

National Aeronautics and Space Administration

**SMALL BUSINESS
INNOVATION RESEARCH (SBIR)
&
SMALL BUSINESS
TECHNOLOGY TRANSFER (STTR)
General Solicitation**

**Opening Date: September 17, 2012
Closing Date: November 29, 2012**

***The electronic version of this document
is at: <http://sbir.nasa.gov>***

2012 SBIR/STTR Solicitation Noteworthy Changes

Changes to both Phase I and Phase II SBIR/STTR Solicitations:

Phase I and Phase II Instructions

The instructions for both Phase I and Phase II are still separated into two separate documents; however, the Phase II instructions have had some instructions removed that are repetitive and are carried forward for both Phase I and Phase II submissions.

1.2 Program Authority and Executive Order

On December 31, 2011, the President signed into law the National Defense Reauthorization Act of 2012 (Defense Reauthorization Act), Public Law 112-81, Section 5001, Division E of the Defense Reauthorization Act contains the SBIR/STTR Reauthorization Act of 2011 (SBIR/STTR Reauthorization Act)), extending authorization of the SBIR/STTR Programs until September 30, 2017.

1.3 Program Management

The Exploration Systems Mission Directorate and the Space Operations Mission Directorate have been merged into one Mission Directorate called the Human Exploration and Operations Mission Directorate.

1.4 Three-Phase Program (1.2 and 1.3 in the Phase II instructions)

The description for the Phase II Enhancement (Phase II-E) contract option has changed and a new contract option has been added, called Phase II eXpanded (Phase II-X).

1.5.4 Restrictions on Funding Activity with the Peoples Republic of China

This is a new restriction.

1.6 (1.5 in the Phase II instructions) NASA SBIR Technology Available (TAV)

All subtopics now have the option to use TAV with NASA IP.

3.2.4 (2.2.4 in the Phase II instructions) Technical Content, Part 8: Facilities/Equipment

Firms are only required to have a facility waiver for Federal facilities and not Federal laboratories; however, the offeror must provide a letter from the Government agency that verifies the availability, this should be uploaded in Form C of the proposal for ALL Federal facility/laboratory use.

5.11 Contractor Commitments

An outline has been provided that is illustrative of the types of clauses to which the contractor would be committed. This list is not a complete list of clauses to be included in the funding agreements, and is not the specific wording of such clauses.

Firm Certifications

Firm certifications have significantly changed, with different requirements, so please look at each one carefully.

Forms A, B, and C

Electronic endorsement is now required to be performed by both the Principal Investigator and the authorized Business Official. Forms A, B, and C have all been revamped with significant changes and different requirements, so please look at each one carefully.

Specific Phase I Changes:

3.2.2 Format Requirements

The maximum allowable page count for the Phase I technical content has **DECREASED and is not to exceed 20 pages for SBIR and 19 pages for STTR**, including all graphics, with a table of contents.

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Evaluation Criteria for the
NASA 2012 SBIR/STTR Solicitation**

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2012 NASA SBIR/STTR Program Solicitations

1. Program Description

1.1 Introduction

This document includes two NASA program solicitations with separate research areas under which small business concerns (SBCs) are invited to submit proposals: the Small Business Innovation Research (SBIR) Program and the Small Business Technology Transfer (STTR) Program. Program background information, eligibility requirements for participants, information on the three program phases, and information for submitting responsive proposals are contained herein. The 2012 Solicitation period for Phase I proposals begins September 17, 2012 and ends November 29, 2012.

The purposes of the SBIR/STTR programs, as established by law, are to stimulate technological innovation in the private sector; to strengthen the role of SBCs in meeting Federal research and development needs; to increase the commercial application of these research results; and to encourage participation of socially and economically disadvantaged persons and women-owned small businesses.

Technological innovation is vital to the performance of the NASA mission and to the Nation's prosperity and security. To be eligible for selection, a proposal must present an innovation that meets the technology needs of NASA programs and projects as described herein and has significant potential for successful commercialization. Commercialization encompasses the transition of technology into products and services for NASA mission programs, other U.S. Government agencies, and non-Government markets.

NASA considers every technology development investment dollar critical to the ultimate success of NASA's mission and strives to ensure that the research topic areas described in this solicitation are in alignment with its Mission Directorate high priorities and technology needs. In addition, the Solicitation is structured such that SBIR/STTR investments are complementary to other NASA technology investments. NASA's ultimate objective is to achieve infusion of the technological innovations developed in the SBIR/STTR programs into its Mission Directorates programs and projects.

The NASA SBIR/STTR programs do not accept proposals solely directed towards system studies, market research, routine engineering development of existing product(s), proven concepts, or modifications of existing products without substantive innovation.

It is anticipated that SBIR and STTR Phase I proposals will be selected for negotiation of firm-fixed-price contracts around the February 2013 timeframe. Historically, the percentage of Phase I proposals to awards is approximately 13-15% for SBIR and STTR, and approximately 35-40% of the selected Phase I contracts are competitively selected for Phase II follow-on efforts.

Under this Solicitation NASA will not accept more than 10 proposals to either program from any one firm in order to ensure the broadest participation of the small business community. NASA does not plan to award more than 5 SBIR contracts and 2 STTR contracts to any offeror.

Proposals must be submitted online via the Proposal Submissions Electronic Handbook at <http://sbir.nasa.gov> and include all relevant documentation. Unsolicited proposals will not be accepted.

1.2 Program Authority and Executive Order

SBIR and STTR opportunities are solicited annually pursuant to the Small Business Innovation Development Act of 1982, P.L. 97-219 (codified at 15 U.S.C. 638) as amended by the Small Business Innovation Research (SBIR) Program, Extension, P.L. 99-443 which extended the program through September 30, 1993. On October 28, 1992, through the Small Business Innovation Research and Development Act of 1992 (P.L. 102-564), Congress reauthorized and extended the SBIR Program for another seven years (2000). Subsequently, on December 21, 2000, through the Small Business Reauthorization Act of 2000 (P.L. 106-554) Congress again reauthorized the SBIR Program. With the approval of H.R. 2608, Continuing Appropriations Act 2012, the SBIR Program was authorized through December 31, 2011. On December 31, 2011, the President signed into law the National Defense Reauthorization Act of 2012 (Defense Reauthorization Act), P. L. 112-81, Section 5001, Division E of the Defense Reauthorization Act contains the SBIR/STTR Reauthorization Act of 2011 (SBIR/STTR Reauthorization Act)), which extends both the SBIR and Small Business Technology Transfer (STTR) programs through September 30, 2017.

Executive Order

This solicitation complies with Executive Order 13329 (issued February 26, 2004) directing Federal agencies that administer the SBIR and STTR programs to encourage innovation in manufacturing related research and development consistent with the objectives of each agency and to the extent permitted by law.

On February 26, 2004, the President issued Executive Order 13329 (69 FR 9181) entitled “Encouraging Innovation in Manufacturing.” In response to this Executive Order, NASA encourages the submission of applications that deal with some aspect of innovative manufacturing technology. If a proposal has a connection to manufacturing this should be indicated in the Part 5 (Related R/R&D) of the proposal and a brief explanation of how it is related to manufacturing should be provided.

Energy Independence and Security Act of 2007, section 1203, stated that federal agencies shall give high priority to small business concerns that participate in or conduct energy efficiency or renewable energy system research and development projects. If a proposal has a connection to energy efficiency or alternative and renewable energy this should be indicated in Part 5 (Related R/R&D) of the proposal. Provide a brief explanation of how it is related to energy efficiency and alternative and renewable energy.

1.3 Program Management

The Office of the Chief Technologist under the Office of the NASA Associate Administrator provides overall policy direction for implementation of the NASA SBIR/STTR programs. The NASA SBIR/STTR Program Management Office, which operates the programs in conjunction with NASA Mission Directorates and Centers, is hosted at the NASA Ames Research Center. NASA Shared Services Center (NSSC) provides the overall procurement management for the programs. All of the NASA Centers actively participate in the SBIR/STTR programs; and to reinforce NASA’s objective of infusion of SBIR/STTR developed technologies into its programs and projects, each Center has personnel focused on that activity.

NASA research and technology areas to be solicited are identified annually by Mission Directorates. The Directorates identify high priority research and technology needs for their respective programs and projects. The needs are explicitly described in the topics and subtopics descriptions developed by technical experts at NASA’s Centers. The range of technologies is broad, and the list of topics and subtopics may vary in content from year to year. See section 9.1 for details on the Mission Directorate research topic descriptions for the SBIR Program.

The STTR Program is aligned with the priorities of NASA’s Space Technology Roadmaps, as well as the associated core competencies of the NASA Centers as described in section 9.2.

Information regarding the Mission Directorates and the NASA Centers can be obtained at the following web sites:

NASA Office of the Chief Technologist (OCT)	
Space Technology Roadmaps	http://www.nasa.gov/offices/oct/home/roadmaps/index.html

NASA Mission Directorates	
Aeronautics Research	http://www.aeronautics.nasa.gov/
Human Exploration and Operations	http://www.nasa.gov/directorates/heo/home/
Science	http://nasascience.nasa.gov

NASA Centers	
Ames Research Center (ARC)	http://www.nasa.gov/centers/ames/home/index.html
Dryden Flight Research Center (DFRC)	http://www.nasa.gov/centers/dryden/home/index.html
Glenn Research Center (GRC)	http://www.nasa.gov/centers/glenn/home/index.html
Goddard Space Flight Center (GSFC)	http://www.nasa.gov/centers/goddard/home/index.html
Jet Propulsion Laboratory (JPL)	http://www.nasa.gov/centers/jpl/home/index.html
Johnson Space Center (JSC)	http://www.nasa.gov/centers/johnson/home/index.html
Kennedy Space Center (KSC)	http://www.nasa.gov/centers/kennedy/home/index.html
Langley Research Center (LaRC)	http://www.nasa.gov/centers/langley/home/index.html
Marshall Space Flight Center (MSFC)	http://www.nasa.gov/centers/marshall/home/index.html
Stennis Space Center (SSC)	http://www.nasa.gov/centers/stennis/home/index.html

1.4 Three-Phase Program

Both the SBIR and STTR programs are divided into three funding and development stages.

Maximum value and period of performance for Phase I and Phase II contracts:

Phase I Contracts	SBIR	STTR
Maximum Contract Value	\$125,000	\$125,000
Period of Performance	6 months	12 months
Phase II Contracts	SBIR	STTR
Maximum Contract Value	\$750,000	\$750,000
Period of Performance	24 months	24 months

Phase I

The purpose of Phase I is to determine the scientific, technical, commercial merit and feasibility of the proposed innovation, and the quality of the SBC's performance. Phase I work and results should provide a sound basis for the continued development, demonstration and delivery of the proposed innovation in Phase II and follow-on efforts. Successful completion of Phase I objectives is a prerequisite to consideration for a Phase II award.

Phase II

The purpose of Phase II is the development, demonstration and delivery of the innovation. Only SBCs awarded a Phase I contract are eligible to submit a proposal for a Phase II funding agreement. Phase II projects are chosen as a result of competitive evaluations and based on selection criteria provided in the Phase II Proposal Instructions and Evaluation Criteria.

Phase II Enhancement (Phase II-E)

The purpose of the Phase II-E Option is to further encourage the advancement of innovations developed under Phase II contracts via an extension of R/R&D efforts to the current Phase II contract. Eligible firms must secure a third-party investor to partner and invest in enhancing their technology for further research, infusion, and commercialization. Under this option, the NASA SBIR/STTR Program will match, on a dollar-to-dollar basis, up to \$125,000 of non-NASA-SBIR/non-NASA-STTR investments to extend a project from 6-to-12 months. There is a minimum funding requirement for Phase II-E, as eligible firms must secure at least \$25,000 in third party investments. These non-NASA-SBIR/non-NASA-STTR third party investments can come from a NASA project,

NASA contractor, or any commercial investor. The total cumulative award for the Phase II contract plus the Phase II-E match is not expected to exceed \$875,000 of SBIR/STTR funding. The non-SBIR/non-STTR contribution is not limited since it is regulated under the guidelines for Phase III awards.

The Phase II-E application may be submitted anytime during the 4th month before the end of the contract period of performance (for example, a 24 month period of performance, the application would be due any time during the 20th month of the period of performance; a 18 month period of performance, the application would be due any time during the 14th month of the period of performance). Also, any additional information regarding the submission of a Phase II-E proposal will be included in the Phase II contracts. Firms interested in executing a Phase II-E option are requested to notify the NASA SBIR/STTR Program of its intent to propose in writing to ARC-SBIR-PMO@mail.nasa.gov, by the end of the 13th month of performance of the Phase II contract. This written notification will be non-binding.

Maximum value and period of performance for the Phase II-E contract option:

Phase II Enhancement	Minimum non-SBIR/STTR Funding Required for Eligibility for Matching in Phase II-E	Corresponding SBIR/STTR Program Contribution	Anticipated Period of Additional Performance
	\$25,000	\$25,000	6-12 Months
	Maximum non-SBIR/STTR Funding to be Matched by SBIR/STTR Program in Phase II-E	Corresponding SBIR/STTR Program Contribution	Anticipated Period of Additional Performance
	\$125,000	\$125,000	6-12 Months

Phase II contracts with a period of performance less than 18 months, will NOT be eligible for a Phase II-E. In addition, to be eligible for this option, the contractor's performance must be on time in accordance with the contract work plan. The number of Phase II-E options to be exercised is subject to the availability of funds and will be selected based on criteria provided in the Phase II contract.

Phase II eXpanded (Phase II-X)

The purpose of the Phase II-X Option is to establish a strong and direct partnership between the NASA SBIR/STTR Program and other NASA projects undertaking the development of new technologies of innovations for future use. Under a Phase II-X option, innovations developed in Phase II are to be advanced via an extension of R/R&D efforts to the current Phase II contract. There are two specific requirements to be met for firms to be eligible for a Phase II-X option. First, eligible firms must secure a NASA program or project (other than the NASA SBIR/STTR Program) as a partner to invest in enhancing their technology for further research or infusion. Second, there is a minimum funding requirement for Phase II-X, as eligible firms must secure at least \$75,000 in NASA program or project funding. Under this option, the NASA SBIR/STTR Program will match, on a 2-for-1 basis, up to \$250,000 of NASA program or project funding, thus enabling a maximum of \$500,000 of SBIR/STTR award funds to be added from the NASA SBIR/STTR Program. Note: A firm may acquire additional, non-NASA, third-party investments as part of a Phase II-X option, but those funds will not be counted in the NASA SBIR/STTR Program's matching calculation. Executing a Phase II-X option is anticipated to extend a Phase II from 12-to-24 months after the completion of Phase II. The total cumulative award for the Phase II contract plus the Phase II-X match is not expected to exceed \$1,250,000 of SBIR/STTR funding. The NASA contribution is not limited since it is regulated under the guidelines for Phase III awards.

