described below.

d) **For custom collections or studies with live vertebrate animals that require review and approval by an animal care and use committee the following documentation is required:**

(1) **Requirement for Assurance.** An applicable assurance for the care and use of the live vertebrate animal(s) to be used in the proposed research is required. NIST may request documentation to confirm an assurance, if adequate confirmation is not available through an assuring organization's website. The cognizant IACUC where the research activity is located may hold one or more assurances applicable to the research activity that are acceptable to NIST. These three assurances are:

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

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

1. The name(s) of the institution(s) where the research involving live vertebrate animals will be conducted and/or custom samples collected.
2. The assurance type and number, as applicable, for the cognizant Institutional Animal Care and Use Committee (IACUC) where the research activity is located. [For example: Animal Welfare Assurance from the Office of Laboratory Animal Welfare (OLAW) should be indicated by the OLAW assurance number, i.e. A-1234; an USDA Animal Welfare Act certification should be indicated by the certification number i.e. 12-R-3456; and an Association for the Assessment and Accreditation of Laboratory Animal Care (AAALAC) should be indicated by AAALAC.]

3. The IACUC approval date for the Animal Study Protocol (ASP) (if currently approved).
4. If the review by the cognizant IACUC is pending, the estimated start date for research involving vertebrate animals.
5. If any assurances or IACUCs need to be obtained or established, that should be clearly stated.
6. If any special permits are required for field studies, those details should be clearly provided for each instance, or indicated as pending.

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

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

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

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

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

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

In accordance with Federal appropriations law, an authorized representative of the selected applicant(s) may be required to provide certain pre-award certifications regarding federal

felony and federal criminal tax convictions, unpaid federal tax assessments, and delinquent federal tax returns.

3.0 APPLICATION PREPARATION INSTRUCTIONS AND REQUIREMENTS

3.01 Phase I Application Requirements

Only FY 2017 Phase I applications may be submitted in response to this NOFO. **Phase II applications are not being accepted at this time**. NIST publishes a Phase II NOFO approximately 30 days prior to the end of the previous year's Phase I period of performance to request Phase II applications. That NOFO provides instructions for Phase I awardees to prepare a Phase II application and the closing date for submission of applications. To reiterate, only the previous year's Phase I awardees are eligible to submit a Phase II application.

The application must provide sufficient information to demonstrate that the proposed work represents a sound approach to the investigation of an important scientific or engineering innovation worthy of support. The application must sufficiently address the applicable subtopic in Section 9. 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 (see Sections 4.02 and 8.01).

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

NIST reserves the right to not submit an application for technical review if NIST determines the application has insufficient scientific and technical information, fails to comply with the administrative procedures as outlined in the applicable Screening Criteria in Section 4.02, or is missing any of the required forms and documents listed in Section 8.01.

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

- Any business concern or subsidiary established for the commercial application of a product or service for which an SBIR award is made.

- Revenue from the sale of new products or services resulting from the research conducted under each Phase II award.
- Additional investment from any source, other than Phase I or Phase II awards, to further the research and development conducted under each Phase II award.
- Updated information in the SBA Tech-Net database on sbir.gov for any prior award received by the SBC. The SBC may apportion sales or additional investment information relating to more than one Phase II award among those awards, if it notes the apportionment for each award.

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

3.02 Phase I Application

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

An applicant may submit one application on multiple subtopics or more than one application on one subtopic under this NOFO. 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. Applications on multiple subtopics or multiple applications to the same subtopic must be clearly differentiated.

The Technical Proposal, both the Cover Sheet and Technical Content, is limited to 25 pages. The only exception to the 25-page limit is for applicants covered by the provision for Prior SBIR Phase II Awards (Section 3.02.02 (14)). Additional pages beyond the 25-page limit will not be considered in the evaluation process. Pages should be of standard size (8 1/2” x 11”; 21.6 cm x 27.9 cm) with margins of 2.5 cm and type at least 10-point font. All units of measurement should be presented in metric units.

The Technical Proposal portion of the application requires the following:
(a) Cover Sheet (3.02.01) pages 1 and 2, and
(b) Technical Content (3.02.02) pages 3 through 25.

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

3.02.01 Cover Sheet

A completed Cover Sheet (*see* Appendix A of this NOFO) is a required part of the Technical Proposal. The Cover Sheet is counted as pages 1 and 2 of the Technical Proposal.

If an applicant checks 'Yes' on #11, the applicant's contact information will be provided to the NIST Hollings Manufacturing Extension Partnership (MEP). Such applicants may be contacted by your local MEP to explore business-related support services that could potentially benefit the applicant's proposed project.

The applicant must provide in the space available on the Cover Sheet an abstract (limited to 200 words) and summary of potential commercial application of the research results (limited to 100 words). Each applicant's abstract and summary of potential commercial applications will be provided to the SBA and should not contain proprietary information. Awardee's abstract and summary of potential commercial applications will be published on the NIST SBIR website and www.sbir.gov.

3.02.02 Technical Content

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

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

(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 any third party research assistance would materially benefit the proposed effort and that arrangements for such assistance are in place at time of application submission.

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

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

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

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

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

3. Subawards - As the funding instrument used in this program is financial assistance, an awardee might pass through funds to another organization to carry out part of the

Federally-supported project. A "subaward" relationship fits the circumstances more appropriately than a contract to carry out part of the Federally-supported project. *See* 2 CFR §§ 200.92 (subaward), 200.93 (subrecipient), and 200.330 (Subrecipient and contractor determinations), respectively.

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.

(9) Potential Commercial Application. A program goal is to provide opportunities for small businesses to convert research into technological innovation in the private sector. All proposed research should have some potential commercial outcome. 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. Include any optional letters of support and relevant supporting material such as references to journal articles, literature, or government publications. Provide any indicators of commercial potential and 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(s).

(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 beyond the SBIR award. Describe the existence of any outside, non-SBIR funding or partnering commitments including any Phase II funding commitments from private sector or non-SBIR funding sources and/or the existence of Phase III follow-on commitments for the subject research.

(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 NOFO cannot overlap with the statement of work of an existing CRADA with any federal agency, including NIST, with the awardee. NIST will consider whether there is any overlap on a case by case basis.

(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 and is not considered under an evaluation factor in consideration of Phase I applications.

(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 a funding agreement requiring essentially equivalent work to an SBIR award (*see* 15 U.S.C. § 638(bb)(3)).** If there is any question concerning this, it must be disclosed to the soliciting agency or agencies before award.

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

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

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

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

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

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

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

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

(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 the following information 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 information will not be counted toward the 25-page Technical Proposal limitation.

4.0 METHOD OF SELECTION AND EVALUATION CRITERIA

4.01 Introduction

All applications will be evaluated and judged on a competitive basis. Applications will be evaluated based only on information provided in the application. Applications will be initially screened to determine responsiveness, eligibility, and completeness (see Sections 4.02 and 8.01). Applications passing these initial screenings will be technically evaluated in accordance with the evaluation criteria (see Section 4.03). Each application will be judged on its own merit. NIST is under no obligation to fund any application or any specific number of applications in a given topic. NIST may elect to fund several or none of the applications for the same topic or subtopic. If an application is submitted for a subtopic that requires a license to use a NIST-owned invention covered by a patent or patent application and such NIST-owned invention has become unavailable for licensing prior to the close of this NOFO in the field of use relevant to the subtopic, NIST has the sole discretion to deem such application ineligible under the subtopic.

4.02 Phase I Screening Criteria

Please carefully read the entire NOFO and review the following Phase I Screening Criteria to assure that your application meets NIST requirements. Phase I applications that do not satisfy all the screening criteria will not be reviewed and will be eliminated from consideration for award. However, NIST, in its sole discretion, may continue the review process for an application that is missing minor non-substantive information, the absence of which may easily be rectified. The screening criteria are:

(1) The application must be received by NIST before the deadline specified in Section 6.01.

(2) The proposing firm must qualify as eligible according to the criteria provided in Section 1.03.

(3) The Phase I application must include all required forms and documents listed in Section 8.01:

i) SF-424, Application for Federal Assistance
ii) SF424A, Budget Information – Non-Construction Programs
iii) SF-424B, Assurances – Non Construction Programs
iv) CD-511, Certification Regarding Lobbying
v) SF-LLL – Disclosure of Lobbying Activities (if applicable)

vi) Technical Content – see Section 3.02
    a. Cover Sheet – see Section 3.02.01
    b. Technical Proposal – see Section 3.02.02
vii) Budget Narrative – see Section 8.01.7
viii) Indirect Cost Rate Agreement – see Section 8.01.8
ix) SBA Company Registry Form – see Section 8.01.9
x) Data Management Plan -see Section 8.01.10

(4) The Phase I application must be submitted only under one of the subtopics in Section 9 and must clearly addresses research for that subtopic.

(5) The Phase I total proposed budget must not exceed $100,000. For Phase I, a minimum of two-thirds of the research and/or analytical effort must be performed by the awardee. The total cost for all consultant fees, facility leases, usage fees, and other subcontract/subaward or purchase agreements may not exceed one-third of the total award (Section 1.03).

(6) The feasibility research duration for the Phase I project must not exceed 6 months.

(7) If an application is submitted for a subtopic that requires a license to use a NIST-owned invention covered by a patent or patent application, the relevant NIST-owned invention must be available for licensing prior to the close of this NOFO in the field of use relevant to the subtopic.

4.03 Phase I Evaluation Criteria

Phase I applications that comply with the screening criteria in Section 4.02 will undergo an internal, two-step scored review process.

Step 1: Technical Review. The applications will be evaluated by three reviewers in accordance with the following, equally weighted criteria, on a scale of 1 to 5:

(1) The soundness of the technical approach to the proposed research.

(2) The likelihood the proposed effort will result in significant results leading to a product within the subtopic.

(3) The likelihood the proposed approach will contribute toward the field of study of the subtopic.

(4) Qualifications of the proposed principal/key investigators, supporting staff, and

consultants as they relate to accomplishing the proposed research effort.

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

Applicants should be specific and clear when writing their applications and not assume information not clearly spelled out can be inferred by the reviewer. No technical clarifications may be made after application submission. The Selecting Official will determine the average score above which applications will be considered "technically superior." Applications not rated as technically superior will not be considered further.

Step 2: Evaluation Panel. A panel composed of at least three (3) NIST employees will review the content of applications rated as technically superior in Step 1, score them based on the following evaluation factors, and by consensus develop a final ranking:

(1) The 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 optional letters of support and references to journal articles, literature, and Government publications). (10 points)

(2) The SBIR program priorities including manufacturing-related research; energy efficiency or renewable energy; participation by woman-owned and socially and economically disadvantaged SBCs, and SBCs from HUBZones or under-served states. (5 points)

4.04 Phase I Award Selections

Final selection decisions will be made by the Selecting Official, the Director of the NIST Technology Partnerships Office, or designee, based upon scores assigned by the technical reviewers and the rankings assigned by the panel, diversity across the sub-topics and participants, possible duplication of other federally-funded research, and the availability of funding. The Selecting Official will give preference to applicants that have received fewer than 20 SBIR awards in the past. In the event of a "tie" between applications, manufacturing-related projects, as well as those regarding energy efficiency and renewable energy system will receive priority in the award selection process. NIST may select some, all, or none of the applications, or part(s) of any particular application. Subsequent to the assessment and prior to award, NIST may ask for supplemental information and may negotiate the scope and amount of the award. The final approval of selected applications

and issuance of awards will be by the NIST Grants Officer. The award decisions of the NIST Grants Officer are final.

4.04.01 Federal Awarding Agency Review of Risk Posed by Applicants

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

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

4.04.02 Release of Proposal Review Information

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

5.0 CONSIDERATIONS

5.01 Awards

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

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

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

Contingent upon availability of funds, NIST anticipates making a total number of approximately twelve (12) Phase I awards of no more than $100,000 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 24 months. One year after completing the R&D activity, the awardee shall be required to report on its commercialization activities. The total period of performance for Phase II is 36 months.

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

Funding for the program listed in this NOFO is contingent upon the availability of appropriations. In no event will NIST or DoC be responsible for application preparation costs. This NOFO 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 NOFO 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 performance (technical) report covering the award's first three months during the fourth month of the period of performance, and a final report seven months after the start of the award.

Performance (technical) 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 the plan. Inclusion of proprietary information within the performance (technical) reports and final report may be necessary in order to effectively communicate progress and gain appropriate consultation from NIST experts regarding next steps. All such proprietary information must be marked by the awardee according to instructions provided in Section 5.04.02.(d)(1).

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

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."

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

DOC policy requires that in the usual case, non-Federal entities time advance payment requests so that Federal funds are on hand for a maximum of three calendar days before being disbursed by the non-Federal entity for eligible award costs. In no case should advances exceed the amount of cash required for a 30-day period.

5.04 Innovations, Inventions and Patents

5.04.01 Proprietary Information Proposals

Information contained in unsuccessful proposals will remain the property of the applicant. The Government may, however, retain copies of all proposals. Public release of information in any proposal submitted will be subject to existing statutory and regulatory requirements. If proprietary information is provided by an applicant in a proposal, which constitutes a

trade secret, proprietary commercial or financial information, confidential personal information or data affecting the national security, it will be treated in confidence, to the extent permitted by law. This information must be clearly marked by the applicant with the term "confidential proprietary information" and the following legend must appear on the title page of the proposal:

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

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

5.04.02 Rights in Data Developed Under SBIR Funding Agreements

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

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

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

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

"Data" means recorded information, regardless of form or the media on which it may be recorded. The term includes technical data and computer software. The term does not include information incidental to contract administration, such as financial, administrative, cost or pricing or management information.