The Phase II-X application may be submitted anytime during the 4th month before the end of the contract period of performance (for example, a 24 month period of performance, the application would be due any time during the 20th month of the period of performance; a 18 month period of performance, the application would be due any time during the 14th month of the period of performance). Also, any additional information regarding the submission of a Phase II-X proposal will be included in the Phase II contracts. Firms interested in executing a Phase II-X option are requested to notify the NASA SBIR/STTR Program of its intent to propose in writing to ARC-SBIR-PMO@mail.nasa.gov, by the end of the 13th month of performance of the Phase II contract. This written notification will be non-binding.

Maximum value and period of performance for Phase II- X contract options:

Phase II eXpanded	Minimum Funding Required from non-SBIR/STTR NASA Source for Eligibility for Matching in Phase II-X	Corresponding SBIR/STTR Program Contribution	Anticipated Period of Additional Performance
	\$75,000	\$150,000	12-24 Months
	Maximum Funding Amount from non-SBIR/STTR NASA Source to be Matched in Phase II-X	Corresponding SBIR/STTR Program Contribution	Anticipated Period of Additional Performance
	\$250,000	\$500,000	12-24 Months

Phase II contracts with a period of performance less than 18 months, will NOT be eligible for a Phase II-X. The number of Phase II-X options to be exercised is subject to the availability of funds and will be selected based on criteria provided in the Phase II contract.

Proposing to the Phase II-E or Phase II-X Option

Note: The SBIR/STTR Program will allow firms with a Phase II contract that follows a Phase I contract from this solicitation to submit a proposal for either a Phase II-E contract option or a Phase II-X contract option. Firms are not permitted to submit a proposal for both options. The number of Phase II- E and Phase II-X options to be exercised may be limited by availability of funds and will be selected based on the evaluation criteria.

Phase III

NASA may award Phase III contracts for products or services with non-SBIR/STTR funds. The competition for SBIR/STTR Phase I and Phase II awards satisfies any competition requirement of the Armed Services Procurement Act, the Federal Property and Administrative Services Act, and the Competition in Contracting Act. Therefore, an agency that wishes to fund a Phase III project is not required to conduct another competition in order to satisfy those statutory provisions. Phase III work may be for products, production, services, R/R&D, or any combination thereof that is derived from, extends, or concludes efforts performed under prior SBIR/STTR funding agreements. A Federal agency may enter into a Phase III agreement at any time with a Phase I or Phase II awardee.

There is no limit on the number, duration, type, or dollar value of Phase III awards made to a business concern. There is no limit on the time that may elapse between a Phase I or Phase II and a Phase III award. The small business size limits for Phase I and Phase II awards do not apply to Phase III awards.

1.5 Eligibility Requirements

1.5.1 Small Business Concern

Only firms qualifying as SBCs, as defined in section 2.22, are eligible to participate in these programs. Socially and economically disadvantaged and women-owned SBCs are particularly encouraged to propose.

1.5.2 Place of Performance

R/R&D must be performed in the United States (section 2.27). However, based on a rare and unique circumstance (for example, if a supply or material or other item or project requirement is not available in the United States), NASA may allow a particular portion of the research or R&D work to be performed or obtained in a country outside of the United States. Proposals must clearly indicate if any work will be performed outside the United States. Prior to award, approval by the Contracting Officer for such specific condition(s) must be in writing.

Note: Offerors are responsible for ensuring that all employees who will work on this contract are eligible under export control and International Traffic in Arms (ITAR) regulations. Any employee who is not a U.S. citizen or a permanent resident may be restricted from working on this contract if the technology is restricted under export control and ITAR regulations unless the prior approval of the Department of State or the Department of Commerce is obtained via a technical assistance agreement or an export license. Violations of these regulations can result in criminal or civil penalties.

1.5.3 Principal Investigator (PI) Employment Requirement

The primary employment of the Principal Investigator (PI) shall be with the SBC under the SBIR Program, while under the STTR Program, either the SBC or RI shall employ the PI. Primary employment means that more than 50% of the PI's total employed time (including all concurrent employers, consulting, and self-employed time) is spent with the SBC or RI at time of award and during the entire period of performance. Primary employment with a small business concern precludes full-time employment at another organization. If the PI does not currently meet these primary employment requirements, then the offeror must explain how these requirements will be met if the proposal is selected for contract negotiations that may lead to an award. Co-Principle Investigators are not allowed.

Note: NASA considers a fulltime workweek to be nominally 40 hours and we consider 19.9-hour or more workweek elsewhere to be in conflict with this rule. In rare occasions, minor deviations from this requirement may be necessary; however, any minor deviation must be approved in writing by the contracting officer after consultation with the NASA SBIR/STTR Program Manager/Business Manager.

Requirements	SBIR	STTR
Primary Employment	PI must be with the SBC	PI must be employed with the RI or SBC
Employment Certification	The offeror must certify in the proposal that the primary employment of the PI will be with the SBC at the time of award and during the conduct of the project	The offeror must certify in the proposal that the primary employment of the PI will be with the SBC or the RI at the time of award and during the conduct of the project
Co-PIs	Not Allowed	Not Allowed
Misrepresentation of Qualifications	Shall result in rejection of the proposal or termination of the contract	Shall result in rejection of the proposal or termination of the contract
Substitution of PIs	Shall receive advanced written approval from NASA	Shall receive advanced written approval from NASA

1.5.4 Restrictions on Funding Activity with the Peoples Republic of China

NASA is restricted by specific applications of Section 1340(a) of The Department of Defense and Full-Year Appropriations Act, Public Law 112-10 and Section 539 of the Consolidated and Further Continuing Appropriation Act of 2012, PL 112-55, from using funding appropriated in the Acts to contract to participate, collaborate or coordinate bilaterally in any way with China or any Chinese-owned firm, at the prime contract or any tier subcontract level.

1.6 NASA SBIR/STTR Technology Available (TAV)

All subtopics have the option of using Technology Available (TAV) with NASA IP (defined below), which may also include NASA non-patented software technology requiring a Software Usage Agreement (SUA) or similar permission for use by others. All subtopics address the objective of increasing the commercial application of innovations derived from Federal R&D. While NASA scientists and engineers conduct breakthrough research that leads to innovations, the range of NASA's effort does not extend to commercial product development in any of its intramural research areas. Additional work is often necessary to exploit these NASA technologies for either infusion or commercial viability and likely requires innovation on behalf of the private sector. NASA provides these technologies "as is" and makes no representation or guarantee that additional effort will result in infusion or commercial viability.

The NASA technologies identified in a subtopic or via the IP search tool (<http://technology.nasa.gov>): (1) are protected by NASA-owned patents (NASA Patents), (2) are non-patented NASA-owned or controlled software (NASA software), or (3) are otherwise available for use by the public. In the event offeror requests to use NASA owned or controlled technologies, which are not NASA patents or NASA software, NASA shall consider such request and permit such uses as NASA, in its sole discretion, deems appropriate and permissible. If a proposer elects to use a NASA patent, a non-exclusive, royalty-free research license will be required to use the NASA IP during the SBIR/STTR performance period.

Similarly, if a proposer wishes to use NASA software, the parties will be required to enter into a Software Usage Agreement on a non-exclusive, royalty-free basis in order to use such NASA software for government purposes and “Government-Furnished Computer Software and Related Technical Data” will apply to the contract. As used herein, “NASA IP” refers collectively to NASA patents and NASA software disclaimer: All subtopics include an opportunity to license or otherwise use NASA IP on a non-exclusive, royalty-free basis, for research use under the contract. Use of the NASA IP is strictly voluntary. Whether or not a firm uses NASA IP within their proposed effort will not in any way be a factor in the selection for award. NASA software release is governed by NPR 2210.1C.

Use of NASA Patent

All offerors submitting proposals citing a NASA patent must submit a non-exclusive, royalty-free license application if the use of a NASA patent is desired. The NASA license application is available on the NASA SBIR/STTR website: http://sbir.gsfc.nasa.gov/SBIR/research_license_app.doc. NASA only will grant research licenses to those SBIR/STTR offerors who submitted a license application and whose proposal resulted in an SBIR/STTR award under this solicitation. Such grant of non-exclusive research license will be set forth in the successful offeror’s SBIR/STTR contract. License applications will be treated in accordance with Federal patent licensing regulations as provided in 37 CFR Part 404.

SBIR/STTR offerors are notified that no exclusive or non-exclusive commercialization license to make, use or sell products or services incorporating the NASA patent will be granted unless an SBIR/STTR offeror applies for and receives such a license in accordance with the Federal patent licensing regulations at 37 CFR Part 404. Awardees with contracts that identify a specific NASA patent will be given the opportunity to negotiate a non-exclusive commercialization license or, if available, an exclusive commercialization license to the NASA patent.

An SBIR/STTR awardee that has been granted a non-exclusive, royalty-free research license to use a NASA patent under the SBIR/STTR award may, if available and on a non-interference basis, also have access to NASA personnel knowledgeable about the NASA patent. The NASA Intellectual Property Manager (IPM) located at the appropriate NASA Center will be available to assist awardees requesting information about a patent that was identified in the SBIR/STTR contract and, if available and on a non-interference basis, provide access to the inventor or surrogate for the purpose of knowledge transfer.

Note: Access to the inventor for the purpose of knowledge transfer, will require the requestor to enter into a Non-Disclosure Agreement (NDA), the awardee “may” be required to reimburse NASA for knowledge transfer activities.

Use of NASA Software

Software identified and requested under a SBIR/STTR contract shall be treated as Government Purpose Rights. Government purpose releases includes releases to other NASA Centers, Federal government agencies, and recipients who have a government contract. The software may be used for "government purposes" only. The recipients of such software releases are typically U.S. citizens. Non U.S. citizens will not be allowed access to NASA software under the SBIR/STTR contract.

A Software Usage Agreement (SUA) shall be requested after contract award from the appropriate NASA Center Software Release Authority (SRA). The SUA request shall include the NASA software title, version number, requesting firm contract info including recipient name, and SBIR/STTR contract award info. The SUA will expire when the contract ends.

1.7 General Information

1.7.1 Solicitation Distribution

This 2012 SBIR/STTR Program Solicitation is available via the NASA SBIR/STTR website (<http://sbir.nasa.gov>), SBCs are encouraged to check the website for program updates and information. Any amendment to the Solicitation will be posted there. If the SBC has difficulty accessing the Solicitation, please contact the Help Desk (section 1.7.2).

1.7.2 Means of Contacting NASA SBIR/STTR Program

- (1) NASA SBIR/STTR Website: <http://sbir.nasa.gov>
- (2) Help Desk: The NASA SBIR/STTR Help Desk can answer any questions regarding clarification of proposal instructions and any administrative matters. The Help Desk may be contacted by:

E-mail: sbir@reisystems.com
Telephone: 301-937-0888 between 9:00 a.m.-5:00 p.m. (Mon.-Fri., Eastern Time)
Facsimile: 301-937-0204

The requestor must provide the name and telephone number of the person to contact, the organization name and address, and the specific questions or requests.

- (3) NASA SBIR/STTR Program Manager: Specific information requests that could not be answered by the Help Desk should be mailed or e-mailed to:

Dr. Gary C. Jahns, Program Manager
NASA SBIR/STTR Program Management Office
MS 202A-3, Ames Research Center
Moffett Field, CA 94035-1000
Gary.C.Jahns@nasa.gov

1.7.3 Questions About This Solicitation

To ensure fairness, questions relating to the intent and/or content of research topics in this Solicitation cannot be addressed during the Phase I solicitation period. Only questions requesting clarification of proposal instructions and administrative matters will be addressed.

2. Definitions

2.1 Allocation of Rights Agreement

A written agreement negotiated between the Small Business Concern and the single, partnering Research Institution, allocating intellectual property rights and rights, if any, to carry out follow-on research, development, or commercialization.

2.2 Awardee

The organizational entity receiving an SBIR/STTR Phase I, Phase II, or Phase III award.

2.3 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.

2.4 Cooperative Research or Cooperative Research and Development (R/R&D)

For purposes of the NASA STTR Program, cooperative R/R&D is that which is to be conducted jointly by the SBC and the RI in which a minimum of 40 percent of the work (before any cost sharing or fee/profit proposed by the firm) is performed by the SBC and a minimum of 30 percent of the work is performed by the RI.

2.5 Economically Disadvantaged Women-Owned Small Businesses (EDWOSBs)

To be an eligible EDWOSB, a firm must:

(1) Be a Women Owned Small Business (WOSB) that is at least 51% owned by one or more women who are “economically disadvantaged”. (2) Have one or more economically disadvantaged women manage the day-to-day operations, make long-term decisions for the business, hold the highest officer position in the business and work at the business full-time during normal working hours. A woman is presumed economically disadvantaged if she has a personal net worth of less than \$750,000 (with some exclusions), her adjusted gross yearly income averaged over the three years preceding the certification less than \$350,000, and the fair market value of all her assets is less than \$6 million.

Please note that for both WOSB and EDWOSB, the 51% ownership must be unconditional and direct. For a general definition please see FAR 2.101 ([https://www.acquisition.gov/far/current/html/Subpart 2_1.html](https://www.acquisition.gov/far/current/html/Subpart%202_1.html)).

2.6 Essentially Equivalent Work

The “scientific overlap,” which occurs when (1) substantially the same research is proposed for funding in more than one contract proposal or grant application submitted to the same Federal agency; (2) substantially the same research is submitted to two or more different Federal agencies for review and funding consideration; or (3) a specific research objective and the research design for accomplishing an objective are the same or closely related in two or more proposals or awards, regardless of the funding source.

2.7 Feasibility

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

2.8 Federal Laboratory

As defined in 15 U.S.C. §3703, means any laboratory, any federally funded research and development center, or any center established under 15 U.S.C. §§ 3705 & 3707 that is owned, leased, or otherwise used by a Federal agency and funded by the Federal Government, whether operated by the Government or by a contractor.

2.9 Funding Agreement

Any contract, grant, cooperative agreement, or other funding transaction entered into between any Federal agency and any entity for the performance of experimental, developmental, research and development, services, or research work funded in whole or in part by the Federal Government.

2.10 Funding Agreement Officer

A contracting officer, a grants officer, or a cooperative agreement officer.

2.11 Historically Underutilized Business Zone (HUBZone) Small Business Concern

A HUBZone small business concern means a small business concern that appears on the List of Qualified HUBZone Small Business Concerns maintained by the Small Business Administration. To see the full definition of a HUBzone see the FAR 2.101 ([https://www.acquisition.gov/far/current/html/Subpart 2_1.html](https://www.acquisition.gov/far/current/html/Subpart%202_1.html)) or go to the SBA HUBzone site (www.sba.gov/hubzone) for more details.

2.12 Infusion

The integration of SBIR/STTR developed knowledge or technologies within NASA programs and projects, other Government agencies and/or commercial entities. This includes integration with NASA program and project funding, development and flight and ground demonstrations.

2.13 Innovation

An innovation is something new or improved, having marketable potential, including: (1) development of new technologies, (2) refinement of existing technologies, or (3) development of new applications for existing technologies.