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

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

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

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

"Technical data" means recorded information (regardless of the form or method of the recording) of a scientific or technical nature (including computer databases and computer software documentation). This term does not include computer software or financial, administrative, cost or pricing, or management data or other information incidental to contract administration. (*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) section regarding copyright, the Government shall have unlimited rights in—

(i) Data specifically identified in this award as data to be delivered without restriction;
(ii) Form, fit, and function data delivered under this award;
(iii) Data delivered under this award (except for restricted computer software) that constitute manuals or instructional and training material for installation, operation, or routine maintenance and repair of items, components, or processes delivered or furnished for use under this award; and
(iv) All other data delivered under this award unless provided otherwise for SBIR data in accordance with paragraph (d) of this clause or for limited rights data or restricted computer software in accordance with paragraph (f) of this clause.

(2) The Awardee shall have the right to—

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

(c) ***Copyright*****.**

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

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

Government. For computer software, the Awardee grants to the Government, and others acting on its behalf, a paid-up, nonexclusive, irrevocable, worldwide license in such copyrighted computer software to reproduce, prepare derivative works, and perform publicly and display publicly, by or on behalf of the Government.

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

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

(d) *Rights to SBIR data*.

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

SBIR Rights Notice

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

(End of notice)

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

(e) ***Omitted or incorrect markings***.

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

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

(i) Identifies the data to which the omitted notice is to be applied;
(ii) Demonstrates that the omission of the notice was inadvertent;
(iii) Establishes that the use of the proposed notice is authorized; and
(iv) Acknowledges that the Government has no liability with respect to the disclosure or use of any such data made prior to the addition of the notice or resulting from the omission of the notice.

(3) If the data has been marked with an incorrect notice the Grants Officer may—

(i) Permit correction, at the Awardee's expense, if the Awardee identifies the data and demonstrates that the correct notice is authorized, or
(ii) Correct any incorrect notices.

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

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

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

5.04.03 NIST-Owned Inventions

Awardees will not have any automatic rights to make, use or sell products or services incorporating NIST-owned inventions. For any SBIR award for a subtopic that requires a license to use a NIST-owned invention covered by a patent or patent application, the SBIR awardee will be required to contact NIST's Technology Partnerships Office for a patent license for research or for commercial use.

Such awardees will be granted a non-exclusive research license and will be given the opportunity to negotiate a non-exclusive or an exclusive commercialization license to the NIST-owned invention, in accordance with the Federal patent licensing regulations, set forth in 37 C.F.R. Part 404, and to the extent that such NIST-owned invention is available for licensing and has not otherwise been exclusively licensed to another party.

5.04.04 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 NOFO; however, cost sharing is not required and will not be considered in evaluation of applications.

5.06 Profit or Fee

A reasonable profit or fee not to exceed 7% is allowed.

5.07 Joint Ventures or Limited Partnerships

See 13 C.F.R. § 121.103(h). Joint ventures and limited partnerships are eligible, provided the entity created qualifies as a small business as defined in this NOFO. 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. The total cost for all consultant fees, facility leases, usage fees, and other subcontract/subaward or purchase agreements may not exceed one-third of the total award. For Phase II, a minimum of one-half of the research and/or analytical effort, per Section 1.03, must be performed by the applicant. The total

cost for all consultant fees, facility leases, usage fees, and other subcontract/subaward or purchase agreements may not exceed one-half of the total award.

5.09 Awardee Commitments

Upon award of a funding agreement, the awardee will be required to make certain legal commitments through acceptance of numerous Special Award Conditions (SAC) in the funding agreement. Awards also will be governed by the Department of Commerce Financial Assistance Standard Terms and Conditions (December 2014), Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards at 2 C.F.R. Part 200, adopted by the Commerce Department through 2 C.F.R. § 1327.101; when applicable, 48 C.F.R. Subpart 31.2, Contracts with Commercial Organizations; and the DoC Pre-Award Notification Requirements for Grants and Cooperative Agreements, 79 FR 78390 (December 30, 2014).

Section 5.10 describes 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 and Phase II funding agreements and is not the specific wording of such terms and conditions.

5.10 Summary Statements

The following statements apply to Phase I and Phase II awards and 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* 2 C.F.R. § 200.336.

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

(3) Non-Discrimination. The awardee will be required to comply with statutory and other non-discrimination requirements. No person in the United States shall, on the ground of race, color, national origin, handicap, age, religion, or sex, be excluded from participation in, be denied the benefits of, or be subject to discrimination under any program or activity

receiving Federal financial assistance. *See* Department of Commerce Financial Assistance Standard Terms and Conditions, Section K.

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

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

5.11 Additional Information

If there is any inconsistency between the information contained herein and the terms of any resulting SBIR funding agreement, the terms of the funding agreement are controlling. Before award of a SBIR funding agreement, the Government may request the applicant to submit certain organizational, management, personnel, and financial information to assure responsibility of the applicant.

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

This program NOFO 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 NOFO, a representative of the awardee will be required to certify that the concern has not previously been, nor is currently being, paid for essentially equivalent work by any Federal agency.

The responsibility for the performance of the principal investigator, and other employees or consultants who carry out the proposed work, including those of

subrecipients or contractors, lies with the management of the organization receiving an award.

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

5.12 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 affirmatively to the statement (#11) about MEP on the Cover Sheet.

6.0 SUBMISSION OF APPLICATIONS

6.01 Deadline for Applications

Phase I applications must be received no later than 11:59 p.m. Eastern Time, Thursday, March 30, 2017. Only electronic applications submitted via Grants.gov will be accepted.

Applicants should be aware, and factor in their application submission planning, that the Grants.gov system is expected to be closed for routine maintenance at these times: from 12:01 a.m. Eastern Time, Saturday January 21, 2017 until 6:00 a.m. Eastern Time, Monday, January 23, 2017; and again from 12:01 a.m. Eastern Time, Saturday, February 18, 2017 until Tuesday, February 21, 2017 at 6:00 a.m. Eastern Time; and also from 12:01 a.m. Eastern Time, Saturday, March 18, 2017 until Monday, March 20, 2017 at 6:00 a.m. Eastern Time, and that applications cannot be submitted during those time spans.

Applicants are cautioned to be careful of unforeseen delays that can cause late arrival of applications, with the result that they **will not** be forwarded for evaluation.

Applications not received by the specified due date and time, as recorded by Grants.gov, or

that do not adhere to the other requirements of this NOFO (*see* Section 4.02 Screening Criteria and Section 8.01 Required Forms and Documents) will not be considered.

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

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

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

6.02 Address to Request Application Package

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

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

It can also be obtained by writing to:

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

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

6.03 Application Submission

Applications must be submitted electronically through Grants.gov at www.grants.gov. Paper applications or applications submitted by other electronic means will not be accepted.

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. The last application received in Grants.gov will be used for evaluation. Applications to multiple subtopics or multiple applications to the same subtopic must be clearly differentiated.

(1) Applications must be submitted via Grants.gov at www.grants.gov, under announcement 2017-NIST-SBIR-01.

a) Applicants 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 the electronic application process for the 2017-NIST-SBIR-01 announcement, contact Christopher Hunton by phone at 301-975-5718 or by e-mail at grants@nist.gov.

b) Applicants are strongly encouraged to start early and not wait until the approaching due date before logging on and reviewing the instructions for submitting an application through Grants.gov. The Grants.gov registration process must be completed before a new registrant can apply. If all goes well, the registration process takes three (3) to five (5) business days. If problems are encountered, the registration process can take up to two (2) weeks or more. Applicants must have a valid unique entity identifier number and must maintain a current registration in the Federal government's primary registrant database, the System for Award Management (https://www.sam.gov/), as explained on the Grants.gov Web site. *See also* Section 8.02 of this NOFO. 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 http://www.grants.govhome page. Clicking on the "Applicants" tab produces two exceptionally useful sources of information, Applicant Actions and Applicant Resources, which applicants are advised to review.

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

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

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

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

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

Applicants should be aware that adequate time must be factored into applicants' schedules for delivery of their application. Submitters are advised that volume on Grants.gov may be extremely heavy leading up to the deadline date.

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

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

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 NOFO open period.

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

Applicants should review the following list carefully to ensure the proposal includes all required forms and documents. **Failure to include any of the applicable listed forms and/or documents will result in rejection of the proposal without consideration.** All required forms and documents must be complete. Please also review Section 4.02 Phase I Screening Criteria. Guidelines provided below are based on frequently asked questions and are not intended to be comprehensive – all forms must be fully completed.

A complete application contains the following forms and documents:

1. SF-424, Application for Federal Assistance. Item 12 should list the NOFO number 2017-NIST-SBIR-01. The response to #19 should be 'no' – the NIST SBIR Program is not covered by that Executive Order. For SF-424, Item 21, the list of certifications and assurances is contained in the SF-424B, which is item 3 in this list of Required Forms and Documents.

2. SF-424A, Budget Information – Non-Construction Programs. The budget should reflect all anticipated expenses for the project.

In Section A, the Grant Program Function or Activity on Line 1 under Column (a) should be entered as "Science, Tech., Business and/or Educ. Outreach". The Catalog of Federal Domestic Assistance Number on Line 1 under Column (b) should be entered as "11.620".

In Section B, Acceptable fees (see Section 5.06 of this NOFO) should be included in "Other (h)".

These sections of the SF-424A should reflect funds for the entirety of the award: Section A; Section B; Section C; and Section D. Section E is not relevant to the 2017-NIST-SBIR-01 program.

Further details about this form can be can be found at: http://www.grants.gov/web/grants/form-instructions/sf-424a-instructions.html.

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

4. CD-511, Certification Regarding Lobbying. Enter "2017-NIST-SBIR-01" in the Award Number Field. Enter the title of the application used in field 15 of the SF-424, or an abbreviation of that title, in the Project Name field.

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

6. Cover Sheet and Technical Proposal. Read Section 3.02 of this NOFO very carefully, and in its entirety, for directions on completing this section of the application. Attach this document to the SF-424 as described below.

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

The proposed budget should reflect planned costs, but the awardee must charge actual costs to the award consistent with cost principles applicable to the type of awardee in accordance with the Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards at 2 C.F.R. Part 200, which apply to awards in this program. More information is available at http://go.usa.gov/SBYh and http://go.usa.gov/SBg4. The awardee should have an accounting system that tracks costs per SBIR firm and an allocation plan for activities that may be shared among multiple SBIR firms. Attach this document to the SF-424 as described below.

8. Indirect Cost Rate Agreement. NIST will not negotiate indirect cost rates for Phase I awards. If indirect costs are included in the proposed budget, provide a copy of the current, approved negotiated agreement if this rate was negotiated with a cognizant Federal audit agency. If a rate has not been established, provide a statement to this effect. Applicants without an established rate, may propose estimated indirect costs at a rate not to exceed 40 percent of the total direct costs and will not be required to provide further justification if selected for an award. Attach this document to the SF-424 as described below at the end of Section 8.01.

9. SBA Company Registry Form. SBA maintains and manages a Company Registry at http://www.sbir.gov/registration to track ownership and affiliation requirements for all companies applying to the SBIR Program. The SBIR Policy Directive requires each Phase I applicant to register in the Company Registry prior to submitting an application. The applicant must save its information from the registration in a .pdf document. Attach this document to the SF-424 as described below at the end of Section 8.01.

10. Data Management Plan. In accordance with the Office of Science and Technology Memorandum for the Heads of Executive Departments and Agencies of February 22, 2013[5], *Increasing Access to the Results of Federally Funded Scientific Research*, and as implemented through NIST Policy 5700.00[6], *Managing Public Access to Results of Federally Funded Research,* and NIST Order 5701.00[7], *Managing Public Access to Results of Federally Funded Research*", applicants must include a Data Management Plan (DMP).

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

[5] https://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf
[6] http://www.nist.gov/data/upload/Final-P-5700.pdf
[7] http://www.nist.gov/data/upload/Final-O-5701_0.pdf

plan for storage and maintenance of the data expected to be generated by the identified activities, and a plan describing whether and how data generated by the identified activities will be reviewed and made available to the public. As long as the DMP meets these NIST requirements, it may take the form specified by the applicant's institution or some other entity (e.g., the National Science Foundation[8] or the National Institutes of Health[9]).

All applications for activities that will generate scientific data using NIST funding are required to adhere to a DMP or explain why data sharing and/or preservation are not within the scope of the project.

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

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

The sufficiency of the DMP will be considered as part of the administrative review (*see* Section 4.02. of this NOFO); however, the DMP will not be evaluated against any evaluation criteria. Attach this document to the SF-424 as described below.

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

8.02 Verifying the Submission and Tracking the Application

Applicants are urged to use Grants.gov's Download Submitted Applications feature to check that all required attachments were contained in their submission. Go to the *Grants.gov Online Users Guide available at the Grants.gov site (http://go.usa.gov/cjaEh), choose Applicants, then Applicant Actions, then select the "Check My Application Status" option, click on the* Download Submitted Applications feature, and follow the directions. Applicants can track their submission in the Grants.gov system by following the procedures at the Grants.gov site (http://go.usa.gov/cjamz). It can take up to two

[8] http://www.nsf.gov/bfa/dias/policy/dmp.jsp
[9] https://grants.nih.gov/grants/policy/data_sharing/data_sharing_guidance.htm

business days for an application to fully move through the Grants.gov system to NIST.

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

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

9.0 RESEARCH TOPICS

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

9.01 Collaboration and Partnership

9.01.01.40 NIST Technology Transfer

Small businesses can obtain information about available NIST-owned inventions through multiple sources. NIST provides information on our website at www.nist.gov/tpo and at www.nist.gov/Licensing. Applicants can also obtain information from the U.S. Patent and Trademark Office site (www.uspto.gov) and private search engines.