2.14 Intellectual Property (IP)

The separate and distinct types of intangible property that are referred to collectively as “intellectual property,” including but not limited to: patents, trademarks, copyrights, trade secrets, SBIR/STTR technical data (as defined in section 2.19), ideas, designs, know-how, business, technical and research methods, other types of intangible business assets, and including all types of intangible assets either proposed or generated by the SBC as a result of its participation in the SBIR/STTR Program.

2.15 NASA Intellectual Property (NASA IP)

NASA IP is NASA-owned, patented technologies that NASA is offering under a non-exclusive, royalty-free research license for use under the SBIR award.

2.16 Principal Investigator (PI)

The one individual designated by the SBC to provide the scientific and technical direction to a project supported by the funding agreement.

2.17 Research Institution (RI)

A U.S. research institution is one that is: (1) a contractor-operated Federally funded research and development center, as identified by the National Science Foundation in accordance with the Government-wide Federal Acquisition Regulation issued in Section 35(c)(1) of the Office of Federal Procurement Policy Act (or any successor legislation thereto), or (2) a nonprofit research institution as defined in Section 4(5) of the Stevenson-Wydler Technology Innovation Act of 1980, or (3) a nonprofit college or university.

2.18 Research or Research and Development (R/R&D)

Creative work that is undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture, and society, and the use of this stock of knowledge to devise new applications. It includes administrative expenses for R&D. It excludes physical assets for R&D, such as R&D equipment and facilities. It also excludes routine product testing, quality control, mapping, collection of general-purpose statistics, experimental production, routine monitoring and evaluation of an operational program, and training of scientific and technical personnel.

Basic Research: systematic study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products in mind. Basic research, however, may include activities with broad applications in mind.

Applied Research: systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.

Development: systematic application of knowledge or understanding, directed toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

Note: NASA SBIR/STTR programs do not accept proposals solely directed towards system studies, market research, routine engineering development of existing products or proven concepts and modifications of existing products without substantive innovation (see section 1.1).

2.19 SBIR/STTR Technical Data

Technical data includes all data generated in the performance of any SBIR/STTR funding agreement.

2.20 SBIR/STTR Technical Data Rights

The rights an SBC obtains for data generated in the performance of any SBIR/STTR funding agreement that an awardee delivers to the Government during or upon completion of a federally funded project, and to which the Government receives a license.

2.21 Service Disabled Veteran-Owned Small Business

A Service-Disabled Veteran-Owned Small Business is one that is: (1) Not less than 51% of which is owned by one or more service-disabled veterans or, in the case of any publicly owned business, not less than 51% of the stock of which is owned by one or more service-disabled veterans; (2) management and daily business operations, which are controlled by one or more service-disabled veterans or, in the case of a service-disabled veteran with permanent and severe disability, the spouse or permanent caregiver of such veteran; and (3) is small as defined by e-CFR §125.11.

Service-disabled veteran means a veteran, as defined in 38 U.S.C. 101(2), with a disability that is service connected, as defined in 38 U.S.C. 101(16). For a general definition, see FAR 2.101 ([https://www.acquisition.gov/far/current/html/Subpart 2_1.html](https://www.acquisition.gov/far/current/html/Subpart%202.1.html)).

2.22 Small Business Concern (SBC)

An SBC is one that, at the time of award of Phase I and Phase II funding agreements, meets the following criteria: (1) Is organized for profit, with a place of business located in the United States, which operates primarily within the United States or which makes a significant contribution to the United States economy through payment of taxes or use of American products, materials or labor; (2) is in the legal form of an individual proprietorship, partnership, limited liability company, corporation, joint venture, association, trust or cooperative; except that where the form is a joint venture, there can be no more than 49 percent participation by business entities in the joint venture; (3) is at least 51 percent owned and controlled by one or more individuals who are citizens of, or permanent resident aliens in, the United States: except in the case of a joint venture, where each entity to the venture must be 51 percent owned and controlled by one or more individuals who are citizens of, or permanent resident aliens in, the United States; and (4) has, including its affiliates, not more than 500 employees.

The terms “affiliates” and “number of employees” are defined in greater detail in 13 CFR Part 121. For a general definition please see FAR 2.101 ([https://www.acquisition.gov/far/current/html/Subpart 2_1.html](https://www.acquisition.gov/far/current/html/Subpart%202_1.html)).

2.23 Socially and Economically Disadvantaged Individual

See 13 C.F.R. § § 124.103 & 124.104.

2.24 Socially and Economically Disadvantaged Small Business Concern

See 13 CFR part 124, Subpart B.

2.25 Subcontract

Any agreement, other than one involving an employer-employee relationship, entered into by an awardee of a funding agreement calling for supplies or services for the performance of the original funding agreement.

2.26 Technology Readiness Level (TRLs)

Technology Readiness Level (TRLs) is a uni-dimensional scale used to provide a measure of technology maturity.

Level 1: Basic principles observed and reported.

Level 2: Technology concept and/or application formulated.

Level 3: Analytical and experimental critical function and/or characteristic proof of concept.

Level 4: Component and/or breadboard validation in laboratory environment.

Level 5: Component and/or breadboard validation in relevant environment.

Level 6: System/subsystem model or prototype demonstration in a relevant environment (Ground or Space).

Level 7: System prototype demonstration in an operational (space) environment.

Level 8: Actual system completed and (flight) qualified through test and demonstration (Ground and Space).

Level 9: Actual system (flight) proven through successful mission operations.

Additional information on TRLs is available in Appendix B.

2.27 United States

Includes the 50 States, the territories and possessions of the Federal Government, the Commonwealth of Puerto Rico, the District of Columbia, the Republic of the Marshall Islands, the Federated States of Micronesia, and the Republic of Palau.

2.28 Veteran-Owned Small Business

A veteran-owned SBC is a small business that: (1) is at least 51% unconditionally owned by one or more veterans, as defined at 38 U.S.C. 101(2); or in the case of any publicly owned business, at least 51% of the stock of which is unconditionally owned by one or more veterans; and (2) whose management and daily business operations are controlled by one or more veterans. For a general definition please see FAR 2.101 ([https://www.acquisition.gov/far/current/html/Subpart 2_1.html](https://www.acquisition.gov/far/current/html/Subpart%202_1.html)).

2.29 Women-Owned Small Business (WOSB)

To be an eligible WOSB, a company must: (1) be a small business that is at least 51% percent unconditionally and directly owned and controlled by one or more women who are United States citizens. (2) have one or more women who manage the day-to-day operations, make long-term decisions for the business, hold the highest officer position in the business and work at the business full-time during normal working hours.

Please note that for a WOSB the 51% ownership must be unconditional and direct. For a general definition please see FAR 2.101 ([https://www.acquisition.gov/far/current/html/Subpart 2_1.html](https://www.acquisition.gov/far/current/html/Subpart%202_1.html)).

3. Proposal Preparation Instructions and Requirements

3.1 Fundamental Considerations

Multiple Proposal Submissions

Each proposal submitted must be based on a unique innovation, must be limited in scope to just one subtopic and shall be submitted only under that one subtopic within each program. An offeror shall not submit more than 10 proposals to each of the SBIR or STTR programs. An offeror may submit more than one unique proposal to the same subtopic; however, an offeror should not submit the same (or substantially equivalent) proposal to more than one subtopic. Submitting substantially equivalent proposals to several subtopics may result in the rejection of all such proposals. In order to enhance SBC participation, NASA does not plan to select more than 5 SBIR proposals and 2 STTR proposals from any one offeror under this solicitation.

STTR: All Phase I proposals must provide sufficient information to convince NASA that the proposed SBC/RI cooperative effort represents a sound approach for converting technical information resident at the Research Institution (RI) into a product or service that meets a need described in a Solicitation research topic. SBCs shall submit a research agreement with a Research Institution. This agreement must be completed online through the form provided in the submissions handbook.

Contract Deliverables

All Phase I contracts shall require the delivery of reports that present: (1) the work and results accomplished; (2) the scientific, technical and commercial merit and feasibility of the proposed innovation, and Phase I results; (3) its relevance and significance to one or more NASA needs (section 9); and (4) the strategy for development, transition of the proposed innovation, and Phase I results into products and services for NASA mission programs and other potential customers. Phase I deliverables may also include the demonstration of the proposed innovation and/or the delivery of a prototype or test unit, product or service for NASA testing and utilization. See section 5.2 for gaining access to the Electronic Handbook (EHB) and submitting reports.

Report deliverables shall be submitted electronically via the Electronic Handbook (EHB). NASA requests the submission of report deliverables in PDF or MS Word format.

3.2 Phase I Proposal Requirements

3.2.1 General Requirements

A competitive proposal will clearly and concisely: (1) describe the proposed innovation relative to the state of the art; (2) address the scientific, technical and commercial merit and feasibility of the proposed innovation, and its relevance and significance to NASA needs as described in section 9; and (3) provide a preliminary strategy that addresses key technical, market and business factors pertinent to the successful development, demonstration of the proposed innovation, and its transition into products and services for NASA mission programs and other potential customers.

3.2.2 Format Requirements

Proposals that do not follow the formatting requirement are subject to rejection during administrative screening.

Page Limitations and Margins

Any page(s) going over the required page limited will be deleted and omitted from the proposal review. A Phase I proposal shall not exceed a total of 23 standard 8 1/2 x 11 inch (21.6 x 27.9 cm) pages, inclusive of the technical content and the required forms. Forms A, B, and C count as one page each, regardless of whether the completed forms print as more than one page. Each page shall be numbered consecutively at the bottom. Margins shall be 1.0 inch (2.5 cm). All required items of information must be covered in the proposal and will count towards the total page count. The space allocated to each part of the technical content will depend on the project chosen and the offeror's approach.

Each proposal submitted must contain the following items in the order presented:

- (1) Cover Sheet (Form A), electronically endorsed, counts as 1 page towards the 23-page limit.
- (2) Proposal Summary (Form B), counts as 1 page towards the 23-page limit (and must not contain proprietary data).
- (3) Budget Summary (Form C), counts as 1 page towards the 23-page limit.
- (4) Technical Content (11 parts in order as specified in section 3.2.4, **not to exceed 20 pages for SBIR and 19 pages for STTR**), including all graphics, with a table of contents.
- (5) R/R&D Agreement between the SBC and RI (**STTR only**), counts as 1 page towards the 23-page limit.
- (6) Briefing Chart, is not included in the 23-page limit (and must not contain proprietary data).
- (7) NASA Research License Application is not included in the 23-page limit (only if TAV is being proposed).

Note: Letters of general endorsement are not required or desired and will not be considered during the review process. However, if submitted, such letter(s) will count against the page limit.

In addition to the above items, each offeror must submit the following firm level forms, which must be filled out once during each submission period and are applicable to all firm proposals submissions:

- (8) Firm Level Certifications, are not included in the 23-page limit.
- (9) Audit Information, is not included in the 23-page limit.
- (10) Prior Awards Addendum, is not included in the 23-page limit.
- (11) Commercial Metrics Survey, is not included in the 23-page limit.

Website references, product samples, videotapes, slides, or other ancillary items will not be considered during the review process.

Type Size

No type size smaller than 10 point shall be used for text or tables, except as legends on reduced drawings. Proposals prepared with smaller font sizes will be rejected without consideration.

Header/Footer Requirements

Header must include firm name, proposal number, and project title. Footer must include the page number and proprietary markings if applicable. Margins can be used for header/footer information.

Classified Information

NASA does not accept proposals that contain classified information.

3.2.3 Forms

All form submissions shall be done electronically, with each form counting as 1 page towards the 23-page limit and accounting for pages 1-3 of the proposal regardless of the length.

3.2.3.1 Cover Sheet (Form A)

A sample Cover Sheet (Form A) is provided in section 8. The offeror shall provide complete information for each item and submit the form as required in section 6. The proposal project title shall be concise and descriptive of the proposed effort. The title should not use acronyms or words like "Development of" or "Study of." The NASA research topic title must not be used as the proposal title. Form A counts as one page towards the 23-page limit.

3.2.3.2 Proposal Summary (Form B)

A sample Proposal Summary (Form B) is provided in section 8. The offeror shall provide complete information for each item and submit Form B as required in section 6. Form B counts as one page towards the 23-page limit.

Note: Proposal Summary (Form B), including the Technical Abstract, is public information and may be disclosed. Do not include proprietary information on Form B.

3.2.3.3 Budget Summary (Form C)

A sample of the Budget Summary (Form C) is provided in section 8. The offeror shall complete the Budget Summary following the instructions provided with the sample form. The total requested funding for the Phase I effort shall not exceed \$125,000. A text box is provided on the electronic budget form for additional explanation. Information shall be submitted to explain the offeror's plans for use of the requested funds to enable NASA to determine whether the proposed price is fair and reasonable. Form C counts as one page towards the 23-page limit.

Note: The Government is not responsible for any monies expended by the firm before award of any contract.

3.2.4 Technical Content

This part of the submission should not contain any budget data and must consist of all eleven (11) parts listed below in the given order. All eleven parts of the technical proposal must be numbered and titled. Parts that are not applicable must be included and marked "Not Applicable." A proposal omitting any part will be considered non-responsive to this solicitation and will be rejected during administrative screening. The required table of contents is provided below:

Phase I Table of Contents

Part 1: Table of Contents.....	Page 4
Part 2: Identification and Significance of the Innovation	
Part 3: Technical Objectives	
Part 4: Work Plan	
Part 5: Related R/R&D	
Part 6: Key Personnel and Bibliography of Directly Related Work	
Part 7: Relationship with Phase II or Future R/R&D	
Part 8: Facilities/Equipment	
Part 9: Subcontracts and Consultants	
Part 10: Potential Post Applications	
Part 11: Essentially Equivalent and Duplicate Proposals and Awards	

Part 1: Table of Contents

The technical proposal shall begin with a brief table of contents indicating the page numbers of each of the parts of the proposal and should start on page 4 because Forms A, B, and C account for pages 1-3.

Part 2: Identification and Significance of the Proposed Innovation

Succinctly describe:

- (1) The proposed innovation;
- (2) the relevance and significance of the proposed innovation to a need or needs, within a subtopic described in section 9; and
- (3) the proposed innovation relative to the state of the art.

Part 3: Technical Objectives

State the specific objectives of the Phase I R/R&D effort including the technical questions posed in the subtopic description that must be answered to determine the feasibility of the proposed innovation.

TAV Note: All offerors submitting proposals who are planning to use NASA IP must describe their planned developments with the IP. The NASA Research License Application should be added as an attachment at the end of the proposal and will not count towards the 23-page limit (See paragraph 1.6).

Part 4: Work Plan

Include a detailed description of the Phase I R/R&D plan to meet the technical objectives. The plan should indicate what will be done, where it will be done, and how the R/R&D will be carried out. Discuss in detail the methods planned to achieve each task or objective. Task descriptions, schedules, resource allocations, estimated task hours for each key personnel and planned accomplishments including project milestones shall be included.

STTR: In addition, the work plan will specifically address the percentage and type of work to be performed by the SBC and the RI. The plan will provide evidence that the SBC will exercise management direction and control of the performance of the STTR effort, including situations in which the PI may be an employee of the RI.