Applicants will need to confirm that the NIST-owned invention is available for licensing by searching the invention using the link provided on the websites provided above. Alternatively, the applicant can confirm the status of availability by submitting a question to the NIST SBIR website as directed in Section 1.04. Some NIST-owned inventions are described as only available for licensing on a non-exclusive basis, which typically means that at least one non-exclusive commercialization license has been granted by NIST. Any such NIST-owned inventions are still available for licensing on a non-exclusive basis. Any NIST-owned invention that has been exclusively licensed to another party is not available for

licensing. If the NIST-owned invention has become unavailable for licensing prior to the close of this NOFO in the field of use relevant to the subtopic, NIST has the sole discretion to deem such application ineligible under the subtopic, as stated in Section 4.02 (Phase I Screening Criteria).

A SBIR awardee for this subtopic for a research license, it will need to contact NIST's Technology Partnership Office for a license to use the NIST-owned invention. Such awardees will be granted a non-exclusive research license and will be given the opportunity to negotiate a non-exclusive or an exclusive commercialization license to the NIST-owned invention, in accordance with the Federal patent licensing regulations, set forth in 37 C.F.R. Part 404, and to the extent that such NIST-owned invention is available for licensing and has not otherwise been exclusively licensed to another party. Any research license granted for the purpose of this subtopic will be royalty-free during the award period. More information about licensing NIST inventions is available at www.nist.gov/Licensing.

The technical portion of an application should cite the NIST patent or patent application, and include a description of the research that will be undertaken. Included in this technical portion of the application, the applicant should provide a brief description of the proposed plan to develop the commercial product or to develop a commercial service using the NIST invention. The absence of this development plan will result in the application being less competitive.

Phase I expected results:
Develop a feasibility study that examines expectations of the research to produce a commercial product or service.

Phase II expected results:
Provide further R&D that leads to demonstrated practical application and advancement toward a commercial product or service.

NIST staff may be available for consultation and collaboration to the extent that resources are available.

9.02 Data and Modeling

9.02.01.73 Interactive Software Tools for Processing QIF-formatted Part Models to Generate Realistic and Accurate Measurement Plans and Programs in Standard Digital Languages

The Quality Information Framework (QIF) Version 2.1 suite of quality information models is an ANSI-approved standard developed by the Dimensional Metrology Standards

Consortium. All QIF information models are written in the XML Schema Definition Language (XSDL). Data files (called instance files) conforming to the QIF models are also written in XML. QIF, along with the Dimensional Measuring Interface Specification (DMIS), provide rich and comprehensive digital modeling specifications for every key element in the manufacturing quality measurement process, from digital part models, to measurement resources, to measurement rules, to measurement plans, to measurement programs, to measurement results, to summary measurement statistics. Measurement programs are generated by measurement plans, which in turn are generated from part models and a set of measurement rules. Measurement rules are intended to help users select appropriate measuring equipment, fitting algorithms, and methods for reporting measurement results. Since the use of QIF in actual software systems is in its early stages, measurement system software vendors currently create and consume relatively simplistic rule sets and plans. Furthermore, the ANSI QIF Rules 2.1 standard is still in the early phases of development. What is needed now are sophisticated, human-interactive software tools, which can receive QIF-formatted models and QIF-formatted rules as input, to create complex measurement plans which are validated and verified to be correct, complete, and compliant to ANSI QIF. Such a tool would also be used in testing the validity of the QIF specification itself, which is of special importance to NIST. A well designed tool could reduce measurement plan size substantially, depending on the part to be measured and its features.

This subtopic seeks to enable the development and testing of the QIF Rules specification. The awardee will be able to provide a testing ground for the current version of the QIF Rules specification, and provide valuable input for the development of the next version of QIF Rules. The same can be said for QIF Plans. QIF Plans have not been thoroughly exercised but current software implementations of QIF. If QIF Plans is going to be ready for prime time in the dimensional metrology software world, it needs to be tested against more complex requirements and manufacturing use cases.

Phase I expected results:
The awardee will design a structure for the interactive software tool, develop a prototype, and test the prototype with a real part. The awardee will design, create and test the software tool prototype with relatively simple inputs, but all in QIF format. The software tool will demonstrate its capability with a relatively simple part with geometry, features, and tolerances modeled in QIF Model Based Definition (MBD). The tool will process the part, using simplified QIF Rules, and generate QIF-formatted measurement plans. The goal in this phase is to design a tool, and build a prototype, that can be expanded to produce non-verbose QIF-compliant plans for a rich set of part types with a complex and realistic set of features and tolerances, using the specified rules in QIF Plans format.

Phase II expected results:
The awardee will build and demonstrate a more sophisticated measurement plan

generation tool. First would be a test of the optimization of the tool against 1) a wide variety of parts and features and tolerances and 2) a wide variety of rules for measurement equipment types, measurement tool types, and feature-type measurement requirements.

Second the awardee will test the correctness of the tool against 1) expert (human) analysis of the resulting plans from the tool and 2) the performance of the plan in simulation tools and a real environment. For example, the rules portion of the interactive software tool might have three interrelated functional modules: a module to allow intelligent selection of coordinate machines and probes, a module to allow intelligent selection of fitting algorithms for processing measured points to fit substitute features and a module to allow intelligent selection of the methods to report measurement results. During the software development, information models for software engineering have to be QIF-compliant, e.g., for product models, resource models, and rules models.

Finally, the interactive software tool will generate programs in DMIS for coordinate measuring machines (CMMs) from QIF-formatted plans. The system will also be able to accept a QIF Resources file as input. The proposal may be to extend an existing CMM programming system or to build one from the ground up.

NIST researchers may be available to collaborate with and provide consultation to the awardee.

Reference:
ANSI QIF version 2.1: downloadable from http://qifstandards.org.

9.02.02.73 Modeling and Simulation Analysis for Manufacturing Systems

Global competition requires manufacturers to assess the likely effects of decisions about design and configuration of products, processes, and resources. The complexity of modern manufacturing requires advanced analysis, simulation in particular, to answer questions such as: What will be the capacity of this proposed line? What throughput, cycle time, and other metrics can be achieved for this product with this line configuration? Where should capacity be added if demand increases? Large enterprises usually employ experts to build simulation models to answer these questions, although the process can be lengthy and expensive. Most small- and medium-sized enterprises (SMEs) simply do not have access to the necessary analytical capabilities.

Discrete-event simulation analysis is increasingly critical to analyzing, designing, evaluating, and controlling large-scale, complex, uncertain systems [1]. However, it currently takes too long to design, collect information/data, build, execute, and analyze simulation models, leading to insufficient input to decision-making [2]. These barriers are particularly

formidable to SMEs, leaving them with little ability to quantitatively assess the effect of potential decisions. An ability to automate the development of simulations would have significant benefits for manufacturing enterprises.

The goal is to develop tools that significantly reduce the time, cost, and expertise required to use simulation analysis to answer questions about designing and operating manufacturing systems. Tools are sought that can answer a flexible and general set of questions about manufacturing systems, scenarios within them, and alternatives to them. The tools will leverage models of manufacturing systems that provide the necessary input to analysis.

Phase I expected results:
Demonstrate an architecture with widely understood semantics for manufacturing system modeling, appropriate model-to-model transformations, and well-structured manufacturing system simulations. This demonstration should start with at least one frequently-asked manufacturing question or use case, answer the question using simulation analysis, and elucidate how a proper software implementation would significantly reduce the time, cost, and expertise requirements to answer the question as compared with the status quo.

Phase II expected results:
Deploy the Phase I architecture in a form usable by SMEs who currently have no access to manufacturing system simulations or other advanced analytics. Expand and mature the Phase I implementation to additional questions, use cases, and classes of manufacturing systems. The result should be a prototype of a commercially viable software solution.

NIST staff may be available for consultation, input, and discussion, as needed.

References:
[1] Taylor, S.J., Brailsford, S., Chick, S.E. L'Ecuyer, P., Macal, C.M., Nelson, B.L., "Modeling and Simulation Grand Challenges: An OR/MS Perspective" in Proceedings of the 2013 Winter Simulation Conference, IEEE, pp. 1269-1282, 2013.

[2] Fowler, J.W. Rose, Oliver., "Grand Challenges in Modeling and Simulation of Complex Manufacturing Systems," Simulation, 80:9, pp. 460-476, September 2004.

9.02.03.73 Non-Destructive Testing Qualification of Complex Parts with Digital Image Correlation and Digital Signatures

Qualification of final parts is a highly discussed topic in additive manufacturing (AM). Process immaturity and the associated uncertainty of part quality in metals AM has led many to seek new methods for qualifying manufactured parts, especially those of high complexity and low-

volume production. Manufacturers have defaulted to costly destructive testing methods, often misrepresenting final part properties by creating and testing dog bone-shaped witness specimens. It is becoming progressively understood that due to variations in processing and thermal history that witness specimens do not accurately represent the final characteristics of the manufactured part.

As an alternative to the often costly, destructive testing of AM parts, Non-Destructive Testing (NTD) methods are increasingly part of AM part qualification. The most common methods focus on high-resolution scanning, both internal and external, using methods such as X-ray Computed Tomography, or X-ray CT. While these methods support detailed, fine-grained inspections, they also generate large amounts of data that are not readily interpreted. It is not always known how data should be interpreted to qualify a part against its intended functionality, or how part might perform under intended loading conditions. This subtopic focuses on qualifying parts by leveraging these functional requirements and utilizing NDT techniques to develop repeatable "signatures" of parts. These signatures will be based on the mechanical response of a part's critical geometry under designed loading conditions, therefore qualifying a part against its intended use.

This subtopic addresses gaps in current qualification methods, specifically the need to address performance uncertainty introduced when manufacturing a part with AM processes. New methods are needed for the NDT qualification of complex parts to complement current predictive modeling, destructive, and non-destructive qualification methods. These methods should be robust enough to apply to any complex geometry while being mature enough to qualify against a part's intended functionality.

The subtopic seeks to leverage high resolution Digital Image Correlation (DIC) technologies [1] and digital signatures [2,3] to evaluate mechanical responses under critical loading conditions at critical geometries of complex parts. By establishing acceptable loading thresholds and performance expectations, benchmark measurements taken from qualified parts can be compared with those of parts yet to be qualified under simulated loading conditions. The digital signatures of the qualified parts can then be used to verify and validate untested parts through DIC technologies and signature verification. Applications of such qualification techniques include NDT testing for deliberately introduced defects in AM manufactured parts, a major concern in AM security logistics [3].

The topics addressed under this subtopic directly relate to NIST's goal of supporting U.S. commerce through measurement science. Successful development of the techniques will provide industry an affordable means of qualifying complex AM parts through advanced imaging and modeling technologies while maintaining manageable amounts of data generation.

The goal of this project is to develop and validate novel NDT methods that are well suited for the low-volume, high complexity, high cost production requirements in additive manufacturing. Methods should include novel, high-resolution digital image correlation techniques that can be applied to any complex geometry (including lattice). Based on predictive analytics and modeling, methods will identify functionally-critical locations and establish correlations between critical geometries in the design and surface points from which deformations will be measured. The stress and strain measurements, and analyses results, around these critical point locations will then be used to form a repeatable, function-based, response "signature."

This project will develop new methods for qualifying functional parts based on DIC technologies and functional loading requirements. Goals include establishing the following methods:

- Based on actual loading conditions, a method will be developed for identifying critical surfaces and volumes on a functional part.
- A method will be developed to correlate actual loading conditions with simulated loading. The method will use simplified loading conditions to simulate stresses observed at critical surfaces and volumes under complex loading conditions. The method will demonstrate that loading experienced critical geometries of complex parts/shapes in actual loading conditions can be simplified so that the same loading conditions can be simulated in a lab environment. The method will be validated by demonstrating consistent mechanical testing results, and alignment between simulated and actual loading conditions.
- A method will be developed that utilizes high-resolution DIC to observe and analyze previously identified critical surfaces/ volumes. Results of the DIC related to stress and strain will then be mapped to the 3D geometry, providing a "DIC signature" that can be benchmarked to establish expected performance of a given material and geometry for given loading conditions.
- Methods will be established that correlate known responses of a qualified parts with the "DIC signatures" of parts yet to be qualified. Methods and thresholds will be established that will then allow for simulated loading conditions and corresponding DIC to attain "DIC signatures" of unqualified parts. These signatures will then be verified and validated against the signature of the qualified part. The "signature verification" method will be validated by demonstrating consistent results across "DIC signatures" for a given geometry, loading, and uncertainty threshold.

  In concert, these methods will support the establishment of performance benchmarks for a given complex part. A benchmark signature will then be used to qualify remaining parts by comparing the established digital signatures with those obtained from other parts of the same material and geometry using high resolution DIC technologies.

Phase I expected results:
1. Validated method that induces the response of critical geometries (surfaces/volumes) experienced under actual loading conditions in a simplified, simulated lab environment.
2. Development and demonstration of a high-resolution DIC method that can be used to attain the stress maps around critical part geometries.
3. Validated method that demonstrates repeatability in high-resolution DIC on the critical geometries of complex shapes.
4. Validated method that matches benchmark “DIC signatures” consistently against parts with same material, geometry and loading.
5. Validated method that demonstrates that parts qualified using “DIC signatures” perform within acceptable thresholds and uncertainty, as predicted when compared against the performance of the benchmark part.

Phase II expected results:
1. Identified conditions on which the DIC method can be applied, demonstration of the limitations of the approach.
2. Demonstrated DIC using embedded markers and other imaging technologies to overcome some of the identified limitations.
3. Development of a prototype software package that supports the integration of the developed methods, including DIC, obtaining DIC signatures, and DIC signature validation.

NIST may be available to work collaboratively and provide technical direction and consultation.

References:
1. Verhulp, Eelco, Bert van Rietbergen, and Rik Huiskes. "A three-dimensional digital image correlation technique for strain measurements in microstructures." Journal of biomechanics 37.9 (2004): 1313-1320.

2. Straub, Jeremy. "Initial Work on the Characterization of Additive Manufacturing (3D Printing) Using Software Image Analysis." *Machines* 3, no. 2 (2015): 55-71.

3. Fadhel, Nawfal F., Richard M. Crowder, and Gary B. Wills. "Maintaining Provenance throughout the Additive Manufacturing Process." *IJISR* 3, no. 3 (2013): 466-475.

9.02.04.77 Parallel Algorithms for Processing Huge Sparsely Labeled Datasets on Clusters of Multicore Processors for Healthcare and Manufacturing Applications

Many health care and manufacturing applications are unavoidably spatio-temporal and generate large amounts of data. Expert interaction and measurement costs for these datasets imply that only a very small fraction of the data can be labeled such that models or

results are presented in a form that supports human understanding. In general, the underlying spatial and spatio-temporal relationships in these data can be represented as three--dimensional grid or graph structures. Traditional machine learning algorithms are not applicable as they tend to be sample-based, requiring labelling of a significant fraction of the data. Therefore, a pressing need exists for algorithms that can handle very large datasets with only a fraction of data labeled. Additionally, data volume and speed of data acquisition requires that such algorithms effectively exploit networked multicore, GPU, and parallel computing resources. The underlying technology should have broad applicability in spatio-temporal big data applications.

The goal of the proposed research is to develop fast, parallel semi--supervised machine learning (ML) algorithms that address challenges of very large datasets and applications in the domains of healthcare and manufacturing. Such ML algorithms should be effective for datasets having millions to billions of data points, with only a few thousands of data points labelled.

Phase I expected results:
Develop novel machine learning algorithms that can work effectively for sparsely labeled datasets. Demonstrate their parallelization capability on hundreds of traditional cores.

Phase II expected results:
Demonstrate the effectiveness of machine learning algorithms developed in Phase I on real-world applications. Demonstrate scalability of these algorithms on large clusters of GPU and multicore machines. Phase II results should lead to a commercialization path for the technology applications in specific domains (for example, healthcare and manufacturing).

NIST may be available to work both in consultative and collaborative capacity in assisting the awardee.

Reference:
Olivier Chapelle, Bernhard Schölkopf and Alexander Zien, Semi-Supervised Learning, MIT Press, 2010.

9.03 Precision Measurements

9.03.01.67 Atomic Vapor Cell Technology for Electric-Field Metrology

NIST is developing a fundamentally new approach for electric (E) field measurements [1]-]9]. The probe is based on the interaction of RF-fields with Rydberg atoms, where alkali atoms placed in atomic vapor cells are excited optically to Rydberg states and an applied RF-

field alters the resonant state of the atoms. The Rydberg atoms act like an RF-to-optical transducer, converting an RF E-field to an optical-frequency response. The probe utilizes the concept of Electromagnetically Induced Transparency (EIT), where the RF transition in the four-level atomic system causes a split of the EIT transmission spectrum for the probe laser. This splitting is easily measured and is directly proportional to the applied RF field amplitude. By measuring this splitting we get a direct measurement of the RF E-field strength. The significant dipole response of Rydberg atoms over the GHz regime enables this technique to make direct SI-traceable measurements over a large frequency band including 400 MHz-500 GHz. One of the main contributions to the uncertainties in the approach is due to the perturbation of the measured E-field caused by the size and shape of the vapor cell [1], [2], [4], and [6]. Fundamental to the development of this technique is to have specially designed vapor cells that will have minimal perturbation on the RF field being measured.

Project goals include the development of compact atomic vapor cells (filled with Rb and/or Cs) suitable for atom-based E-field metrology. Ideally, the vapor-cell should be on the order of a few mm and have no stems (that are common found in current technology) in order to have minimal RF perturbation. These new cells should also include hollow-core fiber vapor cells designs.

Phase I expected results:
Design and simulate results for compact vapor cells. The vapor-cell should be on the order of a few mm and have no stems (that are common found in current technology). Successful designs should be compact and have minimal perturbation in the applied RF field. Results of full three-dimensional RF simulations at a range of frequencies are required in order to evaluate impact of the vapor cell on the measured field.

Phase II expected results:
Phase II expected results include using the compact vapor cells designs in Phase I to develop fiber coupled vapor cells. These vapor cell need to have pure atomic vapor (no buffer gasses) and demonstrate a ground-state absorption of 40% or better. Need to demonstrate EIT in the cell. Successful designs should be compact and have minimal perturbation in the applied RF field. Results of full three-dimensional RF simulations are required in order to evaluate impact of the vapor cell on the measured field. Also, in Phase II hollow-core fiber will be designed. Prototypes will be filled with either Cs or Rb and need to demonstrate EIT.

NIST will use our facilities to test the designs.

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9.03.02.68 Innovative Manufacturing of Nanoscale Calibration Spheres

Nanoscale calibration spheres serve an essential role in dimensional metrology, basically as a means of in-situ size calibration for industrial, scientific and medical applications. Modern usage has increased with the importance of detecting and characterizing nanoparticle materials in the environment. NIST has long been a source of particle standard reference materials such as polystyrene latex (PSL) spheres [Refs. 1- 4] but the quality of its presently available items has not kept pace with current applications and instrumentation. The unmet need is that commercial production methods for PSLs are based on 1950's-era R&D, sufficient for industrial processes but not optimized, or appropriate, for current application requirements as nanoscale size transfer standards. The consequence is that the average size, size distribution, shape, and material properties vary considerably and rapidly degrade as particle size decreases, especially below 100 nm diameter.

There are many commercial vendors of calibration spheres and they rely on NIST reference materials for traceability. But bad reference materials result in poor metrological quality, i.e., traceability and uncertainty, since precision and accuracy of the measurement method are influenced by sample inhomogeneity.

In the interest of improving the practice of dimensional metrology, NIST recognizes that reviving R&D efforts in manufacturing of calibration spheres is essential for fulfilling NIST's mission of disseminating the unit of length.

This subtopic focuses on significantly improving manufacturing methods for PSL spheres by the technique of emulsion polymerization. This industrially useful process has proven to be quite robust; nevertheless, it suffers from numerous secondary reactions which lead to highly polydisperse size distributions particularly for small average particle sizes. That the reaction conditions can be optimized to produce a very narrow, monodisperse size distribution was demonstrated in the production of the discontinued 100 nm diameter NIST SRM 1963 [Ref. 2]. This excellent size distribution was created by accident and has not been duplicated, either by the original manufacturer, JSR (Japan), or any other commercial vendor. However, it does offer a proof of principle and the historical literature offers numerous hints at alternative process conditions and choices of components which could result in the understanding and control necessary to synthesize PSL particles in the range of 20 nm to 100 nm diameter with a size distribution as good as or better than NIST SRM 1963. The project goal is the commercial realization of such high quality PSL calibration spheres for use as transfer standards by NIST and other national measurement institutes and for more general uses in industry and technology fields.

The expected outcome of Phase I is twofold: first, exploration of process control parameters and chemical constituents of the emulsion polymerization system will be undertaken. Rational understanding and control of the PSL particle size distribution parameters will be demonstrated. Multiple sizes below 100 nm will be synthesized and shown to possess a size

distribution close to that of the NIST SRM 1963. Second, metrics to allow statistically significant comparison of the particle size distribution to SRM 1963 will be developed and validated.

The expected outcome of Phase II will be the production of prototype amounts of PSL samples over the range of 20 nm to 100 nm diameter for which the particle size distribution is as good or better than that of the NIST SRM 1963. In addition, the stability and purity of the sample will be assessed for suitability as a viable commercial product.

NIST may be available to work with the awardee principally on choices of measurement and validation methods, such as atomic force microscopy, scanning electron microscopy, and dynamic light scattering.

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9.03.03.68 Multichannel, Chemically Precise X-ray Pulse Processor

Energy dispersive x-ray spectroscopy is a widely used materials analysis technique in industries such as metallurgy and semiconductor manufacturing. In particular, it is used to determine elemental compositions including trace components (e.g. yield-destroying, processed-wafer defects in large semiconductor fabrication lines). In recent years, energy dispersive x-ray spectroscopy using cryogenic microcalorimeter sensors has become commercially viable. Microcalorimeter sensors provide more than 10x better spectral resolving power than previous semiconducting detectors. This additional resolving power can be used to separate overlapping x-ray features, improve peak-to-background ratios for trace constituents, and observe so-called ‘chemical shifts’, x-ray features that identify the chemical state of a particular element. While commercial x-ray pulse processors exist for semiconducting detectors, there is an unmet need for a pulse processor compatible with the electrical signals produced by emerging arrays of superconducting microcalorimeter x-ray sensors. A complete microcalorimeter x-ray spectrometer consists of a cryostat, the sensors, their readout electronics, and a pulse processor. At the present time, all of these components are commercially available except an optimized pulse processor. Hence, the commercial development of a pulse processor will enable the widespread dissemination of

microcalorimeters to the large analytical community that already uses energy dispersive x-ray spectroscopy. NIST has a strong interest in the development of such a pulse processor because of its connections to precision industrial analysis, especially semiconductor manufacturing, its ability to extend precision x-ray measurements to chemical composition, and NIST's previous role in the commercialization of other aspects of microcalorimeter technology. The ability to more precisely quantify chemical composition via this technology is expected to enable analytical applications in a wide range of U.S. industries.

The central goal of this subtopic is the development of pulse processing electronics with the specifications described below:

1. Accept analog input signals spanning range: 0 Volts to 10 Volts.
2. Digitize analog input signals with sampling speeds >= 200 kHz and >=12 bits of sampling.
3. Filter digitized input signals to extract pulse heights with the highest possible signal-to-noise ratio. Pulse processing should produce energy resolutions better than 3 eV at 6 keV and better μthan 2 eV at 1.5 keV from sensors with sufficient intrinsic signal-to-noise to achieve those resolutions. Extracted pulse heights should be independent of DC level of pulse signals.
4. Accept pulse rise times in range 20 μs to 100 μs and pulse fall times in range 100 μs to 500 μs. Pulse decays are expected to be well modeled by a single exponential time constant.
5. Algorithms to extract accurate pulse heights in the presence of pulse pile-up are encouraged.
6. Algorithms to correct pulse heights for slow drifts in system response are encouraged. An example would be the application of a correction based on a previously measured correlation between baseline value and pulse height.
7. Pulse heights measured in electrical units shall be converted into absolute energy by means of a user-supplied non-linear calibration curve. The calibration curve is expected to be a 2^{nd} order polynomial or even more complicated functional form. Provisions for a separate operating mode to determine the calibration curve from spectra of a reference material or materials are encouraged.
8. Processed, calibrated pulse heights shall be output in a format that is accepted by the software environment of one or more vendors of tools for energy dispersive x-ray spectroscopy on scanning electron microscopes. When possible, the number of output pulse height channels shall reflect the improved spectral resolution provided by microcalorimeter sensors. For example, more than 3000 output channels are needed over the range 0 eV to 10 keV to avoid discarding useful energy information. Pulse heights shall be accompanied by time tags or other information needed to correlate x-ray results with the position of the microscope's electron beam so as to generate x-ray maps of spatially varying materials.
9. Pulse processing shall be performed for at least 16 independent sensor channels.

10. User shall have the ability to look at a single co-added master spectrum or 16 individual spectra. User shall have the ability to exclude user-selected channels from the co-added master spectrum.
11. The pulse processing must be performed in real-time but a short latency is acceptable (< 3 sec).
12. Pulse processing shall be compatible with total input count rates > 10 kHz across 16 sensor channels.
13. Pulse processor shall compute and report deadtime.
14. Pulse processing architectures that can be scaled in the future to larger numbers of independent sensor channels (>16) are preferred. In this future vision, input signals might come in a single interleaved timestream as is produced by time-division SQUID multiplexing.
15. Applicant should either be a vendor of x-ray microcalorimeter spectrometers or should collaborate with a vendor of x-ray microcalorimeter spectrometers in order to be sure that the pulse processor is optimally matched to these instruments.
16. Algorithms that detect the loss of flux lock in the SQUID readout electronics and that can rapidly reset such electronics or signal that such a reset is needed are encouraged.

Phase I expected results:
A full design study of the desired pulse processor is expected for Phase I. In addition, partial demonstrations of pulse processing functionality with actual microcalorimeter sensors or with previously digitized and recorded data from microcalorimeter sensors are encouraged. These demonstrations can be performed at the single channel level.

Phase II expected results:
Construction and a full demonstration of the desired pulse processor at the 16 channel scale is expected for Phase II. This demonstration shall be performed with a microcalorimeter x-ray spectrometer. This demonstration shall include seamless integration of the pulse processor with a software environment for energy dispersive x-ray spectroscopy on electron microscopes.

NIST may be available to assist the awardee in consultation on desired specifications and candidate algorithms for filtering, calibration, addressing pileup, and addressing drift; providing previously digitized microcalorimeter pulse data; and exchange of site visits for technical discussions and system demonstrations.

References:
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9.03.04.62 Picogram-scale Atomic Force Microscopy Probes with Integrated Nanophotonic Readout

Atomic Force Microscopy (AFM) is a nanoscale metrology technique essential for both nanoscience and nanotechnology research as well as nanoscale structure and device manufacturing. Decreasing the mass and size of AFM cantilevers both improves the speed of their response and decreases thermal mechanical noise by decreasing drag when operated in air or fluid environments. In both cases the measurement quality and throughput can be increased. Currently such miniaturization is limited by the difficulty of realizing precision measurement of the motion of such cantilevers.

NIST research has demonstrated a way to overcome this difficulty by integrating nanophotonic resonators in close proximity to extremely small cantilevers with masses below 1 pg. These allow motion measurements with a motion noise floor below 1 $fm/Hz^{1/2}$ and a force noise floor of a few $fN/Hz^{1/2}$ in air, and a similarly low force noise in water. High resonance frequencies enable the devices to respond on sub-microsecond time scales.