Part 5: Related R/R&D

Describe significant current and/or previous R/R&D that is directly related to the proposal including any conducted by the PI or by the offeror. Describe how it relates to the proposed effort and any planned coordination with outside sources. The offeror must persuade reviewers of his or her awareness of key recent R/R&D conducted by others in the specific subject area. As an option, the offeror may use this section to include bibliographic references.

Part 6: Key Personnel and Bibliography of Directly Related Work

Identify all key personnel involved in Phase I activities whose expertise and functions are essential to the success of the project. Provide bibliographic information including directly related education and experience.

The PI is considered key to the success of the effort and must make a substantial commitment to the project. The following requirements are applicable:

Functions: The functions of the PI are: planning and directing the project; leading it technically and making substantial personal contributions during its implementation; serving as the primary contact with NASA on the project; and ensuring that the work proceeds according to contract agreements. Competent management of PI functions is essential to project success. The Phase I proposal shall describe the nature of the PI's activities and the amount of time that the PI will personally apply to the project. The amount of time the PI proposes to spend on the project must be acceptable to the Contracting Officer.

Qualifications: The qualifications and capabilities of the proposed PI and the basis for PI selection are to be clearly presented in the proposal. NASA has the sole right to accept or reject a PI based on factors such as education, experience, demonstrated ability and competence, and any other evidence related to the specific assignment.

Eligibility: This part shall also establish and confirm the eligibility of the PI, and indicate the extent to which other proposals recently submitted or planned for submission in 2012 and existing projects commit the time of the PI concurrently with this proposed activity. Any attempt to circumvent the restriction on PIs working more than half time for an academic or a nonprofit organization by substituting an ineligible PI will result in rejection of the proposal. However, for an STTR the PI can be primarily employed by either the SBC or the RI. Please see section 1.5.3 for further explanation.

Part 7: Relationship with Future R/R&D

State the anticipated results of the proposed R/R&D effort if the project is successful (through Phase I and Phase II). Discuss the significance of the Phase I effort in providing a foundation for the Phase II R/R&D effort and for follow-on development, application and commercialization efforts (Phase III).

Part 8: Facilities/Equipment

General: Describe available equipment and physical facilities (this should include physical location [where the work is to be performed], square footage, and major equipment) necessary to carry out the proposed Phase II and projected Phase III efforts. Items of equipment or facilities to be purchased (as detailed in the cost proposal) shall be justified under this section.

Use of Federal facilities or equipment: In accordance with the Federal Acquisition Regulations (FAR) Part 45, it is NASA's policy not to provide facilities (capital equipment, tooling, test and computer facilities, etc.) for the performance of work under SBIR/STTR contracts. Generally an SBC will furnish its own facilities to perform the proposed work on the contract. Government-wide SBIR/STTR policies restrict the use of any SBIR/STTR funds for the use of Federal equipment and facilities (except for those facilities designated as a Federal laboratory). This does not preclude an SBC from utilizing a Federal facility or Federal equipment, but any charges for such use may not be paid for with SBIR/STTR funds. In rare and unique circumstances, SBA may issue a case-by-case waiver to this provision after review of an agency's written justification. Federal facilities designated as Federal laboratories are exempt from this waiver requirement (see 15 U.S.C. § 3710a(d) and the SBA SBIR/STTR Policy Directive). Any NASA facility generally would be considered a Federal laboratory; however, requests for things such as office space would be deemed to be a Federal facility requiring a waiver. Additionally, NASA may not and cannot fund the use of the Federal facility (including Federal laboratories) or personnel for the SBIR/STTR project with NASA program or project money.

When a proposed project or product demonstration requires the use of a unique Federal facility that is not designated as a Federal laboratory to be funded by the SBIR/STTR Program, then the offeror must provide a) a letter from the SBC Official explaining why the SBIR/STTR research project requires the use of the Federal facility or personnel, including data that verifies the absence of non-Federal facilities or personnel capable of supporting the research effort, and b) a statement, signed by the appropriate Government official at the facility, verifying that it will be available for the required effort. Proposals requiring waivers must explain why the waiver is appropriate. NASA will provide this explanation to SBA during the Agency waiver process. NASA cannot guarantee that a waiver from this policy can be obtained from SBA. These letters should be uploaded in Form C of your proposal. **Failure to provide this explanation and the site manager's written availability of use may invalidate any proposal selection.**

When a proposed project or product demonstration requires the use of a Federal laboratory then the offeror must provide a letter justifying the use of a Federal laboratory from the SBC official, as well as, a letter from the Government agency that verifies the availability. These letters should be uploaded in Form C of your proposal. **Failure to provide the site manager's written availability of use of the Federal laboratory and the letter of justification from the SBC may invalidate any proposal selection.**

Additionally, any proposer requiring the use of Federal laboratory, property, or facilities must, within ten (10) business days of notification of selection for negotiations, provide to the NASA Shared Services Center Contracting Officer all required documentation, to include, an agreement by and between the Contractor and the appropriate Federal facility, executed by the Government official authorized to approve such use. The Agreement must delineate the terms of use, associated costs, property and facility responsibilities and liabilities.

Part 9: Subcontracts and Consultants

Subject to the restrictions set forth below, the SBC may establish business arrangements with other entities or individuals to participate in performance of the proposed R/R&D effort. The offeror must describe all subcontracting or other business arrangements, and identify the relevant organizations and/or individuals with whom arrangements are planned. The expertise to be provided by the entities must be described in detail, as well as the functions, services, and number of hours. Offerors are responsible for ensuring that all organizations and individuals proposed to be utilized are actually available for the time periods required. Subcontract costs should be documented in the subcontractor/consultant budget section in Form C and supporting documentation should be uploaded for each (appropriate documentation is specified in Form C). Subcontractors' and consultants' work has the same place of performance restrictions as stated in section 1.5.2.

The following restrictions apply to the use of subcontracts/consultants:

SBIR Phase I Subcontracts/Consultants	STTR Phase I Subcontracts/Consultants
The proposed subcontracted business arrangements must not exceed 33 percent of the research and/or analytical work (as determined by the total cost of the proposed subcontracting effort (to include the appropriate OH and G&A) in comparison to the total effort (total contract price including cost sharing, if any, less profit if any).	A minimum of 40 percent of the research or analytical work must be performed by the proposing SBC and minimum of 30 percent must be performed by the RI. Any subcontracted business effort other than that performed by the RI, shall not exceed 30 percent of the research and/or analytical work (as determined by the total cost of the subcontracting effort (to include the appropriate OH and G&A) in comparison to the total effort (total contract price including cost sharing, if any, less profit if any).

Example: Total price to include profit - \$99,500
 Profit - \$3,000
 Total price less profit - \$99,500 - \$3,000 = \$96,500
 Subcontractor cost - \$29,500
 G&A - 5%
 G&A on subcontractor cost - \$29,500 x 5% = \$1,475
 Subcontractor cost plus G&A - \$29,500 + \$1,475 = \$30,975
 Percentage of subcontracting effort – subcontractor cost plus G&A / total price less profit
 - \$30,975/\$96,500 = 32.1%

For an SBIR Phase I this is acceptable since it is below the limitation of 33%.

For an STTR Phase I this is unacceptable since it is above 30% limitation.

Part 10: Potential Post Applications (Commercialization)

The Phase I proposal shall (1) forecast the potential and targeted application(s) of the proposed innovation and associated products and services relative to NASA needs (infusion into NASA mission needs and projects) (section 9), other Government agencies and commercial markets, (2) identify potential customers, and (3) provide an initial commercialization strategy that addresses key technical, market and business factors for the successful development, demonstration and utilization of the innovation and associated products and services. Commercialization encompasses the transition of technology into products and services for NASA mission programs, other Government agencies, and non-Government markets.

Part 11a: Essentially Equivalent and Duplicate Proposals and Awards

WARNING – While it is permissible with proposal notification to submit identical proposals or proposals containing a significant amount of essentially equivalent work for consideration under numerous Federal program solicitations, it is unlawful to enter into funding agreements requiring essentially equivalent work. Offerors are at risk for submitting essentially equivalent proposals and therefore, are strongly encouraged to disclose these issues to the soliciting agency to resolve the matter prior to award. See Part 11b.

If an applicant elects to submit identical proposals or proposals containing a significant amount of essentially equivalent work under other Federal program solicitations, a statement must be included in each such proposal indicating:

- (1) The name and address of the agencies to which proposals were submitted or from which awards were received.
- (2) Date of proposal submission or date of award.
- (3) Title, number, and date of solicitations under which proposals were submitted or awards received.
- (4) The specific applicable research topics for each proposal submitted for award received.
- (5) Titles of research projects.
- (6) Name and title of principal investigator or project manager for each proposal submitted or award received.

A summary of essentially equivalent work information is also required on Form A.

Part 11b: Related Research and Development Proposals and Awards

All federal agencies have a mandate to reduce waste, fraud, and abuse in federally funded programs. The submission of essentially equivalent work and the acceptance of multiple awards for essentially equivalent work in the SBIR/STTR Program have been identified as an area of abuse and possibly fraud. SBIR/STTR funding agencies and the Office of the Inspector General are actively evaluating proposals and awards to eliminate this problem. Related research and development includes proposals and awards that do not meet the definition of “Essentially Equivalent Work” (see section 2.6), but are related to the technology innovation in the proposal being submitted. Related research and development could be interpreted as essentially equivalent work by outside reviewers without additional information. Therefore, if you are submitting closely related proposals or your firm has closely related research and development that is currently or previously funded by NASA or other federal agencies, it is to your advantage to describe the relationships between this proposal and related efforts clearly delineating why this should not be considered an essentially equivalent work effort. These explanations should not be longer than one page, will not be included in the page count, and will not be part of the technical evaluation of the proposal.

3.2.5 Research Agreement (Applicable for STTR proposals only)

The Research Agreement (different from the Allocation of Rights Agreement, section 2.1) is a single-page document electronically submitted and endorsed by the SBC and Research Institution (RI). A model agreement is provided, or firms can create their own custom agreement. The Research Agreement should be submitted as required in section 6. This agreement counts as one page toward the 23-page limit.

3.2.6 Briefing Chart

An electronic form will be provided during the submissions process. The one-page briefing chart is required to assist in the ranking and advocacy of proposals prior to selection. It is not counted against the 23-page limit, and must not contain any proprietary data or ITAR restricted data. An example chart is provided in Appendix A.

3.2.7 Firm Level Certifications

Firm level certifications that are applicable across all proposal submissions submitted to this solicitation must be completed via the “Certifications” section of the Proposal Submission Electronic Handbook. The offeror must answer Yes or No as applicable. An example of the certification can be found in section 8.

Note: The designated Firm Admin, typically the first person to register your firm, is the only individual authorized to update the certifications.

3.2.8 Audit Information

The SBC shall complete the questions regarding the firm’s rates and upload the Federal agency audit report or related information that is available from the last audit. If your firm has never been audited by a federal agency, then answer "No" to the first question and you do not need to complete the remainder of the form. The “Audit Information” will be used to assist the contracting officer with negotiations if the proposal is selected for award. If the audit provided is not acceptable, they will be advised by the contracting officer on what is required to determine reasonable cost and/or rates. There is a separate “Audit Information” section in Forms C that must also be completed. The audit information is not included in the 23-page limit. An electronic form will be provided during the submissions process.

Note: The designated firm admin, typically the first person to register your firm, is the only individual authorized to update the audit information.

3.2.9 Prior Awards Addendum

If the SBC has received more than 15 Phase II awards in the prior 5 fiscal years, submit name of awarding agency, date of award, funding agreement number, amount, topic or subtopic title, follow-on agreement amount, source, and date of commitment and current commercialization status for each Phase II. If your firm has received any SBIR or STTR Phase II awards, even if it has received fewer than 15 in the last 5 years, it is still recommended that you complete this form for those Phase II awards your firm did receive. This information will be useful when completing the Commercialization Metrics Survey, and in tracking the overall success of the SBIR and STTR programs. Any NASA Phase II awards your firm has received will be automatically populated in the electronic form, as are any Phase II awards previously entered by the SBC during prior submissions (you may update the information for these awards). The addendum is not included in the 23-page-limit. An electronic form will be provided during the submissions process.

Note: The designated firm admin, typically the first person to register your firm, is the only individual authorized to update the addendum information.

3.2.10 Commercial Metrics Survey

NASA has instituted a comprehensive commercialization survey/data gathering process for firms with prior NASA SBIR/STTR awards. If the SBC has received any Phase III awards resulting from work on any NASA SBIR or STTR awards, provide the related Phase I or Phase II contract number, name of Phase III awarding agency, date of award, funding agreement number, amount, project title, and period of performance. The survey will also ask for firm sales and ownership information, as well as any commercialization success the firm has had as a result of Phase II SBIR or STTR awards. This information will allow firms to demonstrate their ability to carry SBIR/STTR research through to achieve commercial success, and allow agencies to track the overall commercialization success of their SBIR and STTR programs. The survey is not included in the 23-page limit and content should be limited to information requested above. An electronic form will be provided during the submissions process.

Note: Information received from SBIR/STTR awardees completing the survey is kept confidential, and will not be made public except in broad aggregate, with no firm-specific attribution. The Commercialization Metrics Survey is a required part of the proposal submissions process and must be completed via the Proposal Submission Electronic Handbook

3.2.11 Contractor Responsibility Information

No later than 10 business days after the notification of selection for negotiations the offeror shall provide a signed statement from your financial institution(s), on its letterhead, stating whether or not your firm is in good standing and how long you have been with the institution will be required. In addition the offeror shall provide three references with a point of contact, e-mail address, telephone number, contract/reference number. Firms must ensure that the information provided is current and accurate.

3.2.12 Allocation of Rights Agreement (STTR awards only)

No more than 10 business days after the notification of selection for negotiation, the offeror should provide to the Contracting Officer, a completed **Allocation of Rights Agreement (ARA)**, which has been signed by authorized representatives of the SBC, RI and subcontractors and consultants, as applicable. The ARA shall state the allocation of intellectual property rights with respect to the proposed STTR activity and planned follow-on research, development and/or commercialization. A sample ARA is available in section 8 of this Solicitation.

If the ARA form is completed and available at the time of submission, offers should upload it in Form C, which will help to expedite contract negotiations.

4. Method of Selection and Evaluation Criteria

4.1 Phase I Proposals

All proposals will be evaluated and ranked on a competitive basis. Proposals will be initially screened to determine responsiveness. Proposals determined to be responsive to the administrative requirements of this Solicitation and having a reasonable potential of meeting a NASA need, as evidenced by the technical abstract included in the Proposal Summary (Form B), will be technically evaluated by NASA personnel to determine the most promising technical and scientific approaches. Each proposal will be reviewed on its own merit. NASA is under no obligation to fund any proposal or any specific number of proposals in a given topic. It also may elect to fund several or none of the proposed approaches to the same topic or subtopic.

4.1.1 Evaluation Process

Proposals shall provide all information needed for complete evaluation. Evaluators will not seek additional information. NASA scientists and engineers will perform evaluations. Also, qualified experts outside of NASA (including industry, academia, and other Government agencies) may assist in performing evaluations as required to determine or verify the merit of a proposal. Offerors should not assume that evaluators are acquainted with the firm, key individuals, or with any experiments or other information. Any pertinent references or publications should be noted in part 5 of the technical proposal.

4.1.2 Phase I Evaluation Criteria

NASA intends to select for award those proposals offering the most advantageous technology to the Government and the SBIR/STTR Program. NASA will give primary consideration to the scientific and technical merit and feasibility of the proposal and its benefit to NASA. Each proposal will be evaluated and scored on its own merits using the factors described below:

Factor 1: Scientific/Technical Merit and Feasibility

The proposed R/R&D effort will be evaluated on whether it offers a clearly innovative and feasible technical approach to the described NASA problem area. Proposals must clearly demonstrate relevance to the subtopic as well as one or more NASA mission and/or programmatic needs. Specific objectives, approaches and plans for developing and verifying the innovation must demonstrate a clear understanding of the problem and the current state of the art. The degree of understanding and significance of the risks involved in the proposed innovation must be presented.

Factor 2: Experience, Qualifications and Facilities

The technical capabilities and experience of the PI, project manager, key personnel, staff, consultants and subcontractors, if any, are evaluated for consistency with the research effort and their degree of commitment and availability. The necessary instrumentation or facilities required must be shown to be adequate and any reliance on external sources, such as Government furnished equipment or facilities, addressed (section 3.2.4, part 8).

Factor 3: Effectiveness of the Proposed Work Plan

The work plan will be reviewed for its comprehensiveness, effective use of available resources, labor distribution, and the proposed schedule for meeting the Phase I objectives. The methods planned to achieve each objective or task should be discussed in detail. The proposed path beyond Phase I for further development and infusion into a NASA mission or program will also be reviewed. Please see Factor 5 for price evaluation criteria.

STTR: The clear delineation of responsibilities of the SBC and RI for the success of the proposed cooperative R/R&D effort will be evaluated. The offeror must demonstrate the ability to organize for effective conversion of intellectual property into products and services of value to NASA and the commercial marketplace.

Factor 4: Commercial Potential and Feasibility

The proposal will be evaluated for the commercial potential and feasibility of the proposed innovation and associated products and services. The offeror's experience and record in technology commercialization, co-funding commitments from private or non-SBIR/non-STTR funding sources, existing and projected commitments for Phase III funding, investment, sales, licensing, and other indicators of commercial potential and feasibility will be considered along with the initial commercialization strategy for the innovation. Commercialization encompasses the infusion of innovative technology into products and services for NASA mission programs, other Government agencies and non-Government markets.

Factor 5: Price Reasonableness

The offeror's cost proposal will be evaluated for price reasonableness based on the information provided in Form C. NASA will comply with the FAR and NASA FAR Supplement (NFS) to evaluate the proposed price/cost to be fair and reasonable.

After completion of evaluation for price reasonableness and determination of responsibility the Contracting Officer shall submit a recommendation for award to the Source Selection Official.

Scoring of Factors and Weighting

Factors 1, 2, and 3 will be scored numerically with Factor 1 worth 50 percent and Factors 2 and 3 each worth 25 percent. The sum of the scores for Factors 1, 2, and 3 will comprise the Technical Merit score. The evaluation for Factor 4, Commercial Potential and Feasibility, will be in the form of an adjectival rating (Excellent, Very Good, Average, Below Average, Poor). For Phase I proposals, Technical Merit is more important than Commercial Merit. Factors 1 - 4 will be evaluated and used in the selection of proposals for negotiation. Factor 5 will be evaluated and used in the selection for award.

4.1.3 Selection

Proposals recommended for negotiations will be forwarded to the Program Management Office for analysis and presented to the Source Selection Official and Mission Directorate Representatives. The Source Selection Official has the final authority for choosing the specific proposals for contract negotiation. The selection decisions will consider the recommendations as well as overall NASA priorities, program balance and available funding. Each proposal selected for negotiation will be evaluated for cost/price reasonableness, the terms and conditions of the contract will be negotiated and a responsibility determination made. The Contracting Officer will advise the Source Selection Official on matters pertaining to cost reasonableness and responsibility. The Source Selection Official has the final authority for selecting the specific proposals for award.

The list of proposals selected for negotiation will be posted on the NASA SBIR/STTR Website (<http://sbir.nasa.gov>). All firms will receive a formal notification letter. A Contracting Officer will negotiate an appropriate contract to be signed by both parties before work begins.

4.2 Debriefing of Unsuccessful Offerors

After Phase I selections for negotiation have been announced, all unsuccessful offerors will be notified. Debriefings will be automatically e-mailed to the designated Business Official within 60 days of the announcement of selection for negotiation. If you have not received your debriefing by this time, contact the SBIR/STTR Program Support Office at ARC-SBIR-PMO@mail.nasa.gov. Telephone requests for debriefings will not be accepted. Debriefings are not opportunities to reopen selection decisions. They are intended to acquaint the offeror with perceived strengths and weaknesses of the proposal in order to help offerors identify constructive future action by the offeror. Debriefings will not disclose the identity of the proposal evaluators, proposal scores, the content of, or comparisons with other proposals.

5. Considerations

5.1 Awards

5.1.1 Availability of Funds

All Phase I awards are subject to availability of funds. NASA has no obligation to make any specific number of awards based on this solicitation, and may elect to make several or no awards in any specific technical topic or subtopic.

SBIR Contracts	STTR Contracts
Phase I contracts will be firm-fixed-price, for values not exceeding \$125,000, and contractors will have up to 6 months to carry out their projects, prepare their final reports, and submit Phase II proposals.	Phase I contracts will be firm-fixed-price, for values not exceeding \$125,000, and contractors will have up to 12 months to carry out their projects, prepare their final reports, and submit Phase II proposals.

5.1.2 Contracting

To simplify contract award and reduce processing time, all contractors selected for Phase I contracts should ensure that:

- (1) All information in your proposal is current, e.g., your address has not changed, the proposed PI is the same, etc... If changes have occurred since submittal of your proposal, notify contracting officer immediately.
- (2) Your firm is registered in CCR and all information is current. NASA uses the CCR to populate its contract and payment systems; if the information in the CCR is not current your award and payments will be delayed. If updates have been made, notify contracting officer immediately.
- (3) The representations and certifications in ORCA (Online Representations and Certifications Application) are current.
- (4) The VETS 100 report submitted by your firm to the Department of Labor is current and submitted to the contracting officer within 10 business days of the notification of selection for negotiation.
- (5) Your firm HAS NOT proposed a Co-Principal Investigator.
- (6) STTR selectees should execute their Allocation of Rights Agreement within 10 business days of the notification of selection for negotiation.
- (7) Your firm has a timely response to all communications from the NSSC Contracting Officer.

From the time of proposal notification of selection for negotiation, until the award of a contract, all communications shall be submitted electronically to NSSC-SBIR-STTR@nasa.gov.

Note: Costs incurred prior to and in anticipation of award of a contract are entirely the risk of the contractor in the event that a contract is not subsequently awarded. A notification of selection for negotiation is not to be misconstrued as an award notification to commence work.

Phase I Model Contract

An example of the Phase I contracts can be found in the in the NASA SBIR/STTR Firm Library: https://sbir.gsfc.nasa.gov/sbir/firm_library/index.html. **Note: Model contracts are subject to change.**

5.2 Phase I Reporting

The technical reports are required as described in the contract and are to be provided to NASA. These reports shall document progress made on the project and activities required for completion. Periodic certification for payment will be required as stated in the contract. A final report must be submitted to NASA upon completion of the Phase I R/R&D effort in accordance with applicable contract provisions.

All required reports shall be submitted electronically via the EHB. Everyone with access to the NASA network will be required to use the NASA Account Management System (NAMS). This is the Agency's centralized system for requesting and maintaining accounts for NASA IT systems and applications. The system contains user account information, access requests, and account maintenance processes for NASA employees, contractors, and remote users such as educators and foreign users. A basic background check is required for this account.

5.3 Payment Schedule for Phase I

All NASA SBIR and STTR contracts are firm-fixed-price contracts. The exact payment terms for the Phase I will be included in the contract.

Invoices: All invoices are required to be submitted electronically via the SBIR/STTR website in the EHB.

5.4 Release of Proposal Information

In submitting a proposal, the offeror agrees to permit the Government to disclose publicly the information contained on the Proposal Summary (Form B). Other proposal data is considered to be the property of the offeror, and NASA will protect it from public disclosure to the extent permitted by law including the Freedom of Information Act (FOIA).

5.5 Access to Proprietary Data by Non-NASA Personnel

5.5.1 Non-NASA Reviewers

In addition to Government personnel, NASA, at its discretion and in accordance with 1815.207-71 of the NASA FAR Supplement, may utilize qualified individuals from outside the Government in the proposal review process. Any decision to obtain an outside evaluation shall take into consideration requirements for the avoidance of organizational or personal conflicts of interest and the competitive relationship, if any, between the prospective contractor or subcontractor(s) and the prospective outside evaluator. Any such evaluation will be under agreement with the evaluator that the information (data) contained in the proposal will be used only for evaluation purposes and will not be further disclosed.

5.5.2 Non-NASA Access to Confidential Business Information

In the conduct of proposal processing and potential contract administration, the Agency may find it necessary to provide proposal access to other NASA contractor and subcontractor personnel. NASA will provide access to such data only under contracts that contain an appropriate NFS 1852.237-72 Access to Sensitive Information clause that requires the contractors to fully protect the information from unauthorized use or disclosure.

5.6 Proprietary Information in the Proposal Submission

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 as confidential proprietary information. NASA will treat in confidence pages listed as proprietary in the following legend that appears on the Cover Sheet (Form A) of the proposal:

"This 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, provided that a funding agreement is awarded to the offeror as a result of or in connection with the submission of this 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 in pages ____ of this proposal."

Note: Do not label the entire proposal proprietary. The Proposal Summary (Form B), and the Briefing Chart should not contain proprietary information; and any page numbers that would correspond to these must not be designated proprietary in Form B.

Information contained in unsuccessful proposals will remain the property of the applicant. The Government will, however, retain copies of all proposals.

5.7 Limited Rights Information and Data

The clause at FAR 52.227-20, Rights in Data—SBIR/STTR Program, governs rights to data used in, or first produced under, any Phase I or Phase II contract. The following is a brief description of FAR 52.227-20, it is not intended to supplement or replace the FAR.

5.7.1 Non-Proprietary Data

Some data of a general nature are to be furnished to NASA without restriction (i.e., with unlimited rights) and may be published by NASA. This data will normally be limited to the project summaries accompanying any periodic progress reports and the final reports required to be submitted. The requirement will be specifically set forth in any contract resulting from this solicitation.

5.7.2 Proprietary Data

If the contractor desires to continue protection of proprietary data, it shall deliver form, fit, and function data and shall not deliver the proprietary data. Data is considered to be “proprietary” when the data is developed at a private expense and (1) embodies trade secrets or contains commercial, financial and confidential, privileged information, or (2) is computer software.

5.7.3 Non-Disclosure Period

For a period of 4 years after acceptance of all items to be delivered under an SBIR /STTR contract, the Government agrees to 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 Contractor, except that subject to the foregoing use and disclosure prohibitions, such data may be disclosed for use by support Contractors. After the aforesaid 4-year period, the Government has a royalty-free 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.

5.7.4 Copyrights

Subject to certain licenses granted by the contractor to the Government, the contractor receives copyright to any data first produced by the contractor in the performance of an SBIR/STTR contract.

5.7.5 Invention Reporting, Election of Title and Patent Application Filing

NASA SBIR and STTR contracts will include FAR 52.227-11 Patent Rights – Ownership by the Contractor, which requires the SBIR/STTR contractors to do the following. Contractors must disclose all subject inventions to NASA within two (2) months of the inventor’s report to the awardees. A subject invention is any invention or discovery which is or may be patentable, and is conceived or first actually reduced to practice in the performance of the contract. Once the contractor discloses a subject invention, the contractor has up to 2 years to notify the Government whether it elects to retain title to the subject invention. If the contractor elects to retain title, a patent application covering the subject invention must be filed within 1 year. If the contractor fails to do any of these within time specified periods, the Government has the right to obtain title. To the extent authorized by 35 USC 205, the Government will not make public any information disclosing such inventions, allowing the contractor the permissible time to file a patent.

Per the NASA FAR Supplement 1852.227-11 Patent Rights--Retention by the Contractor (Short Form) the awardee may use whatever format is convenient to report inventions. NASA prefers that the awardee use either the electronic or paper version of NASA Form 1679, Disclosure of Invention and New Technology (Including Software), to report inventions. Both the electronic and paper versions of NASA Form 1679 may be accessed at the electronic New Technology Reporting Web site <http://ntr.ndc.nasa.gov/>.

A New Technology Summary Report (NTSR) listing all inventions developed under the contract or certifying that no inventions were developed must be also be submitted. Both NASA Form 1679 and the NTSR shall also be uploaded to the SBIR/STTR EHB at <https://ehb8.gsfc.nasa.gov/contracts/public/firmHome.do>

5.8 Profit or Fee

Phase I contracts may include a reasonable profit. The reasonableness of proposed profit is determined by the Contracting Officer during contract negotiations. Reference FAR 15.404-4.

5.9 Joint Ventures and Limited Partnerships

Both joint ventures and limited partnerships are permitted, provided the entity created qualifies as an SBC in accordance with the definition in section 2.22. A statement of how the workload will be distributed, managed, and charged should be included in the proposal. A copy or comprehensive summary of the joint venture agreement or partnership agreement should be appended to the proposal. This will not count as part of the 23-page limit for the Phase I proposal.

5.10 Essentially Equivalent Awards and Prior Work

If an award is made pursuant to a proposal submitted under either SBIR or STTR Solicitations, the firm will be required to certify with every invoice that it has not previously been paid nor is currently being paid for essentially equivalent work by any agency of the Federal Government. Failure to report essentially equivalent or duplicate efforts can lead to the termination of contracts or civil or criminal penalties.

5.11 Contractor Commitments

Upon award of a funding agreement, the awardee will be required to make certain legal commitments through acceptance of numerous clauses in Phase I funding agreements. The outline that follows is illustrative of the types of clauses to which the contractor would be committed. This list is not a complete list of clauses to be included in Phase I funding agreements, and is not the specific wording of such clauses.

- (1) Standards of Work. Work performed under the funding agreement must conform to high professional standards.
- (2) Inspection. Work performed under the funding agreement is subject to Government inspection and evaluation at all times.
- (3) Examination of Records. The Comptroller General (or a duly authorized representative) must have the right to examine any pertinent records of the awardee involving transactions related to this funding agreement.
- (4) Default. The Government may terminate the funding agreement if the contractor fails to perform the work contracted.
- (5) Termination for Convenience. The funding agreement may be terminated at any time by the Government if it deems termination to be in its best interest, in which case the awardee will be compensated for work performed and for reasonable termination costs.
- (6) Disputes. Any dispute concerning the funding agreement that cannot be resolved by agreement must be decided by the contracting officer with right of appeal.
- (7) Contract Work Hours. The awardee may not require an employee to work more than 8 hours a day or 40 hours a week unless the employee is compensated accordingly (for example, overtime pay).
- (8) Equal Opportunity. The awardee will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.
- (9) Affirmative Action for Veterans. The awardee will not discriminate against any employee or application for employment because he or she is a disabled veteran or veteran of the Vietnam era.