Currently such probes are economically difficult to produce in quantity, and are hard to integrate with commercial atomic force microscopes. Further development and commercialization of such probes, together with the development of the associated measurement techniques, will enable large improvements in the state of the art of AFM metrology, and its dissemination to a broader community. NIST in general, and the Center for Nanoscale Science and Technology (CNST) in particular, is interested in enabling innovative commercial research to achieve such improvement in AFM metrology, and fulfill its mission to support the U.S. nanotechnology enterprise from discovery to production by providing industry, academia, NIST, and other government agencies with access to nanoscale measurement and fabrication methods and technology.

The general goals of this subtopic are to increase the quality, availability, and throughput of high-precision AFM metrology by private sector commercialization of an innovative, NIST-developed measurement technology. In addition, this project should use small business to meet federal research and development needs, and to stimulate small business innovation in technology. The specific goals of this project are to develop nanoscale AFM cantilever probes with integrated nanophotonic cavity optomechanical high-precision readout and to develop and establish a manufacturing process that enables their mass production.

Similar to current commercial AFM cantilever probes, the new probes should be available in a variety of stiffnesses. They should be compatible with commercial AFMs and easy to

exchange. They should operate in the optical telecommunication wavelengths range and allow quick and efficient coupling to commercial single-mode optical fiber excitation and detection systems with minimal mechanical alignment.

Development of such probes will meet an immediate need for these devices at NIST and enable and facilitate multiple AFM metrology research projects at CNST. Commercialization of this technology is expected to result in significant advances in the commercial state of the art in AFM instrumentation, with a further positive impact on U.S. nanotechnology enterprise as a whole.

Phase I expected results:
Demonstration of key elements of proposed probe design and fabrication process. Specifically, demonstration of the feasibility of fabricating all on-chip elements required for:
1) single-mode fiberoptic connection (such as single-mode fiber pigtailing or another optical connection approach);
2) exposing the probe tip for interaction with a sample (such as, but not necessarily, overhanging over the edge of the chip);
3) batch fabricating probe chips on 100 mm or 150 mm wafers (this may include e-beam lithography).

The demonstrated approach should be suitable for probes with modal mass below 1 pg and stiffness in the sense direction of 1 N/m to 100 N/m and optomechanical readout with a noise floor below 1 fm/Hz^0.5. Sense direction should be near-normal to the sample surface. NIST is not looking for detailed optomechanical probe structure design, but seeking to establish a clear path to batch fabrication on a wafer scale. Sufficient feasibility demonstration will require fabricating simplified test structures to demonstrate key fabrication process steps (such as overhanging the probe and/or fiber coupling), and a theoretical study specifying a detailed fabrication process flow.

Phase II expected results:
Implementation and demonstration of batch fabrication of functional AFM probes and supplying functional probes to NIST for validation. Optimization of probe's design for improved performance. The probes shall have the modal mass below 1 pg, and optomechanical readout noise below 1 fm/Hz^0.5 with less than 50 mW incident optical power. Probes shall be available in several different designs covering a total stiffness range in the sense direction of at least 1 N/m to 100 N/m. NIST expects the awardee to have established a commercial supply of these probes at the end of the program.

NIST will provide full data on current NIST AFM probe design and performance data and details of currently used fabrication process and its implementation in the NIST CNST NanoFab, including recipes for all steps. Some of these steps are not currently compatible with batch fabrication, and NIST seeks to remedy this. NIST will provide full details of the

current approach to assembly and integration of these probes into a commercial AFM instrument. NIST may be available for regular discussions/consultations regarding optomechanical design, as well as all other aspects of fabrication, as well as use of the probes in AFM. In Phase II, NIST expects to be testing the early prototype probes and final supplied probes in our fiber-optical sensing and AFM systems. NIST will implement the changes necessary to integrate and test the supplied probes in our AFM (such as custom adaptors or fiberoptic couplers, if necessary).

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9.03.05.68 Precision 10 kV Programmable Voltage Source

Measurement of high resistance standards (10 MΩ to 100 TΩ) and high voltage resistive dividers (100 MΩ to 225 MΩ) are made using modified Wheatstone bridge techniques. The most accurate technique used for high resistance uses programmable dc voltage sources in the main ratio arms of a modified Wheatstone bridge. Programmable bipolar dc voltage sources with ranges from 220 mV to 1100 V having expanded uncertainties (k=2) on the order of 6 µV/V provide the best accuracies for high resistance measurement. Similar Wheatstone bridges are used to calibrate high voltage dividers at voltages ranging from 10 kV to 220 kV. The best high voltage sources available in this range have an expanded uncertainty of 100 µV/V. The only commercially-available precision sources have uncertainties on order of 500 µV/V in the 1 kV to 10 kV range, more than an order of magnitude greater than commercial sources covering the other voltage ranges (i.e. 1 kV and below). Test laboratories would benefit from development of a commercial bipolar programmable dc voltage source with expanded uncertainties on the order of 6 µV/V to 10 µV/V to bridge this gap in measurement capability. Such a programmable dc voltage source

would allow extension of the voltage range for calibration of high resistance standards and allow comparison of high voltage resistive dividers to high resistance standards in the 1 kV to 10 kV range with traceability to quantum resistance standards.

Commercial multifunction calibrators are used as the bipolar dc sources for the high resistance bridges as they have state-of-the-art uncertainty for dc voltage for the 220 mV to 1100 V ranges. Unfortunately, as the name suggests, they have other functions such as ac voltage, ac current, and resistance that are not utilized for dc voltage applications and only add cost if they are not used. Commercial dc only calibrators exceed the 1-year specification of multifunction calibrators by 1.4 to 2.8 times on the corresponding ranges of 220 mV to 1100 V. To make high resistance bridges more cost effective and therefore more widely used in standards laboratories, an alternative dc voltage-only source with the same performance as that of state-of-the-art multifunction calibrators is needed.

The development of an alternative 1 kV dc bipolar voltage source technology that could be scaled to 10 kV would (1) improve performance in the 1 kV to 10 kV range and (2) provide a cost effective alternative to calibrators in the 220 mV to 1100 V range. This technology would be of interest to NIST as well as other standards and commercial laboratories.

Technologies that would scale from the existing voltage range of 1 kV up to 10 kV are desired. A programmable bipolar dc voltage source that has linearity error of less than 1 µV/V over the range 1 kV to 10 kV would be complementary to the state of the art sources at 1 kV. State-of-the-art voltage sources have expanded uncertainties of 6 µV/V over a one-year interval at 1 kV. To be useful in automated bridges, the bipolar programmable dc voltage source would need to be controllable by IEEE-488.2 interface or USB interface from a computer just as other instrumentation in an automated bridge would be. Front panel display of the output state (i.e. energized or standby) and voltage would be necessary for safe operation in a laboratory environment.

Phase I expected results:
Design a bipolar programmable dc voltage source that extends the range from 1 kV to 10 kV and meets the project goals described above.

Phase II expected results:
Construct a prototype 1 kV to 10 kV bipolar programmable dc voltage source based on the design of Phase I and demonstrate that the specifications and performance described above are met.

NIST may be available to work collaboratively on design concepts, discuss goals, and to aid in prototype evaluation.

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9.03.06.68 Quantum-based Compact Programmable Primary Thermometer

There is great potential for improved thermometry and new applications with the development of a scalable primary thermometer that can replace the ITS-90 temperature scale, which consists of fixed point artifact standards. A very promising approach is a purely electronic temperature standard that exploits Johnson noise thermometry (JNT) and a quantum voltage noise source (QVNS) based on pulse-driven Josephson junctions made with high-temperature superconductors (HTS). This novel primary thermometer will enable a new paradigm for disseminating temperature that will be independent of artifact standards for the first time. Any national, military, or corporate metrology laboratory could then possess and operate a single primary thermodynamic temperature standard, including the triple point of water, and be able to calibrate a wide range of secondary thermometers over the range from ~230 K to 1300 K. This would essentially replace ten defined “artifact standard” fixed points based on the phase-change states of ten different materials. Additionally, the perfect scalability of the HTS JNT would eliminate the use of complex mathematical interpolation for measurement of temperatures between these points.

In addition to creating the world’s first quantum-accurate primary thermometry, development of an HTS JNT would also enable improved accuracy in industrial point-of-use applications. These include embedded sensors in extreme environments like nuclear or industrial furnaces, where installed probes can continue to be used in place with only an in-situ resistance measurement, which reduces down time and improves process control (as opposed to artifact probes require periodic replacement). Successful execution of this project will lead to practical application of the first temperature metrology systems incorporating quantum-based voltage synthesizers, elimination of many levels of the temperature calibration chain, and placement with immediate users of the world’s first intrinsically accurate, scalable, primary thermodynamic thermometer.

National Measurement Institutes (NMIs) and corporate metrology labs maintain the international temperature scale (ITS-90) with a series of fixed points and Standard Platinum Resistance Thermometers (SPRTs). Operating all of these artifact standards is complicated, labor intensive, and requires a large amount of both capital equipment and floor space. Calibrating temperatures between the fixed points requires interpolation, which increases

uncertainty. A quantum-based electronic primary thermometer is intrinsically linear and programmable. As a single standard it can replace all of these instruments and it can also measure arbitrary temperatures, not just the fixed points, enabling application-specific calibration protocols. NIST currently leads the world in Johnson noise thermometry with a research system designed to measure Boltzmann's constant using a 4 K quantum voltage noise source (QVNS) chip made of niobium-based junctions and custom-built bias and measurement electronics.

The subtopic goal is to replace the current QVNS chip operating at 4 K in a liquid helium dewar with a HTS QVNS on a compact, closed-cycle cryocooler (smaller than a liter). A successful development under this project could mean direct transition through conversion of the research JNT system into an automated programmable primary standard that can be operated by non-experts.

The goal can be met through the following approach:

1) Develop a compact, closed-cycle system operating at 77 K that requires less than 100 W, preferably using a commercially available cryocooler. This system should be capable of providing DC and RF connections to the chip for proper operation. The electrical connections must be optimized to minimize electrical loss and minimize the thermal impact on the chip. The system will need the development of chip packaging and a cryostat microwave design for 30 GHz pulse-drive bias.
2) Develop a HTS QVNS chip that synthesizes accurate voltage waveforms at a temperature of 77 K. This will require the design, fabrication, and testing of the chip. As few as 4 junctions are required for this device, so several possible junction fabrication methods could be used.

Phase I expected results:
The Phase I goal would be a complete system design for a compact closed-cycle system and the design and fabrication of a HTS QVNS chip.

Phase II expected results:
The Phase II goal would be to build a laboratory demonstration of a complete system with a working HTS QVNS chip.

NIST staff may be available to participate in discussions and provide input on the awardee's design during the development process through email, teleconference or face-to-face visits. NIST may also be available to do testing, although the awardee will not be able to count this testing towards the testing requirements of Phase II. NIST scientists may be available for demonstration of the device at the awardee's home site, if desired.

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9.03.08.67 Superconducting RF Filters for Advanced Signal Processing

High-performance filters can be enabled by operation at cryogenic temperatures. The lower loss associated with superconductors can enable unique functionality, such as power-limiting behavior and extremely high selectivity. These two unique characteristics can be combined to develop, for example, auto-limiting mulitplexers, which can be used to excise large in-band interference signals without attenuating smaller signals of interest within a given frequency band. The further development of superconducting filters is of interest for both analog signal processing applications such as multiplexers, as well as for control of signals generated by precision microwave sources. Auto-limiting circuitry based on superconducting devices has been under development at NIST for a number of years, and commercialization of the technology has the potential to improve the performance of sensitive RF and microwave receivers. The results of this research can also be applied for high-performance filtering necessary in the development of precision microwave sources based on superconductor technology.

Subtopic goals include the development of compact superconductor filters for application in auto-limiting multiplexers and precision sources based on superconductor technologies. For signal-limiting applications, there is particular interest in frequency bands centered around 1 GHz and 3.5 GHz. The filters are expected to be implemented in microstrip technology on microwave-friendly substrates such as sapphire, and packaged for operation on closed-cycle cryocooler-based platforms.

Phase I expected results:
Designs and simulated results for compact microstrip filters based on superconductor technology for approximately 20 MHz (3 dB) bandwidth operating at 3.5 GHz. Successful designs should emphasize compact filter layouts, and be designed for high temperature

superconductors deposited on high-quality sapphire substrates. Results of simulations are required in order to evaluate impact of phase II work for fabrication and packaging of the most promising designs.

Phase II expected results:
Phase II expected results include fabricated superconductor filters for operation at 3.5 GHz with approximately 20 MHz (3dB) bandwidth. Up to two packaged devices for operation at cryogenic temperatures on a compact closed-cycle cryocooler as well as one or more unpackaged die are required for detailed evaluation of performance in both linear and nonlinear regimes.

Collaboration may be available in terms of discussion of design configurations, as well as simulated response; preliminary measurements of unpackaged devices that are amenable to wafer-probe style measurements; and support for advanced device modeling.

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9.04 Systems

9.04.01.60 An Automated System for Firearm Evidence Identifications

Since the 2009 NRC report [1], there has been a fundamental challenge in forensic science to establish a stronger scientific foundation and a statistical procedure for accurate firearm evidence identification and error rate estimation. To answer this challenge, researchers at NIST developed the Congruent Matching Cells (CMC) method [2,3], which is based on the principle of discretization that divides the entire image into cells, and uses subsequent cell correlations to quantify the topography similarity and pattern congruency of the correlated images. That makes it possible for ballistics identification and error rate estimation based on objective methods [3].

In addition to the congruent matching cells (CMC) method for correlation of breech face images, NIST researchers have recently developed the congruent matching cross-sections (CMX) method for firing pin correlations [4], the congruent matching profile segments (CMPS) method for bullet correlations [5], and the congruent matching features (CMF) method for a similarity map which shows the similar and dissimilar areas on the correlated images [6]. All validation tests for above methods using known matching (KM) and known non-matching images show clear separation between KM and KNM scores without any false identifications and false exclusions.