- (10) Affirmative Action for Handicapped. The awardee will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.
- (11) Officials Not To Benefit. No Government official must benefit personally from the SBIR/STTR funding agreement.
- (12) Covenant Against Contingent Fees. No person or agency has been employed to solicit or secure the funding agreement upon an understanding for compensation except bona fide employees or commercial agencies maintained by the awardee for the purpose of securing business.
- (13) Gratuities. The funding agreement may be terminated by the Government if any gratuities have been offered to any representative of the Government to secure the award.
- (14) Patent Infringement. The awardee must report each notice or claim of patent infringement based on the performance of the funding agreement.
- (15) American Made Equipment and Products. When purchasing equipment or a product under the SBIR/STTR funding agreement, purchase only American-made items whenever possible.

5.12 Additional Information

5.12.1 Precedence of Contract Over Solicitation

This Program Solicitation reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting SBIR/STTR contract, the terms of the contract are controlling.

5.12.2 Evidence of Contractor Responsibility

In addition to the information required to be submitted in section 3.2.11, before award of an SBIR or STTR contract, the Government may request the offeror to submit certain organizational, management, personnel, and financial information to establish responsibility of the offeror. Contractor responsibility includes all resources required for contractor performance, i.e., financial capability, work force, and facilities.

5.12.3 1852.225-70 Export Licenses

The contractor shall comply with all U.S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). Offerors are responsible for ensuring that all employees who will work on this contract are eligible under export control and International Traffic in Arms (ITAR) regulations. Any employee who is not a U.S. citizen or a permanent resident may be restricted from working on this contract if the technology is restricted under export control and ITAR regulations unless the prior approval of the Department of State or the Department of Commerce is obtained via a technical assistance agreement or an export license. Violations of these regulations can result in criminal or civil penalties. For further information on ITAR visit http://www.pmddtc.state.gov/regulations_laws/itar.html. For additional assistance, refer to http://sbir.gsfc.nasa.gov/SBIR/export_control.html or contact the ARC export control administrator, Mary Williams, at mary.p.williams@nasa.gov.

5.12.4 Government Furnished and Contractor Acquired Property

Title to property furnished by the Government or acquired with Government funds will be vested with the NASA, unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the equipment by NASA.

5.13 Required Registrations and Submissions

5.13.1 Central Contractor Registration

Offerors should be aware of the requirement to register in the Central Contractor Registration (CCR) database prior to contract award. **To avoid a potential delay in contract award, offerors are required to register prior to submitting a proposal. Additionally, firms must certify the NAICS code of 541712.**

The CCR database is the primary repository for contractor information required for the conduct of business with NASA. It is maintained by the Department of Defense. To be registered in the CCR database, all mandatory information, which includes the DUNS or DUNS+4 number, and a CAGE code, must be validated in the CCR system. The DUNS number or Data Universal Number System is a 9-digit number assigned by Dun and Bradstreet Information Services (<http://www.dnb.com>) to identify unique business entities. The DUNS+4 is similar, but includes a 4-digit suffix that may be assigned by a parent (controlling) business concern. The CAGE code or Commercial Government and Entity Code is assigned by the Defense Logistics Information Service (DLIS) to identify a commercial or Government entity. If an SBC does not have a CAGE code, one will be assigned during the CCR registration process.

The DoD has established a goal of registering an applicant in the CCR database within 48 hours after receipt of a complete and accurate application via the Internet. However, registration of an applicant submitting an application through a method other than the Internet may take up to 30 days. Therefore, offerors that are not registered should consider applying for registration immediately upon receipt of this solicitation. Offerors and contractors may obtain information on CCR registration and annual confirmation requirements via the Internet at <http://www.ccr.gov> or by calling 888-CCR-2423 (888-227-2423).

5.13.2 52.204-8 Annual Representations and Certifications

Offerors should be aware of the requirement that the Representation and Certifications required from Government contractors must be completed through the Online Representations and Certifications Application (ORCA) website <https://orca.bpn.gov/login.aspx>. FAC 01-26 implements the final rule for this directive and requires that all offerors provide representations and certifications electronically via the BPN website; to update the representations and certifications as necessary, but at least annually, to keep them current, accurate and complete. NASA will not enter into any contract wherein the Contractor is not compliant with the requirements stipulated herein.

5.13.3 52.222-37 Employment Reports on Special Disabled Veterans, Veterans of the Vietnam-Era, and Other Eligible Veterans

In accordance with Title 38, United States Code, Section 4212(d), the U.S. Department of Labor (DOL), Veterans' Employment and Training Service (VETS) collects and compiles data on the Federal Contractor Program Veterans' Employment Report (VETS-100 Report) from Federal contractors and subcontractors who receive Federal contracts that meet the threshold amount of \$100,000. The VETS-100 reporting cycle begins annually on August 1 and ends September 30. Any federal contractor or prospective contractor that has been awarded or will be awarded a federal contract with a value of \$100,000 or greater must have a current VETS 100 report on file. Please visit the DOL VETS 100 website at <http://www.dol.gov/vets/programs/fcp/main.htm>. NASA will not enter into any contract wherein the firm is not compliant with the requirements stipulated herein.

5.13.4 1852.225-72 Restriction on funding Activity with China – Representation

- (a) Definition - “China” or “Chinese-owned” means the People’s Republic of China, any firm owned by the People’s Republic of China or any firm incorporated under the laws of the People’s Republic of China.
- (b) Public Laws 112-10, Section 1340(a) and 112-55, Section 536, restrict NASA from contracting to participate, collaborate, or coordinate bilaterally in any way with China or a Chinese-owned firm with funds appropriated on or after April 25, 2011. Contracts for commercial and non-developmental items are excepted from the prohibition as they constitute purchase of goods or services that would not involve participation, collaboration, or coordination between the parties.
- (c) Representation. By submission of its offer, the offeror represents that the offeror is not China or a Chinese-owned firm.

5.13.5 Software Development Standards

Offerors proposing projects involving the development of software should comply with the requirements of NASA Procedural Requirements (NPR) 7150.2, “NASA Software Engineering Requirements” are available online at <http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=7150&s=2>.

5.13.6 Human and/or Animal Subject

Due to the complexity of the approval process, use of human and/or animal subjects is not allowed for Phase I contracts.

5.13.7 HSPD-12

Firms that require access to federally controlled facilities for six consecutive months or more must adhere to the following:

PIV Card Issuance Procedures in accordance with FAR clause 52.204-9 Personal Identity Verification of Contractor Personnel.

Purpose: To establish procedures to ensure that recipients of contracts are subject to essentially the same credentialing requirements as Federal Employees when performance requires physical access to a federally-controlled facility or access to a Federal information system **for six consecutive months or more**. (Federally - controlled facilities and Federal information system are defined in FAR 2.101(b)(2)).

Background: Homeland Security Presidential Directive 12 (HSPD-12), “Policy for a Common Identification Standard for Federal Employees and Contractors”, and Federal Information Processing Standards Publication (FIPS PUB) Number 201, “Personal Identity Verification (PIV) of Federal Employees and Contractors” require agencies to establish and implement procedures to create and use a Government-wide secure and reliable form of identification NLT October 27, 2005. See: <http://csrc.nist.gov/publications/fips/fips201-1/FIPS-201-1-chng1.pdf>. In accordance with the FAR clause 52.204-9 Personal Identity Verification of Contractor Personnel which states in parts contractor shall comply with the requirements of this clause and shall ensure that individuals needing such access shall provide the personal background and biographical information requested by NASA.

If applicable, detailed procedures for the issuance of a PIV credential can be found at the following URL:
<http://itcd.hq.nasa.gov/PIV.html>.

5.14 False Statements

Knowingly and willfully making any false, fictitious, or fraudulent statements or representations may be a felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to \$10,000, up to five years in prison, or both. The Office of the Inspector General has full access to all proposals submitted to NASA.

6. Submission of Proposals

6.1 Submission Requirements

NASA uses electronically supported business processes for the SBIR/STTR programs. An offeror must have Internet access and an e-mail address. Paper submissions are not accepted.

The Electronic Handbook (EHB) for submitting proposals is located at <http://sbir.nasa.gov>. The Proposal Submission EHB will guide the firms through the steps for submitting an SBIR/STTR proposal. All EHB submissions are through a secure connection. Communication between NASA's SBIR/STTR programs and the firm is primarily through a combination of EHBs and e-mail.

6.2 Submission Process

SBCs must register in the EHB to begin the submission process. Firms are encouraged to start the proposal process early, to allow for sufficient time to complete the submissions process. It is recommended that the Business Official, or an authorized representative designated by the Business Official, be the first person to register for the SBC. The SBC's Employer Identification Number (EIN)/Taxpayer Identification Number is required during registration.

Note: The designated firm admin, typically the first person to register your firm, is the only individual authorized to update and change the firm level forms (see section 6.2.1 (5)).

For successful proposal submission, SBCs must complete all forms online, upload their technical proposal in an acceptable format, and have the Business Official and Principle Investigator electronically endorse the proposal. Electronic endorsement of the proposal is handled online with no additional software requirements. The term "technical proposal" refers to the part of the submission as described in section 3.2.4.

STTR: The Research Institution is required to electronically endorse the Research Agreement prior to the SBC endorsement of the completed proposal submission.

6.2.1 What Needs to Be Submitted

The entire proposal including Forms A, B, C, the briefing chart, and other firm level forms must be submitted/completed via the Submissions EHB located on the NASA SBIR/STTR website. (Note: Other forms of submissions such as postal, paper, fax, diskette, or e-mail attachments are not acceptable).

- (1) Forms A, B, and C are to be completed online.
- (2) The technical proposal is uploaded from your computer via the Internet utilizing secure communication protocol.
- (3) STTR proposers must submit the Research Agreement between the SBC and RI (**STTR only**).
- (4) Firms must submit a briefing chart online, which is not included in the page count (see section 3.2.6).
- (5) NASA Research License Application (only if the use of TAV is proposed).
- (6) The certifications, audit information, prior awards addendum, commercialization metrics survey are required and to be completed online. These are not included in the page count.

6.2.2 Technical Proposal Submissions

NASA converts all technical proposal files to PDF format for evaluation. Therefore, NASA requests that technical proposals be submitted in PDF format or MS Word. Note: Embedded animation or video will not be considered for evaluation.

Virus Check

The offeror is responsible for performing a virus check on each submitted technical proposal. As a standard part of entering the proposal into the processing system, NASA will scan each submitted electronic technical proposal for viruses. **The detection, by NASA, of a virus on any electronically submitted technical proposal, may cause rejection of the proposal.**

6.2.3 Technical Proposal Uploads

Firms will upload their proposals using the Submissions EHB. Directions will be provided to assist users. All transactions via the EHB are encrypted for security. Firms cannot submit security/password protected technical proposal and/or briefing chart files, as reviewers may not be able to open and read the files. An e-mail will be sent acknowledging each successful upload. Please verify the file name and file size in the confirmation email to ensure the correct proposal was uploaded. An example is provided below:

Sample E-mail for Successful Upload of Technical Proposal

Subject: Successful Upload of Technical Proposal

Upload of Technical Document for your NASA SBIR/STTR Proposal No. _____

This message is to confirm the successful upload of your technical proposal document for:

Proposal No. _____

(Uploaded File Name/Size/Date)

Please note that any previous uploads are no longer considered as part of your submission.

This e-mail is NOT A RECEIPT OF SUBMISSION of your entire proposal

IMPORTANT! The Business Official or an authorized representative must electronically endorse the proposal in the Electronic Handbook using the "Endorse Proposal" step. Upon endorsement, you will receive an e-mail that will be your official receipt of proposal submission.

Thank you for your participation in NASA's SBIR/STTR Program.

NASA SBIR/STTR Program Support Office

You may upload the technical proposal multiple times, with each new upload replacing the previous version, but only the final uploaded and electronically endorsed version will be considered for review.

6.3 Deadline for Phase I Proposal Receipt

All Phase I proposal submissions must be received no later than 5:00 p.m. EDT on Thursday, November 29, 2012, via the NASA SBIR/STTR website (<http://sbir.nasa.gov>). The EHB will not be available for Internet submissions after this deadline, so firms are also advised to print all forms prior to the deadline since the EHB will not be available. Any proposal received after that date and time shall be considered late and handled according to NASA FAR Supplement 1815.208.

6.4 Acknowledgment of Proposal Receipt

The final proposal submission includes successful completion of Form A (electronically endorsed by the SBC Official), Form B, Form C, the uploaded technical proposal, and the briefing chart. NASA will acknowledge receipt of electronically submitted proposals upon endorsement by the SBC Official to the SBC Official's e-mail address as provided on the proposal cover sheet. If a proposal acknowledgment is not received, the offeror should call NASA SBIR/STTR Program Support Office at 301-937-0888. An example is provided below:

Sample E-mail for Official Confirmation of Receipt of Full Proposal:

Subject: Official Receipt of your NASA SBIR/STTR Proposal No. _____

Confirmation No. _____

*This message is to acknowledge electronic receipt of your NASA SBIR/STTR Proposal No. _____.
Your proposal, including the forms and the technical document, has been received at the NASA SBIR/STTR Support Office.*

SBIR/STTR 2012 Phase I xx.xx-xxxx (Title)

Form A completed on:

Form B completed on:

Form C completed on:

Technical Proposal Uploaded on:

File Name:

File Type:

File Size:

Briefing Chart completed on:

Proposal endorsed electronically by:

This is your official confirmation of receipt. Please save this email for your records, as no other receipt will be provided. The notification and announcement for negotiation is currently scheduled for February 2013, and will be posted via the SBIR/STTR website (<http://sbir.nasa.gov>).

Thank you for your participation in the NASA SBIR/STTR program.

NASA SBIR/STTR Program Support Office

6.5 Withdrawal of Proposals

Prior to the close of submissions, proposals may be withdrawn via the Proposal Submission Electronic Handbook hosted on the NASA SBIR/STTR website (<http://sbir.nasa.gov>). In order to withdraw a proposal after the deadline, the designated SBC Official must send written notification via email to sbir@reisystems.com.

6.6 Service of Protests

Protests, as defined in section 33.101 of the FAR, that are filed directly with an agency and copies of any protests that are filed with the General Accounting Office (GAO) shall be served on the Contracting Officer by obtaining written and dated acknowledgement of receipt from the NASA SBIR/STTR Program contact listed below:

Cassandra Williams
NASA Shared Services Center
Building 1111, C Road
Stennis Space Center, MS 39529
Cassandra.Williams-1@nasa.gov

The copy of any protest shall be received within one calendar day of filing a protest with the GAO.

7. Scientific and Technical Information Sources

7.1 NASA Websites

General sources relating to scientific and technical information at NASA is available via the following web sites:

NASA Budget Documents, Strategic Plans, and Performance Reports:

<http://www.nasa.gov/about/budget/index.html>

NASA Organizational Structure: <http://www.nasa.gov/centers/hq/organization/index.html>

NASA Office of the Chief Technologist (OCT): <http://www.nasa.gov/offices/oct/home/index.html>

NASA SBIR/STTR Programs: <http://sbir.nasa.gov>

7.2 United States Small Business Administration (SBA)

The Policy Directives for the SBIR/STTR Programs may be obtained from the following source. SBA information can also be obtained at: <http://www.sba.gov>.

U.S. Small Business Administration
Office of Technology – Mail Code 6470
409 Third Street, S.W.
Washington, DC 20416
Phone: 202-205-6450

7.3 National Technical Information Service

The National Technical Information Service is an agency of the Department of Commerce and is the Federal Government's largest central resource for Government-funded scientific, technical, engineering, and business related information. For information regarding their various services and fees, call or write:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 703-605-6000
URL: <http://www.ntis.gov>

8. Submission Forms and Certifications

Firm Certifications

a. As defined in section 2 of the Solicitation, the offeror qualifies as a Small Business Concern (SBC)	Yes	No
b. It has no more than 500 employees, including the employees of its affiliates Number of employees: _____	Yes	No
i) Has SBA issued a size determination currently in effect finding that this Small Business Concern exceeds the 500 employee size standard?	Yes	No
c. The firm is owned and operated in the United States	Yes	No
i) 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
If No, explain why: _____		
d. The firm is owned by a faculty member or a student of an institution of higher education as defined in 20 U.S.C. § 1001)	Yes	No
<i>As defined in section 2 of the Solicitation, the offeror qualifies as a:</i>		
e. Socially and Economically Disadvantaged SBC	Yes	No
f. Woman-owned SBC	Yes	No
i) Economically Disadvantaged Women-owned SBC	Yes	No
g. HUBZone-owned SB	Yes	No
h. Veteran-owned SBC	Yes	No
i) Service Disabled Veteran-owned SBC	Yes	No
<i>In accordance with NFS 1852.209-73, the offeror certifies:</i>		
i. It is not the Association of Community Organizations for Reform Now (ACORN) or a subsidiary thereof	Yes	No
<i>In accordance with NFS 1852.209-75, the offeror certifies that:</i>		
j. It is not a corporation that has had any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability	Yes	No
k. It is not a corporation that was convicted, or had an officer or agent acting on behalf of the corporation convicted, of a felony criminal violation under a Federal law within the preceding 24 months	Yes	No

I understand that providing false information is a criminal offense under Title 18 US Code, Section 1001, False Statements, as well as Title 18 US Code, Section 287, False Claims.

Guidelines for Completing Firm Certifications

Certifications: Firm level certifications that are applicable across all proposal submissions submitted to this Solicitation must be completed via the “Certifications” section of the Proposal Submission Electronic Handbook. The offeror must answer Yes or No to certifications (a) through (k) as applicable.

Form A – SBIR Cover Sheet

	Subtopic No.	System generated 4-digits
Proposal Number:	--. --	- ----
Topic Title:		
Subtopic Title:		
Proposal Title:		

Firm Name:
Mailing Address:
City:
State/Zip:
Phone:
Fax:
EIN/Tax ID:

ACN (Authorized Contract Negotiator) Name:	
ACN E-mail:	
ACN Phone:	Extension:
DUNS + 4:	
Cage Code:	
Amount Requested: \$_____ (auto-populated upon completion of Budge Form C)	
Duration: _____ months	

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 OFFEROR HAS REVIEWED AND CERTIFIES THAT:

<p>a. During the performance of the contract, the Principal Investigator will spend more than one half of his/her time as an employee of the awardee (based on a 40 hour workweek). If no, the offeror must request a written deviation from this requirement from the funding agreement officer. Note: The Principal Investigator's tasks cannot be split between two people. Co-PIs are not acceptable. Refer to section 1.5.3.</p>	Yes No																																								
<p>b. Gender of the Principal Investigator</p>	Male Female																																								
<p>c. Is the Principal Investigator a socially and economically disadvantaged individual?</p>	Yes No																																								
<p>d. All, essentially equivalent work, or a portion of the work proposed under this project (check the applicable line):</p> <p>___ Has not been submitted for funding by another Federal agency.</p> <p>___ Has been submitted for funding by another Federal agency but has not been funded under any other Federal grant, contract, subcontract or other transaction. (Complete section i below)</p> <p>___ A portion has been funded by another grant, contract, or subcontract as described in detail in the proposal. Before award, this must be approved in writing by the funding agreement officer. (Complete section ii below)</p> <p>___ Has received funding for essentially equivalent work under this project by any other Federal grant, contract, or subcontract.</p> <p style="margin-left: 40px;">i) If submitted for other Federal funding, provide information on essentially equivalent proposal submissions below:</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;">Proposal No.</th> <th style="text-align: center;">Proposal Title</th> <th style="text-align: center;">Date of Submission</th> <th style="text-align: center;">Soliciting Agency</th> <th style="text-align: center;">(Anticipated) Selection Announcement Date</th> </tr> </thead> <tbody> <tr><td>_____</td><td>_____</td><td>_____</td><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td><td>_____</td><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td><td>_____</td><td>_____</td><td>_____</td></tr> </tbody> </table> </div> <p style="margin-left: 40px;">ii) If a portion has been Federally funded by another grant, contract, or contract, provide information on essentially equivalent proposal submissions below:</p> <div style="border: 1px solid black; padding: 5px;"> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;">Contract/ Grant No.</th> <th style="text-align: center;">Proposal Title</th> <th style="text-align: center;">Date of Submission</th> <th style="text-align: center;">Soliciting Agency</th> <th style="text-align: center;">Date of Award</th> </tr> </thead> <tbody> <tr><td>_____</td><td>_____</td><td>_____</td><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td><td>_____</td><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td><td>_____</td><td>_____</td><td>_____</td></tr> </tbody> </table> </div>	Proposal No.	Proposal Title	Date of Submission	Soliciting Agency	(Anticipated) Selection Announcement Date	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	Contract/ Grant No.	Proposal Title	Date of Submission	Soliciting Agency	Date of Award	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
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<p>e. During the performance of the contract, the SBC will perform at least two-thirds (66 2/3%) of the applicable percentage of work*</p>	Yes No																																								
<p>f. During the performance of the contract, the research/research and development will be performed in the United States*</p> <p style="margin-top: 10px;">* In rare occasions, minor deviations from this requirement may be necessary; however, any minor deviation must be approved in writing by the contracting officer after consultation with the agency SBIR Program Manager/Business Manager.</p>	Yes No																																								

g. During the performance of the contract, the research/research and development will be performed at the offeror's facilities by the offeror's employees except as otherwise indicated in the SBIR technical proposal	Yes	No
<i>As described in Section 3 of this solicitation, the offeror meets the following requirements completely:</i>		
h. All 11 parts of the technical proposal are included in part order and the page limitation is met	Yes	No
i. Subcontracts/consultants proposed?	Yes	No
i) If yes, does the proposal comply with the subcontractor/consultant limitation? (section 3.2.4, part 9)	Yes	No N/A
j. Federal facilities, laboratories, or equipment required?	Yes	No
i) If yes, is justification for the use uploaded in Form C?	Yes	No N/A
ii) If yes, is a signed statement of availability uploaded in Form C?	Yes	No N/A
<i>In accordance with ITAR, 22 CFR 120-130, as applicable:</i>		
k. The offeror understands and shall comply with export control regulations	Yes	No
<i>In accordance with FAR 52.223-13, FAR 52.223-3, 29 CFR 1910.1200(g) and the latest version of Federal Standard No. 313 as applicable, indicate if the following will be used (must comply with Federal regulations):</i>		
l. Toxic Chemicals	Yes	No
m. Hazardous Materials	Yes	No
<i>As referenced in section 1.2 of the Solicitation, indicate if the R&D to be performed is related to:</i>		
n. Renewable Energy	Yes	No
o. Manufacturing	Yes	No
<i>Disclosure permission:</i>		
p. Will you permit the Government to disclose your name, address, and telephone number of the Business Official of your concern, if your proposal 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
<i>As a representative of the offeror, I certify the following:</i>		
— The offeror 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		

<p>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 non-procurement transactions (FAR Subpart 9.4 or 2 C.F.R. part 180); and (6) other administrative penalties including termination of SBIR/STTR awards.</p>	
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ENDORSEMENTS:

Principal Investigator:

Name: Title:
Phone: E-mail:

Endorsed by: Date:

Corporate/Business Official:

Name: Title:
Phone: E-mail:

Endorsed by: Date:

PROPRIETARY NOTICE (If applicable, see sections 5.5, 5.6)

NOTICE: This 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, provided that a funding agreement is awarded to the offeror as a result of or in connection with the submission of this 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 in pages _____ of this proposal.

Note: Do not mark the entire proposal as proprietary. Form B (page 2 of your proposal submission) cannot contain proprietary data. (See section 3.2.3 of the 2012 Solicitation)

Guidelines for Completing SBIR Cover Sheet

Complete Cover Sheet Form A electronically via the Proposal Submission Electronic Handbook.

Proposal Number: This number does not change. The proposal number consists of the four-digit subtopic number and four-digit system-generated number.

Topic Title: Select the topic that this proposal will address. Refer to section 9 for topic descriptions.

Subtopic Title: Select the subtopic that this proposal will address. Refer to section 9 for subtopic descriptions.

Proposal Title: Enter a brief, descriptive title using no more than 80 keystrokes (characters and spaces). Do not use the subtopic title. Avoid words like "development" and "study."

Firm Name: Enter the full name of the firm submitting the proposal. If a joint venture, list the firm chosen to negotiate and receive contracts. If the name exceeds 40 keystrokes, please abbreviate.

Mailing Address: Must match CCR address and should be the address where mail is received.

City, State, Zip: City, 2-letter State designation (i.e. TX for Texas), 9-digit Zip code (i.e. 20705-3106)

Phone, Fax: Number including area code

EIN/Tax ID: Employer Identification Number/Taxpayer ID

ACN Name: Enter the name of the Authorized Contract Negotiator from your firm

ACN E-mail: Email address

ACN Phone, Ext.: Number including area code and extension (if applicable)

DUNS + 4: 9-digit Data Universal Number System; a 4-digit suffix is also required if owned by a parent concern. For information on obtaining a DUNS number go to <http://www.dnb.com>.

CAGE Code: Commercial Government and Entity Code that is issued by the Central Contractor Registration (CCR). For information on obtaining a CAGE Code, go to <http://www.ccr.gov>.

Amount Requested: Proposal amount auto-populated from Budget Summary. The amount requested should not exceed \$125,000 (see sections 1.4, 5.1.1).

Duration: Proposed duration in months. The requested duration should not exceed 6 months (see Sections 1.4, 5.1.1).

Certifications: Answer Yes or No as applicable for certifications a – p (see the referenced sections for definitions). Where applicable, SBCs should make sure that their certifications on Form A agree with the content of their technical proposal.

- a. The Principal Investigator is required to be “primarily employed” by the organization as defined in section 1.5.3 of the Solicitation.
- b. As required by the SBIR/STTR Policy Directive, the offeror should indicate the gender of the Principal Investigator. This data is collected for statistical purposes only.
- c. As required by the SBIR/STTR Policy Directive, the offeror should indicate if the Principal Investigator is a socially and economically disadvantaged individual as defined in 13 C.F.R. § 124.103 and 124.104. This data is collected for statistical purposes only.

- d. The firm must disclose if any essentially equivalent work has been submitted for funding or funded by another Federal agency. While it is permissible to submit essentially equivalent proposals, it is unlawful to enter into funding agreements requiring essentially equivalent work. If essentially equivalent work under this project has been submitted to other Federal Agencies/programs for funding, then the SBC must provide the proposal number, proposal title, date of submission, soliciting agency, and the (anticipated) selection announcement date in subsection i. If a portion of the work has been funded by another grant, contract, or subcontract, then the SBC must provide the contract/grant number, proposal title, date of submission, awarding agency, date of award in subsection ii.
- e. The SBC is required to perform at least two-thirds (66%) of the work. Refer to section 3.2.4, part 9.
- f. R/R&D must be performed in the United States (see sections 1.5.2 and 2.27) except in rare and unique circumstances which require approval by the Contracting Officer prior to award.
- g. The offeror must certify that during the performance of the contract the R/R&D will be performed at the offeror's facilities by the offeror's employees unless otherwise indicated in the SBIR proposal.
- h. As stated in section 3.2 of the Solicitation, the entire proposal must not exceed the 23-page limitation (technical proposal plus Forms A, B, and C) and must consist of all eleven (11) required parts.
- i. By answering "Yes", the SBC certifies that subcontracts/consultants have been proposed and arrangements have been made to perform on the contract, if awarded.
 - i) Proposed subcontractor/consultant business arrangements must not exceed 33 percent of the research and/or analytical work (as determined by the total cost of the proposed subcontracting effort (to include the appropriate OH and G&A) in comparison to the total effort (total contract price including cost sharing, if any, less profit if any). Refer to section 3.2.4, part 9 of the Solicitation.
- j. By answering "Yes", the SBC certifies that Federal furnished facilities, laboratories, or equipment are required to perform the proposed activities. By answering "No", the SBC certifies that no such Federal furnished facilities, laboratories, or equipment is required to perform the proposed activities. See section 3.2.4, part 8 of the Solicitation.
 - i) If proposing to use Federal facilities, laboratories, or equipment a justification statement from the SBC must be uploaded in Form C. Proposals requiring waivers must explain why the waiver is appropriate. Facilities designated as a Federal laboratory are exempt from the waiver requirement.
 - ii) If proposing to use Federal furnished facilities, laboratories, or equipment, a signed statement of availability must be uploaded in Form C that describes the uniqueness of the facility and its availability to the offeror at specified times, signed by the appropriate Government official.
- k. Offerors are responsible for ensuring compliance with export control and International Traffic in Arms (ITAR) regulations. All employees who will work on this contract must be eligible under these regulations or the offeror must have in place a valid export license or technical assistance agreement. Violations of these regulations can result in criminal or civil penalties. For further information on ITAR visit http://www.pmddtc.state.gov/regulations_laws/itar.html. For additional assistance, contact the ARC export control administrator, Mary Williams, at mary.p.williams@nasa.gov. See section 5.12.3.
- l.-m. Offeror must indicate by answering "Yes" or "No" as applicable if toxic chemicals and/or hazardous materials will be used. SBCs must be in compliance with federal regulations. Reference FAR 52.223-13 Certification of Toxic Chemical Release Reporting and FAR 52.223-3 Hazardous Material identification and Material Safety Identification.