NIST has received requests from U.S. and international customers to provide a commercial system or source code based on the NIST invented congruent methods to support their firearm evidence identification and error rate estimation. The goal of the proposed SBIR project is an Automated System for Firearm Evidence Identification and Error Rate Estimation. This will be a commercialized system based on NIST invented CMC, CMX, CMPS and CMF methods. It will be used for automatic and objective firearm evidence identification covering all ballistics images including breech face, firing pin, ejector mark of cartridge cases and bullets. The output of the system will include an objective and conclusive result of identification or exclusion with false positive (for identifications) or false negative (for exclusions) error rate estimations. A similarity map is also developed from the system to visualize the similar and dissimilar areas on the correlated image pairs. Both the error rate estimation and the similarity mapping will provide a powerful tool to support ballistics examiners in court proceedings.

Phase I expected results:

- Based on the NIST invented CMC method [2,3], conduct a feasibility study for the development of a commercialized correlation program system using C++, OpenCV, Java, Python or other languages with high correlation speed and accuracy for breech face image correlations.

- Validation tests using two sets of breech face images in the NIST's ballistics and toolmark research database, that include:
  - Fadul dataset with 40 images including 63 KM and 717 KNM image pairs;
  - Weller dataset with 95 images including 370 KM and 4095 KNM image pairs.

  The correlation results must show clear separation between KM and KNM scores without any false identifications and false exclusions.

Phase II expected results**:**

- Based on the NIST invented CMC [2,3], CMX [4], CMPS [5] and CMF [6] methods, develop an automated system for automatic and objective identification of all ballistics images including breech face, firing pin, ejector mark of cartridge cases and bullets.
- Validation tests for the developed commercial software using at least two sets of breech face, firing pin and ejector images of cartridge cases and at least two sets of bullet images in the NIST's ballistics and toolmark research database. The correlation results must show clear separation between KM and KNM scores without any false identifications and false exclusions.
- A similarity map showing the similar and dissimilar areas in the correlated image pairs.
- A Statistical Fitting Program based on the NIST proposed statistical procedures [2,3] combined with an Error Rate Procedure [2,3] which can report the cumulative and individual error rates [2,3] for both the identification and exclusions conclusions using the CMC [2,3], CMX [4], CMPS [5] and CMF [6] methods for bullets and cartridge case correlations.

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9.04.02.77 Design Recovery Driven Porting and Refactoring of Fortran 77 Codes for Performance, Sustainability, and Consistency

NIST has a substantial code base written in Fortran 77 that will become very difficult to maintain as the generation of original developers retires; this issue was highlighted during the massive drive to update enterprise software systems to address the Y2K problem and will manifest itself again when the Unix “epoch” will reach its 32-bit limit in 2038. As such, there is a need for a tool that assists developers in modernizing this code base by (1) porting it to a more modern version of the language (e.g., Fortran 2008) or an altogether different language (e.g., C++), and transforming the code into a system that is documented, maintainable, and with a far better performance. This task is simply too onerous to achieve manually without tool support if the system at hand exceeds a few thousand lines of code. Furthermore, this need is not unique to NIST, but is rather universal across many federal agencies and national labs.

The project should develop a new tool or extend an existing tool that will assist developers in modernizing Fortran 77 systems and port them to more modern versions of the language (e.g., Fortran 2003 or 2008) or to a completely unrelated programming language such as C++. It is important to note that this is not a purely syntactic translation and will serve to reveal the underlying algorithms and data structures, document them, and potentially replace them by alternatives that are functionally equivalent, but deliver higher performance because they have lower runtime complexity or can take advantage of hardware parallelism that is available in modern computing platforms. Furthermore, the infrastructure embedded in the tool can be used to provide novel functionalities such as annotating a program’s source code to augment quantities with units (as in SI units) and evaluating the consistency of a program’s use of units.

At a minimum, the tool should provide the following functionality:
• Identify idioms of the language (common blocks, GOTO statements, poorly specified prototypes…) that impede sustainability and to replace them with more appropriate programming constructs. This should happen under the guidance of the developer who will specify the idioms to identify and how they will be replaced in the target language.

• Identify “dead code”.
• Support developers as they identify pieces of code that they want to refactor into separate routines. In doing so, the tool should automate many of the syntactic tasks that are associated with this refactoring (e.g., define prototype of new routine, declare variables in the new routine, and remove unneeded declarations from the calling routine, and format the source code of the new routine).
• Identify code sections that were replicated via “cut-and-paste” operations or that differ by simple changes in variable names.
• Allow developers to document code via text and Boolean expressions that can be evaluated at compile time or even during runtime.
• Keep track of all transformations implemented by developers so they can replay them in full or selectively to regenerate the “new” version of the system or to generate a different version of the system that is targeted at a new platform.
• Analyze the transformations put in place by developers to keep track of dependencies between these transformations. This will allow the tool to notify developers that they are introducing transformations that will break existing assumptions or prevent other transformations from being applied.
• Instrument the code to identify computational bottlenecks so developers can reengineer the code to reveal the underlying algorithms and data structures and, if possible, replace them by alternatives with the same functionality, but with better performance characteristics.

Phase I expected results:
The first phase should develop an architecture for the tool along with an implementation that provides a first set of functionalities. This first phase will be tested on a small system (e.g., 1–10,000 lines of Fortran 77 code).

Phase II expected results:
The second phase should provide an implementation with a complete set of functionalities. The tool will be tested on systems consisting of 10–100,000 lines of code. It will allow a “learned” developer to modernize a system consisting of 10–50,000 lines of code in a matter of weeks instead of months or years.

NIST may be available to consult with the awardee, discuss the problem and potential solutions, and evaluate the proposed implementations.

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9.04.03.60 Digital Data Structure Understanding Tools

Digital Forensic Investigators often encounter structured data in an unknown format. So that an investigator can present accurate and complete evidence to the court, the data needs to be well understood. There has been at least one court case [1] where an incomplete understanding of data recovered from a web browser log was misleading in court. A better understanding of the data structure involved could have prevented presentation of inaccurate testimony in this case.

There are several scenarios where such data can be encountered, e.g., a non-standard file system, a memory acquisition of an unknown OS version (or custom kernel), or a database with unknown schema. An investigator has few automated options for analysis of digital objects within an unstructured environment. For example, file carving is often productive for individual files with a known structure and a known signature identifying specific file

types. An investigator can try to unravel the unknown object structure manually, but this is a tedious, error-prone process.

NIST would like to see development of one or more tools that can aid the understanding of the structure of a digital object. Such a tool would be useful for developers of forensic tools used by law enforcement and also research in digital forensics currently conducted at NIST.

There are many different ways to approach this problem. One way such a tool could work would be to take a baseline image of the object and then to apply a series of operations and analyze changes produced by each operation. The tool would be given a description of the applied operation and a list of information to look for within changes, then the tool can examine the previous state before the operation was applied to infer some object parameter.

Depending on the type of data structure being reverse engineered, a set of questions can be posed. For example, reverse engineering a file system might proceed as follows:

- Create a single file, making note of the time. Identifying a list of differences between the state before creating the file and the state after creating the file creates a set of candidate locations for the file name and any meta-data such as recorded time values or file size.
- Append data to the file created above. This operation may reveal the location of a file size field.
- Create some more files. This could reveal the basic structure of directory entries and general layout.

In general, the tools would make a small modification to a digital object with known data and then examine the raw object for changes including the known data.

This is just one of many possible approaches. A successful applicant is expected to be creative and innovative.

Phase I expected results:
An architecture of and development plan for an automated method to discover the layout and structure of an unknown data object of interest to a digital forensics investigator.

Phase II expected results:
A demonstration version of a tool that, given an unknown data object, deduces, relevant to a forensic exam, parts of the object. This tool will be marketable to law enforcement and forensic science entities.

NIST may be available to work collaboratively and for consultation, input and discussion.

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9.04.04.77 Facilitating Security, Reliability, and Privacy in Networked Internet of Things (IoT) Devices

The Internet of Things (IoT) increasingly appears to be the next great technology revolution. It is expected to impact everything from healthcare delivery, to how food is produced, to how we work, to all forms of transportation and communication, and to virtually all forms of automation. With that said, IoT will impact everyone, and in multiple ways.

With a technology revolution of such large impact on society, it is imperative that IoT-based systems can be trusted. This means that they should exhibit secure, reliable, and private behaviors, as well as many other attributes associated with quality [2, 4]. Privacy is particularly important because IoT-based systems will likely spin off huge amounts of data as a result of sensing and surveillance [1, 3, 4]. Therefore, techniques, tools, and methods to mitigate the numerous 'trust' challenges are needed before these automated IoT-based networks manage much of daily life.

Therefore, innovative research is needed to aid in answering the following question: "how can a network be trusted that was built based on the core principles of IoT?" These core principles include computing power, sensing, communication protocols and bandwidth between devices and objects, and actuation affecting the external systems that the IoT networks will control. The approaches sought could include testing techniques, formal methods, certification of devices, auditing and logging during operational usage, certification of networks, analysis of networks of things, and any other approach that addresses the question.

The goal of this subtopic is to facilitate the security, reliability, and privacy of clusters of networked IoT devices (NoTs) by securely auditing and logging their internal and external operations and data interactions in a scalable manner. The presence of an auditing system that can operate independently of any IoT vendor will foster IoT vendor interoperability and will steer technologies toward standards that will enable auditing for both security and reliability of IoT systems. Furthermore, it will offer end-users with operational transparency and will empower them to identify components that can be used together thus improving utility of the IoT systems. Another advantage of auditing and logging is that they offer the ability to increase reliability and resilience without requiring major changes to architectures of NoTs. Moreover, in the future, NIST envisions NoT platforms where individual devices and sensors become the enabling platform for third-party applications to offer services in

the form of an application. Having a common auditing system for the system operations will help identify and address reliability and security issues. NIST is interested specifically in applications for home automation, building access control, personal health, and NoT use cases that are deployed as part of monitoring and control of functionality in critical infrastructures.

Phase I expected results:
Proof of concept using a simple network of IoT sensors, devices, and applications in one or two use cases showing how the innovation can produce a secure audit log of the overall IoT network operations. Also, show a system design of a functional prototype that can provide continuous reliable performance, log immutability, and protocol and device scalability.

Phase II expected results:
A full-scale prototype utility that can be applied to a more complex network of IoT sensors, devices, applications for multiple use cases and for different vertical markets (e.g., healthcare, transportation, agriculture, etc.), a user's manual for the innovation, and experimental results from applying the prototype should be produced.

NIST may be available for consultation, input, and discussions.

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9.04.05.77 High Speed Large Field-of-View Optical Microscope

In time-lapse optical microscopy of multiple field of views (FOVs), there is a trade-off between the spatial coverage that can be achieved at high spatial resolution and the temporal resolution. In other words, the larger the spatial coverage, the longer it takes to acquire all small (FOVs) to create one large FOV. Consequently, the events in a specimen that are characterized by high rates of changes that require high temporal resolution cannot be captured over a large FOV (e.g.., at population levels).

To address this tradeoff, NIST is interested in designs (Phase I) and prototypes (Phase II) of an optical microscope that would enable large FOV imaging of dynamic events and meet the specifications provided by the project goals.

Included are a few references [1-4] that describe some of the published designs addressing the current tradeoff. Proposers are encouraged to innovate published designs or pursue their own new designs.

The project goals are to enable microscopy measurements that could assist in characterizing dynamic events over entire populations of mammalian cells. One such example would be time-lapse imaging of live cell cultures.

To enable such measurements, the microscope design and its prototype should aim at meeting the following specifications:

Resolution: 1.4 μm or smaller when using the imaging system in a non-automated fashion and manually focusing on an object. This figure was arrived at by computing the Abbe diffraction limited resolution given by $L_{Abbe} = \lambda/2NA$, where λ=550 nm, NA = 0.3 and allowing for a 50% deviation from ideality. The measurement of resolution can be performed using the method described by Vainrub[5] or an equivalent method. Preference will be given to solutions that provide for similar resolutions with functioning in an automated mode with auto-focusing.

Spatial coverage and acquisition time: Solutions should be capable of imaging a 1 cm^2 area/60 seconds.

Modality: Widefield or confocal solutions (solutions that include also transmitted light imaging are preferred).

Modularity: Plug-and-play component to an automated microscope equipped with a scanning stage and focus control.

Material cost: < $20K

Phase I expected results:
Design an optical microscope that could acquire high-resolution large-FOV images “near real time” as specified by the project goals.

Phase II expected results:
Prototype the designed optical microscope

NIST may be available to discuss microscope design approaches and to provide additional specific inputs about a variety of demanding imaging applications at NIST.

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9.04.06.63 Infrastructure Requirements, Strategy and Architecture to Enable Scalable Scientific Data and Metadata Acquisition and Curation in Support of the Materials Genome Initiative

As a part of the Materials Genome Initiative, NIST is charged with developing a materials innovation infrastructure. Key aspects of this infrastructure include the real-time acquisition and curation of experimental and simulation data and associated metadata and control of scientific equipment over a network. To accomplish this, NIST needs research and development on the core requirements and on an overall strategy and software architecture that would enable control of diverse and geographically distributed experimental equipment (e.g. SEM, TEM, x-ray diffractometers, dilatometry, differential scanning calorimeters), computational resources (e.g. workstations, clusters, demonstration code), and the automatic capture and curation of their acquired scientific data and associated metadata across a network using backend systems such as the NIST developed Materials Data Curation System and the National Data Service's Material Data Facility.

There is a need for developing an infrastructure to push results and metadata from instruments into a data curation system/platform. The goal of the project is to discover and

document core requirements and develop an overall strategy and software architecture that when implemented will allow for the control of geographically distributed research equipment and computational resources and their integration with scientific informatics backends including the NIST Materials Data Curator and the National Data Service's Material Data Facility. Both the Materials Data Curator and the Materials Data Facility have REST APIs to facilitate automated data curation. The project will provide documented requirements and develop a specific strategy and software architecture for controlling scientific instruments and computational resources and interfacing them scientific informatics backends in a format amenable to implementation by software engineers.

Phase I activities and expected results:
Discover, validate, and document requirements for a system to enable scientific equipment control and scalable scientific data and metadata acquisition and curation as described in the project goals. Using previously documented requirements, develop and document an overall strategy and then develop and document a software architecture that when implemented will meet the project goals. We believe that a successful architecture would have several key properties: 1) It would be structured in independent layers, the top-most layer would present a high-level user interface to allow unified user access and control, while the lowest layer would provide connectivity to the scientific equipment or computational output, 2) the architecture relies on two public interfaces one for the highest level and the other at the lowest level that would allow the components to interact as a single application, 3) the architecture includes the notion of a default scripting language and provisions for integrated development environments to facilitate customization and extension of a system implementing the architecture in a standardized fashion, 4) the architecture is highly modular and includes the concepts of plugins and a generalized, abstract command set that facilitates interaction with the scientific equipment, 5) the public interfaces and abstract command set are conceived as being language neutral and allow users to control and extend a system implementing the architecture from a large variety of commonly used programming languages including Python, Java, and C++, 6) the architecture will provide for the capture of scientific provenance and system configuration to facilitate in reproducibility, 7) the architecture will support the concept of scientific workflows. We have been largely inspired by the Micro-Manager project (https://www.micro-manager.org/wiki/Micro-Manager%20Project%20Overview) and recommend that awardees review this project.

Phase II activities and expected results:
Develop an extensible infrastructure for the development of APIs to facilitate data curation of materials data from dilatometers, x-ray diffractometers, scanning electron microscopes (e.g. EDS- composition scans, EBSD patterns), transmission electron microscopes, differential scanning calorimeters, and tensile testing machines.

NIST staff familiar with the various instruments (SEM, TEM, optical microscopes, dilatometer, x-ray diffractometer) and simulations may be available to work with awardee to discover the requirements and develop the metadata schemas needed to collect the data. NIST staff responsible for the development of the Materials Data Curation System may be made available to help the awardee understand the architecture and capabilities of the MDCS.

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9.04.07.73 Low-Latency High-reliability Wireless Protocol for Advanced Manufacturing Applications

The future of manufacturing will include highly adaptive, reconfigurable, and mobile machinery that can interact with and collaborate with humans safely, reconfigure quickly and cost-effectively depending factory needs, and anticipate the situational environment. Mobile robotic work agents will have the ability to move between work cells, reconfigure, and perform tasks within that work-cell. The control systems that operate such factories will require communication technologies for command and control of machines with rapidity, reliability, and timeliness. Wireless protocols such as IEEE 802.11 currently address these requirements singularly but not all of them simultaneously. For example, existing protocols can provide low latency for steaming video at the cost of reliability. Other protocols can provide high reliability using low density parity check codes for forward error correction, but they sacrifice latency. Still others such as IEEE 802.15.4-based protocols offer reliability while sacrificing latency and throughput. New protocols are needed to address reliability (data transaction error rate < 1e-9) and latency (closed-loop sense-to-actuation time < 1ms) simultaneously within a factory work cell with at least ten (10) sensing/actuation devices such as proximity sensors, scanners, and switches. Such a system would address all aspects of the communications system including RF band selection, antenna selection, radio

diversity, forward error correction, bandwidth, and interference mitigation. Ideally, the solution would build upon existing physical layer specifications.

This project addresses the wireless requirements of the future factory by developing a solution using existing physical layer technologies such as IEEE 802.11. The project will produce models and simulations of the proposed wireless communications system within a discrete manufacturing work-cell. The proposed communications system will include all aspects of the channel including the antenna system, radio front-ends, baseband processing, and error coding. Study of the proposed solution will include the co-simulation of the wireless communications model with a model of a factory process. Coexistence of the proposed solution with other competing data sources within the factory will be addressed.

Phase I expected results:
Produce a model of the end-to-end communications system with particularly detailed attention placed on the focal point of the model such as the antenna system that addresses the communications reliability requirement (data transaction error rate < 1e-9) while maintaining latency constraints (closed-loop sense-to-actuation time < 1ms).

Phase II expected results:
Produce a working system prototype of the wireless communications system. The hardware prototypes will include all aspects of the system modeled during Phase I. The prototype will include an Ethernet-based port for injecting/extracting sensor/actuator data. The prototype will also include common analog inputs and outputs such as on/off and pulse-width modulation interfaces. The prototypes will be demonstrated within a testbed that emulates the harsh radio frequency environment of the future factory, and may be used to demonstrate a wireless protocol standardization candidate. The prototype design shall demonstrate the commercialization potential of the wireless solution.

The NIST Engineering Lab has conducted several RF measurements campaigns to assess the characteristics of RF propagation within the factory environment. The results of these measurement campaigns which are publically available (http://doi.org/10.18434/T44S3N) include channel impulse responses (magnitude and phase) and can be used to develop novel approaches for wireless communications that are highly reliable and have low latency. In addition, NIST industrial wireless project staff may be available to collaborate with the incumbent as an advisor, provide manufacturing use case examples, and offer test-bed resources including the use of a wireless channel emulator.

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9.04.08.77 Medical Device Cybersecurity Tools or Compensating Controls

Medical devices, such as infusion pumps, are a critical component of our national healthcare delivery system. There are millions of digitally connected medical devices in our hospitals, nursing homes, outpatient clinics, other commercial points of care and, increasingly, in the home. These devices are connected to people and to critical networks in these environments, and vulnerabilities in their programming provide entry points for cyber attacks with significant consequences [1].

There will be billions of exposures between patients and connected medical devices over the next 10 years. It is imperative that the technology, security, medical and public health experts collaborate to better design, implement and operate medical devices that compose critical cyber physical human systems.

NIST is working on cybersecurity guidance for wireless infusion pumps [2]. NIST is interested in funding innovative technologies to better secure medical devices, device associated

networks to deliver safer clinical work flow and environments. These technologies should have near term commercial potential and promise of adoption by healthcare delivery systems. These technologies would deliver increased awareness of device fitness, function and security threat in the promotion of safer healthcare delivery environments.

Phase I expected results:
Design of the hardware and/or software for a medical device or compensating control for medical device that demonstrates the desired security properties/features while not having a negative impact on the functionality or safety of the device. Some examples of these security properties/feature are malware protection, device monitoring, asset inventory, risk assessment, encryption, patching and updating, device tracking, etc. Description of the threats that the design will counter. Example scenarios of specific attacks that will be thwarted by the device.

Phase II expected results:
Provide a prototype that demonstrates the design and attack scenarios from Phase I. Along with the prototype, provide a discussion of the security properties/features it addresses and how this fits within the healthcare ecosystem. Taking into consideration the cyber-safety concerns of medical devices as well as the usability challenges presented within the healthcare environment.

References:
1. Alexandra Ossola, "Hacked Medical Devices May Be the Biggest Cyber Security Threat in 2016," November 23, 2015 http://www.popsci.com/hackers-could-soon-hold-your-life-ransom-by-hijacking-your-medical-devices.

2. National Cybersecurity Center of Excellence, Wireless Infusion Pumps Use Case, https://nccoe.nist.gov/projects/use_cases/medical_devices.

9.04.09.77 Policy Machine/Next Generation Access Control Implementation

To solve the interoperability and policy enforcement problems of today's access control paradigm, NIST has developed a specification [1] and open source reference implementation [2], of an access control system, referred to as the Policy Machine (PM). The PM is designed in support of, and in alignment with an emerging ANSI/INCITS standard under the title of "Next Generation Access Control" (NGAC) [3], [4]. The PM/NGAC is a fundamental reworking of traditional access control into a form suited to the needs of the modern, distributed, interconnected enterprise. It is based on a flexible infrastructure that can provide access control services for a number of different types of resources accessed by a number of different types of applications and users. The PM/NGAC infrastructure is proven scalable and can support policies of various types [5] simultaneously while

remaining manageable in the face of changing technology, organizational restructuring, and increasing data volumes.

The PM/NGAC is defined in terms of a standardized set of configurable data relations and a set of standardized functions that are generic to the specification and enforcement of arbitrary combinations of attribute-based access control policies. The PM is not an extension or adaptation of any existing access control model or mechanism, but instead is an attempt to fundamentally redefine access control in terms of its basic configuring data abstractions and functions. Its objective is to provide a unifying framework to support not only current OS and application policies, but also a host of orphan policies for which no mechanism yet exists for their viable enforcement. The PM requires changes only in its data configuration in the enforcement of arbitrary and organization-specific, attribute-based access control policies.

The current version of the open source is a close Java implementation of the NGAC standard, to include a policy and attribute store, a Policy Enforcement Point and a centralized Policy Decision Point, and an administrative tool for managing policies and attributes. In addition, the implementation includes in memory structures, a session manager, several applications, a system for viewing available resources, among others.

The PM and NGAC compare favorably [6] to XACML [7], the current de facto access control standard, in many respects, including performance, scalability, policy expression and enforcement, policy and attribute administration and visualization, and application adaptation.

Of the two standard Attribute-Based Access Control methodologies, XACML is the oldest with the first version having been published in 2003. Compared to the relatively young NGAC standard (published in 2013), there exist many more implementations and it has achieved much greater adoption. This is most likely because XACML was available first and, up to this point, there has been a lack of compelling evidence to convince the community to use PM/NGAC. Paramount to the argument to deploy PM/NGAC is a demonstration of its scalability. This concern has recently been put to rest with a publication showing linear run-time algorithms for both computing decisions and reviewing policies [8]. These algorithms are now included in the latest version 1.6 of the open source reference implement. The next logical step in promoting PM/NGAC's wide spread use is the availability of a commercially viable implementation.

In addition to fundamental features of the Open source version of the PM, advanced features are required for enhanced performance and usability. This SBIR subtopic seeks development of additional PM features, which may include: (1) easy and general user interface for managing, visualizing and analyzing policies; (2) extend the current in memory structures developed for a subset of the policy relations to the entire standard set

necessary for computing decisions and reviewing policies; (3) adopt a more efficient and flexible storage mechanism for importing and exporting policies to/from memory; (4) enhance existing permission delegation approach through a better API and GUI; (5) replace the exist windows manager (Microsoft dependent) with a Java based implementation for enhanced portability; (6) Review and remove dormant features for better maintainability and increased performance; and (7) Better user, administrator, and application developer documentation.

Phase I activities and expected results:
Plan, specification and design for an enhanced implementation based on the existing PM open source for future commercial use. Completed development plan, specification, and design including test plan for the proposed capabilities.

Phase II activities and expected results:
Code development, documentation, and testing of the Beta version of a commercially viable PM/NGAC product. A robust beta version of PM/NGAC product that contains the proposed enhance capabilities, documentation for the code and user manual, and testing results to verify the completeness of the development.

In addition to PM source code, NIST may be available to provide consultation, input, and discussion with the awardee to help with the evaluation of the proposed development.

References:
[1] D. Ferraiolo, S. Gavrila, and W. Jansen, Policy Machine: Features, Architecture, and Specification, National Institute of Standards and Technology (NIST) Internal Report (IR) 7987 Revision 1, October 2015. http://dx.doi.org/10.6028/NIST.IR.7987r1.

[2] NIST Policy Machine Versions 1.5 and 1.6 - Harmonia [Website], https://github.com/PM-Master.

[3] American National Standards Institute, Information technology - Next Generation Access Control - Functional Architecture (NGAC-FA), INCITS 499-2013, American National Standard for Information Technology, March 2013.

[4] American National Standards Institute, Information technology – Next Generation Access Control – Generic Operations and Data Structures (GOADS), INCITS 526-2016, American National Standard for Information Technology, January 2016.

[5] P. Mell, J. Shook, S. Gavrila, Restricting Insider Access through Efficient Implementation of Multi-Policy Access Control Systems. In Proceedings of the 8th ACM CCS International Workshop on Managing Insider Security Threats. Vienna, Austria, October 24-26, 2016.

[6] D. F. Ferraiolo, R. Chandramouli, V. C. Hu, and D. R. Kuhn, “A Comparison of Attribute Based Access Control (ABAC) Standards for Data Service Applications: Extensible Access Control Markup Language (XACML) and Next Generation Access Control (NGAC)”, NIST Special Publication 800-178, Computer Security Division, Information Technology Laboratory, National Institute of Standards and Technology, October 2016.http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-178.pdf.

[7] OASIS, *eXtensible Access Control Markup Language (XACML) Version 3.0*, January 22, 2013. http://docs.oasis-open.org/xacml/3.0/xacml-3.0-core-spec-os-en.pdf [accessed 8/29/16].

9.04.10.73 Smart Visualization for Smart Manufacturing

Today’s manufacturing systems are able to collect vast amounts of data; however, much of that data is never used unless and until there is a known problem with the equipment. Sometimes the problem will not even be detected until the product is being used in the field, implying that the manufacturing problem may have persisted for several generations of the product. Advances in data visualization, which is a fundamental means of observing data and discovering problems, hold the potential of faster detection of issues and more rapid improvements. However, data visualization still requires considerable effort to easily integrate with the systems generating data [1].

Current approaches (drag-and-drop dashboards, tableaus, etc.) to visualizing smart and sustainable manufacturing enterprises are limited and suffer from many drawbacks. Substantial manual effort from experienced practitioners is required. In some cases, skilled programming is necessary. In other cases, significant visualization expertise is necessary. Understanding large amounts of data, often stored as combinations of relational and non-relational data in a variety of quasi-federated databases or being streamed directly from machines and not well understood by anyone in an enterprise, adds further difficulty. Combining all of these skills in a single person is costly and is likely to remain out of reach, particularly for small manufacturers. (Large manufacturers have similar problems although for different reasons – while visualization teams exist, inordinately larger data sets make visualization harder in other ways.)

Currently, even the best results are inflexible, unable to adapt to in-process schema changes or schema-less databases. This leads to inflexible software that either suffers from “bit rot” as schemas and databases change out from under the visualization software or from the inability to incorporate new data to improve visualizations.

Manufacturing systems pose other unique characteristics for data. For instance, correlations between time and spatial coordinates are one fundamental concept for assessing manufacturing performance. Performance is often plagued by the interaction of variables along multiple dimensions, rather than a two-factor correlation. In response, some solutions focus on prioritizing dimensions or mathematically reducing dimensionality to best fit to practical visualizations. However, such data transformations can lead to a loss in context and information. Other unique characteristics exist. All in all, the manufacturing environment has become *data rich* but *information poor*.

The goal is to make available manufacturing visualization software that is more flexible, powerful, and easy to use than existing tools. The project will study fundamental concepts that are of relevance to manufacturing data, develop procedures for automatically applying visualization techniques to those concepts, and provide a natural language-based user interface to allow manufactures to quickly assemble their own visualizations based on their datasets. The solution is expected to make use of accepted and practical visualization principles, such as the proper mapping of visual variables to its target data [2], and apply these principles to create a manufacturing-focused toolset.

Additional features of the toolset may include a natural language-based front-end, user guidance on types of visualizations to apply to a given dataset, and data crawling capabilities. A natural language-based front-end will be a helpful component and, for some users, a superior interface to traditional drag-and-drop techniques. User guidance may come in the form of proffering certain visualization techniques that are recognizably appropriate for a dataset, dissuading the use of visualization techniques that are inappropriate for given data, and explaining visualizations that are not immediately obvious. The tool should offer and suggest appropriate choices to deal with challenging data such as high-dimension data. The software should include an expandable library of plugin visualization components allowing for inclusion of new visualization technologies as they become available. A backend data crawler may adapt to new data as it becomes available within the enterprise, with and even without explicit schemas.

Phase I expected results:
Phase I of this subtopic will demonstrate the feasibility of developing software for visualizations using limited natural language and based on a library of visualizations for manufacturing-specific “big data” (large and varied databases).

Phase II expected results:
Phase II of the project will focus on richer natural language interfaces, techniques to recommend visualizations based on data, and automated assistance at understanding novel visualizations. The end goal of Phase II will be a user interface that accepts natural language as an input and then produces interactive visualizations as an output.

At the end of the project, non-visualization specialists should be able to interact with the system, producing visualizations that are better than Excel, at least as good as those from R, Wolfram, D3JS, etc., but much more quickly and without the development time or skills required by current visualization software.

NIST may be available to work collaboratively with the awardee providing consultation and input on the activities and directions and providing data and scenarios.

References:
[1] Visualization-related collections described in "visualization zoos" such as https://queue.acm.org/detail.cfm?id=1805128., http://www.idea.org/blog/2012/10/25/great-tools-for-data-visualization/, and http://d3js.org.

[2] Carpendale, M.S.T. (2003). Considering Visual Variables as a Basis for Information Visualisation. Computer Science TR #2001-693-16. Dept. Computer Science, University of Calgary; http://dspace.ucalgary.ca/handle/1880/45758.

9.04.11.77 Sources of and Triggers for Cybersecurity Failures

NIST is developing a "Bugs Framework" (BF) to categorize and describe classes of bugs in software. For each bug class, the framework includes rigorous definitions and attributes of the class, along with its related dynamic properties, such as proximate, secondary, and tertiary fault causes, consequences, and sites in code. The boundary of the framework is source code; it does not describe the source of the bug (that is, when in the software lifecycle the programmer made a mistake causing the bug) nor what inputs trigger a failure from the bug. The sources and triggers are vital to connect the BF to the software development life cycle. Once this connection is made, software developers can determine the proper tools and techniques to preclude, find, remove, or mitigate bugs.

This project will develop an automated method to discovery the source of a bug and what triggers it given the identification of an instance of a bug that is in a particular class. The automated method will draw on the history of changes to the code and test inputs to the software under development. Although the programming languages that NIST is interested in are Turing Complete, NIST believes that undecidable problems, such as the Halting Problem, need not prevent development of a satisfactory method. Choosing a particular class of bugs should allow a stochastic or heuristic approach to suffice.

Phase I expected results:
An architecture of and development plan for an automated method to discover the source

of and one or more triggers for an instance of a program bug, from one of the BF classes.

Phase II expected results:
A demonstration version of a tool that, given an instance of a bug from a BF class, (a) identifies the source of a bug and (b) one or more set of inputs that trigger the bug.

NIST may be available for consultation, input, and discussion.

References:
1. Irena Bojanova, Paul E. Black, Yaacov Yesha, and Yan Wu, "The Bugs Framework (BF): A Structured Approach to Express Bugs," 2016 IEEE International Conference on Software Quality, Reliability, and Security (QRS 2016), Vienna, Austria. August 1-3, 2016.

2. Joe Jarzombek and Karen Mercedes Goertzel, "Security in the Software Life Cycle", CrossTalk the Journal of Defense Software Engineering, September 2006.

3. Tim Rains, "How Vulnerabilities are Exploited: The Root Causes of Exploited Remote Code Execution CVEs", Microsoft Secure Blog, June 24, 2014. Available at https://blogs.microsoft.com/microsoftsecure/2014/06/24/how-vulnerabilities-are-exploited-the-root-causes-of-exploited-remote-code-execution-cves/ .

Appendix A. COVER SHEET

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

Application to National Institute of Standards and Technology (NIST) Small Business Innovation Research (SBIR) Program 2017-NIST-SBIR-01 Cover Sheet				
Name of Submitting Firm:	Click here to enter text.			
Subtopic Number	Click here to enter text.	**Project Title**	Click here to enter text.	
Principal Investigator (PI) Name	Click here to enter text.	**PI Title**	Click here to enter text.	
PI Phone #	Click here to enter text.	**PI E-mail**	Click here to enter text.	

NIST may verify the following responses with information provided elsewhere in your application or by independent sources.

THE APPLICANT CERTIFIES THAT:	
1. It is a small business concern (SBC) and meets the definition as stated in this Notice of Funding Opportunity (NOFO).	☐ Yes ☐ No
2. The primary employment of the PI will be with the SBC at the time of award and during the conduct of research.	☐ Yes ☐ No
3. A minimum of either two-thirds for Phase I or one-half for Phase II of the research will be performed by the SBC as determined by data provided in the Budget Narrative. See NOFO Section **1.03.01** for details on funding determination.	☐ Yes ☐ No
4. The applicant and/or PI ☐ has / ☐ has not submitted applications for essentially equivalent work under other Federal program FFOs and ☐ has / ☐ has not received other Federal awards for essentially equivalent work. If "has", what agency? **Click here to enter text.** See NOFO Section 3.02.02 (13) for additional details that must be provided.	
5. The applicant qualifies as a socially and economically disadvantaged SBC and meets the definition as stated in this NOFO.	☐ Yes ☐ No
6. The applicant qualifies as a woman-owned SBC and meets the definition as stated in this NOFO.	☐ Yes ☐ No
7. The applicant qualifies as a HUBZone-owned SBC and meets the SBA's definition (see http://www.sba.gov/hubzone).	☐ Yes ☐ No
8. Year SBC founded:	**Click here to enter text.**
9. Number of Employees:	**Click here to enter text.**
STATEMENTS:	
10. The applicant will permit the Government to disclose contact information if this application does not result in an award, to appropriate local and State-level economic development organizations that may be interested in contacting you for further information.	☐ Yes ☐ No
11. The applicant authorizes contact information and project title to be provided to the NIST Manufacturing Extension Partnership (MEP) after awards have been announced. If 'Yes' your contact information will be provided to NIST MEP. If so, you will be contacted by your local MEP to explore business-related support services that could benefit the potential of the project you proposed.	☐ Yes ☐ No
TECHNICAL ABSTRACT (limit to 200 words):	
Click here to enter text.	

POTENTIAL COMMERCIAL APPLICATION OF THE RESEARCH: (limit to 100 words)

Click here to enter text.

OTHER 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 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.

PROPRIETARY NOTICE

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

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.

This collection of information contains Paperwork Reduction Act (PRA) requirements approved by the Office of Management and Budget (OMB). Notwithstanding any other provisions of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA unless that collection of information displays a currently valid OMB control number. Public reporting burden for this collection is estimated to be 60 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed and completing and reviewing the collection of information. Send comments regarding this burden estimate or any aspect of this collection of information, including suggestions for reducing this burden, to the National Institute of Standards and Technology, Attn: Mary Clague, 100 Bureau Dr., MS 2200, Gaithersburg, MD 20899.

OMB Control No. 0693-0072
Expiration Date: 10/31/2017

Appendix B. CERTIFICATIONS

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

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

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

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

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

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

(1) The business concern meets the ownership and control requirements set forth in 13 C.F.R. § 121.702.
☐Yes ☐No

(2) If a corporation, all corporate documents (articles of incorporation and any amendments,

articles of conversion, by-laws and amendments, shareholder meeting minutes showing officer elections, organizational meeting minutes, all issued stock certificates, stock ledger, buy-sell agreements, stock transfer agreements, voting agreements, and documents relating to stock options, including the right to convert non-voting stock or debentures into voting stock) evidence that it meets the ownership and control requirements set forth in 13 C.F.R. § 121.702.
☐Yes ☐No ☐N/A Explain why N/A:
_____

(3) If a partnership, the partnership agreement evidences that it meets the ownership and control requirements set forth in 13 C.F.R. § 121.702.
☐Yes ☐No ☐N/A Explain why N/A:
_____

(4) If a limited liability company, the articles of organization and any amendments, and operating agreement and amendments, evidence that it meets the ownership and control requirements set forth in 13 C.F.R. § 121.702.
☐Yes ☐No ☐N/A Explain why N/A:
_____

(5) The birth certificates, naturalization papers, or passports show that any individuals it relies upon to meet the eligibility requirements are U.S. citizens or permanent resident aliens in the United States.
☐Yes ☐No ☐N/A Explain why N/A:
_____

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

(7) SBA has not issued a size determination currently in effect finding that this business concern exceeds the 500 employee size standard.
☐Yes ☐No

(8) During the performance of the award, the principal investigator will spend more than one half of his/her time as an employee of the awardee or has requested and received a written deviation from this requirement from the funding agreement officer.
☐Yes ☐No ☐Deviation approved in writing by funding agreement officer: _____ %

(9) All, essentially equivalent work, or a portion of the work proposed under this project (check the applicable line):
☐Has not been submitted for funding by another Federal agency.

☐Has been submitted for funding by another Federal agency but has not been funded under any other Federal grant, contract, subcontract or other transaction.
☐A portion has been funded by another grant, contract, or subcontract as described in detail in the application and approved in writing by the funding agreement officer.

(10) During the performance of award, it will perform the applicable percentage of work unless a deviation from this requirement is approved in writing by the funding agreement officer (check the applicable line and fill in if needed):
☐SBIR Phase I: at least two-thirds (66 2/3%) of the research.
☐SBIR Phase II: at least half (50%) of the research.
☐Deviation approved in writing by the funding agreement officer: _____ %

(11) During performance of award, the research/research and development will be performed in the United States unless a deviation is approved in writing by the funding agreement officer.
☐Yes ☐No ☐Waiver has been granted

(12) During performance of award, the research/research and development will be performed at my facilities with my employees, except as otherwise indicated in the SBIR application and approved in the funding agreement.
☐Yes ☐No

(13) It has registered itself on SBA's database as majority-owned by venture capital operating companies, hedge funds or private equity firms.
☐Yes ☐No ☐N/A Explain why N/A:
_____

(14) It is a Covered Small Business Concern (a small business concern that:
(a) was not majority-owned by multiple venture capital operating companies (VCOCs), hedge funds, or private equity firms on the date on which it submitted an application in response to an SBIR NOFO; and (b) on the date of the SBIR award, which is made more than 9 months after the closing date of the NOFO, is majority-owned by multiple venture capital operating companies, hedge funds, or private equity firms).
☐Yes ☐No

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

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

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

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

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

Print Name (First, Middle, Last)

_____

Title

_____

Business Name

_____

SBIR Funding Agreement Certification (Life-Cycle Certification)

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

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

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

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

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

(1) The principal investigator spent more than one half of his/her time as an employee of the awardee or the awardee has requested and received a written deviation from this requirement from the funding officer.
☐Yes ☐No ☐Deviation approved in writing by funding agreement officer: _____ %

(2) All, essentially equivalent work, or a portion of the work performed under this project (check applicable line):
☐Has not been submitted for funding by another Federal agency.
☐Has been submitted for funding by another Federal agency but has not been funded under any other Federal grant, contract, subcontract or other transaction.
☐A portion has been funded by another grant, contract, or subcontract as described in detail in the application and approved in writing by the funding agreement officer.

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

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

(4) The work is completed and it has performed the applicable percentage of work, unless a deviation from this requirement is approved in writing by the funding agreement officer (check the applicable line and fill in if needed):
☐SBIR Phase I: at least two-thirds (66 2/3%) of the research.
☐SBIR Phase II: at least half (50%) of the research.
☐Deviation approved in writing by the funding agreement officer: _____ %
☐N/A because work is not completed.

(5) The research/research and development is performed in the United States unless a deviation is approved in writing by the funding agreement officer.
☐Yes ☐No ☐Waiver has been granted

(6) The research/research and development is performed at my facilities with my employees, except as otherwise indicated in the SBIR application and approved in the funding agreement.
☐Yes ☐No

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

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

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

Signature _____Date ___ /___ /___

Print Name (First, Middle, Last)

_____

Title

_____

Business Name

_____