Offerors must list any hazardous material to be delivered under this contract. The apparently successful offeror agrees to submit, for each item as required prior to award, a Material Safety Data Sheet, meeting the requirements of 29 CFR 1910.1200(g) and the latest version of Federal Standard No. 313, for all hazardous material identified in paragraph (b) of this clause. Data shall be submitted in accordance with Federal Standard No. 313, whether or not the apparently successful offeror is the actual manufacturer of these items. Failure to submit the Material Safety Data Sheet prior to award may result in the apparently successful offeror being considered non-responsible and ineligible for award.

- n. Answer “Yes” if this proposal has a connection to energy efficiency or alternative and renewable energy. This should also be indicated in part 5 (Related R/R&D) of the proposal with a brief explanation of how it is related to energy efficiency or alternative and renewable energy. See section 1.2 of the Solicitation.
- o. Answer “Yes” if this proposal has a connection to manufacturing. This should also be indicated in part 5 (Related R/R&D) of the proposal with a brief explanation of how it is related to manufacturing. See section 1.2 of the Solicitation.
- p. The offeror must indicate if they permit the Government to disclose the name, address, and telephone number of the Business Official of your concern, if the proposal does not result in an award, to appropriate local and State-level economic development organizations that may be interested in contacting the Business Official for further information.

Electronic Endorsement:

Electronic endorsement is performed by the Principal Investigator and the authorized Business Official from the “Endorsement” link located on the Activity Worksheet for each proposal. Electronic endorsement by the Business Official is the final step in the proposal submission process and can only be performed when all required sections of the proposal submission are complete and the Principal Investigator has performed his/her separate electronic endorsement. Once endorsed, the name and date of endorsement will populate under the “Endorsement” section of this form. If any changes are made to the submission after endorsement by the Principal Investigator and/or Business Official, the proposal must be re-endorsed to be considered complete and submitted.

Endorsement of the proposal by the Business Official certifies that all information submitted in connection with this application is true and correct as of the date of submission. 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 non-procurement transactions (FAR Subpart 9.4 or 2 C.F.R. part 180); and (6) other administrative penalties including termination of SBIR/STTR awards.

Form B – SBIR Proposal Summary

Proposal Number: Subtopic No. System generated 4-digits
 --.- -- - - - - - -
Subtopic Title:
Proposal Title:

Small Business Concern:

Name:
Address:
City/State/Zip:
Phone:

Principal Investigator/Project Manager:

Name:
Address:
City/State/Zip:
Phone: Extension:
E-mail:

Business Official:

Name:
Address:
City/State/Zip:
Phone: Extension:
E-mail:

Estimated Technology Readiness Level (TRL) at beginning and end of contract:

Begin: _____
End: _____

Technology Available (TAV):

All subtopics listed in this solicitation have Technology Available (TAV) with NASA Intellectual Property. The use of the NASA IP is strictly voluntary. Refer to section 1.6 of the Solicitation for additional information.

Do you plan to use NASA Intellectual Property (IP) under the award? Yes No

If yes, [click here](#) to access the NASA Research License Application that must be completed and appended to your technical proposal.

Technical Abstract: (Limit 2,000 characters, approximately 200 words)

Potential NASA Application(s): (Limit 1,500 characters, approximately 150 words)

Potential Non-NASA Application(s): (Limit 1,500 characters, approximately 150 words)

Technology Taxonomy: (Select only the technologies relevant to this specific proposal)

NASA's technology taxonomy has been developed by the SBIR/STTR Program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.

Guidelines for Completing SBIR Proposal Summary

Complete Proposal Summary Form B electronically via the Proposal Submission Electronic Handbook.

Proposal Number: Auto-populated with proposal number as shown on Cover Sheet.

Subtopic Title: Auto-populated with subtopic title as shown on Cover Sheet.

Proposal Title: Auto-populated with proposal title as shown on Cover Sheet.

Small Business Concern: Auto-populated with firm information as shown on Cover Sheet.

Principal Investigator/Project Manager: Enter the full name of the PI/PM and include all required contact information.

Business Official: Enter the full name of the Business Official and include all required contact information.

Technology Readiness Level (TRL): Provide the estimated Technology Readiness Level (TRL) at the beginning and end of the contract. See section 2.26 and Appendix B for TRL definitions.

Technology Available (TAV): All subtopics listed in this solicitation have Technology Available (TAV) with NASA Intellectual Property. Refer to section 1.6 of the Solicitation for more information. The offeror shall answer “Yes” if planning to use NASA IP under the award, and must complete the NASA Research License Application and append it to the technical proposal.

Technical Abstract: Summary of the offeror’s proposed project is limited to 2,000 characters, approximately 200 words, and shall summarize the implications of the approach and the anticipated results of the Phase I. NASA will reject a proposal if the technical abstract is determined to be non-responsive to the subtopic. The abstract must not contain proprietary information and must describe the NASA need addressed by the proposed R/R&D effort.

Potential NASA Application(s): Summary of the direct or indirect NASA applications of the innovation, assuming the goals of the proposed R/R&D are achieved. The response is limited to 1,500 characters, approximately 150 words.

Potential Non-NASA Application(s): Summary of the direct or indirect NASA applications of the innovation, assuming the goals of the proposed R/R&D are achieved. The response is limited to 1,500 characters, approximately 150 words.

Technology Taxonomy: Selections for the technology taxonomy are limited to technologies supported or relevant to the specific proposal. The listing of technologies for the taxonomy is provided in Appendix C.

Form C – SBIR Budget Summary

PROPOSAL NUMBER:

SMALL BUSINESS CONCERN:

(1) DIRECT LABOR:

Category	Description	Education	Years of Experience	Hours	Rate	Fringe Rate % (if applicable)	Total
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Document uploaded for labor rate documentation: (file name)

TOTAL DIRECT LABOR:

(1)

\$ _____

(2) OVERHEAD COST;

_____ % of Total Direct Labor or \$ _____

Comments:

Overhead Cost Sources:

OVERHEAD COST:

(2)

\$ _____

(3) OTHER DIRECT COSTS (ODCs):

Materials:

Description: _____

Vendor: _____

Quantity: _____ Cost: _____

Consumable? Yes No

Competitively Sourced? Yes No

Used Exclusively for this Contract? Yes No

Supporting Comments: _____

Supporting Documents: (file name)

Supplies:

Description: _____

Vendor: _____

Quantity: _____ Cost: _____

Consumable? Yes No

Competitively Sourced? Yes No

Used Exclusively for this Contract? Yes No

Supporting Comments: _____

Supporting Documents: (file name)

Equipment:

Description: _____
 Vendor: _____
 Quantity: _____ Cost: _____
 Competitively Sourced? Yes No
 Used Exclusively for this Contract? Yes No
 Supporting Comments: _____
 Supporting Documents: (file name) _____

Other:

Description: _____
 Vendor: _____
 Quantity: _____ Cost: _____
 Competitively Sourced? Yes No
 Used Exclusively for this Contract? Yes No
 Supporting Comments: _____
 Supporting Documents: (file name) _____

Travel:

Location From: _____ Location To: _____
 Number of People: _____ Number of Days: _____
 Purpose of Trip: _____
 Airfare: _____ Car Rental: _____
 Per Diem: _____ Other Costs: _____
 Total Costs: _____
 Sources of Estimates: _____
 Explanation/Justification: _____

Explanation of ODCs:

Provide any additional information on the Other Direct Costs listed above, including the basis used for estimating the costs.

Subcontractor/Consultants:	Total Cost:
_____	_____
_____	_____
_____	_____

Supporting Documents: (file name) _____

(Note: Separate Budget Summaries completed for all proposed Subcontractors/Consultants via the Subcontractors/Consultants section of Form C)

	TOTAL OTHER DIRECT COSTS:	
	(3)	\$ _____
(1)+(2)+(3)=(4)	SUBTOTAL:	
	(4)	\$ _____

(5) GENERAL & ADMINISTRATIVE (G&A) COSTS

_____ % of Subtotal or \$ _____

G&A COSTS:

(5)

\$ _____

Comments:

G&A Cost Elements:

(4)+(5)=(6)

TOTAL COSTS

(6)

\$ _____

(7) ADD PROFIT or SUBTRACT COST SHARING PROFIT/COST SHARING:

(As applicable)

(7)

\$ _____

Comments:

(6)+(7)=(8)

AMOUNT REQUESTED:

(8)

\$ _____

FEDERAL FACILITIES, LABORATORIES, OR EQUIPMENT:

If you require the use of a Federal facility, laboratory, or equipment, identify it below as well as in part 8 of your technical proposal and upload a signed statement of availability from the Government agency. In addition, a letter of justification should be uploaded. (See certification j on Form A and section 3.2.4, part 8).

AUDIT AGENCY:

If your firm's accounting system has been audited, are the rates from that audit agreement used for this proposal?

☐ The rates listed in the negotiated rate agreement were used to prepare the budget summary

☐ Other rates were used to prepare the budget summary

☐ My firm's accounting system has not been audited

If the listed rates are not being used to prepare the budget summary, please provide an explanation:

Guidelines for Preparing SBIR Budget Summary

Complete Budget Summary Form C electronically.

The offeror shall electronically submit a price proposal of estimated costs with detailed information for each cost element, consistent with the offeror's cost accounting and estimating system.

This summary does not eliminate the need to fully document and justify the amounts requested in each category. Such documentation should be contained, as appropriate, in the text boxes or via uploads as indicated in the electronic form.

Offerors with questions about the appropriate classification of costs are advised to consult with an experienced accountant that has experience in government contracting and cost accounting principles. Information provided by the Defense Contract Audit Administration in their publication "Information for Contractors" may also be useful. This publication can be found via the following site under publications: <http://www.dcaa.mil/>

Firm: Same as Cover Sheet.

Proposal Number: Same as Cover Sheet.

Direct Labor: Select the appropriate labor category for each person who will be working directly on the proposed research effort and provide the labor description, level of education, years of experience, total number of hours, labor rate, and fringe rate percentage (if applicable). Detail the labor hours used for each year of the proposed research effort separately.

Labor rate documentation should include costs that are included in the fringe rate percentage (if applicable). Provide the breakout rate such as the labor hour rate, health benefits, life insurance etc. Some examples of direct labor include Principal Investigator, Engineer, Scientist, Analyst or Research Assistant/Laboratory Assistant. All listed categories shall be directly related to proposed work to be performed under contract with NASA. Any contributions from non-technical personnel proposed under direct labor shall be explicitly explained. Labor rates that do not compare favorably to comparable state average rates at <http://www.bls.gov> require additional documentation, supporting the proposed rate or salary.

Note: Costs associated with firm executives, accountants or administrative support are typically included in a firm's general and administrative costs. If these costs are being proposed as direct labor then provide the details of how the proposed hours were allocated to this effort and verify that these costs are not also covered in your overhead or G&A rate.

Overhead Cost: Specify current rate and base. Use current rate(s) negotiated with your firm's cognizant Federal-auditing agency, if available. A rate that has not been audited requires a detailed explanation of the cost base used to develop the rate and if possible, historical actual overhead rates for the past three years.

Specify the cost elements of the firm's overhead costs in the text boxes provided. Possible overhead cost elements include insurance, sick leave, and vacation.

Note: If no labor overhead rate is proposed and the proposed direct labor includes all fringe benefits, you may enter "0" for the overhead cost line.

Other Direct Costs (ODCs): Refer to FAR 31.205 – Selected Costs for determination of cost allowability.

Materials and Supplies: Under the Materials and Supplies sections, indicate type, vendor, quantity required, and cost. Identify whether each item is consumable, which year it will be purchased, if it was competitively sourced, and if it will be used exclusively for this contract. Your proposed cost shall be justified and supporting documents should be uploaded. General materials or supplies without adequate explanation of the components, quantity and use of said items are not an acceptable breakdown. In the supporting comments block, provide the basis for the proposed price (vendor quote, competitive quotes, catalog price, estimate, etc.). The Contracting Officer will make the final determination.

Special Tooling, Testing, and Test Equipment: The need for these items, if proposed, will be carefully reviewed. Equipment must be made in the USA to the maximum extent practical. The offeror should provide competitive quotes to support the proposed costs or should justify why only one source is available. Competitive quotes may be signed quotes from vendors or copies of catalogue pages. Normally the costs of any equipment should be quoted on a purchase basis, unless the offeror can demonstrate that lease or rent of the equipment is clearly advantageous to the government. The Contracting Officer will make the final determination. Upload supporting documentation as necessary. In the supporting comments block provide the basis for the proposed price (vendor quote, competitive quotes, catalog price, estimate etc.). The Contracting Officer will make the final determination.

Travel: All proposed travel must be necessary for the success of the research. Include a detailed accounting of all proposed expenses to include the purpose of proposed trips, number of trips, travelers per trip, as well as meals, hotel, and rental car estimated costs. Sources of estimate should be identified when travel is proposed along with a justification for each trip. Proposed travel costs shall be in accordance with the Federal Travel Regulation <http://www.gsa.gov/federaltravelregulation>.

Subcontracts/Consultants: Subcontracts/Consultants costs are included in the Other Direct Costs total. A separate budget summary must be completed for each subcontract/consultant proposed. Further instructions are provided in the Subcontracts/Consultants section below.

Note: Do not add subcontractors or consultants as a line item under the ODCs section of Form C. It will automatically be added to the ODCs upon completion of the separate Subcontractor/Consultant budget summary form.

Other: List all other direct costs that are not otherwise included in the categories described above such as rental of facilities, etc.

Note: The purchase of equipment, instrumentation, or facilities under SBIR must be justified by the offeror and approved by the Government during contract negotiations. Firms should be prepared to justify all material, supplies, and equipment costs during negotiations. See section 3.2.4, part 8 for further guidance.

Explanation of ODCs: Provide any additional information for the proposed ODCs, including basis for cost estimation, in the text box provided.

Subcontracts/Consultants: List consultants by name and specify, for each, the number of hours and hourly costs. Detailed quotes from subcontractors should be provided in the same format. Note that a subcontract entered into for performance of research or research and development differs from an arrangement with a vendor to provide a service such as machining, analysis with test equipment or use of computer time. The costs of such arrangements with vendors should be covered under Special Tooling, Testing, Test Equipment and Material or under Other Direct Costs. Upon request of the contracting officer, the subcontractor's cost proposals may be sealed or mailed directly for government eyes only.

A letter of commitment shall be uploaded for each proposed subcontractor/consultant from the Subcontractor/Consultant Letter of Commitment section of the subcontractor/consultant budget summary form. If a commitment letter is not available, you must upload alternate documentation that sufficiently substantiates that the subcontractor/consultant is available to perform the proposed work during the proposed timeframe. Note that not providing the information now may delay contract negotiations and award.

General and Administrative (G&A) Costs: Specify a current rate and base to which G&A costs will be applied. If available, use the current rate recommendations from the cognizant Federal-auditing agency. If an audit rate is not available, provide a detailed explanation of the cost base used to develop the rate and if possible, a historical actual G&A rate for the past three years.

Specify the elements of the firm's G&A costs in the text boxes provided. Possible G&A cost elements include rent, utilities, and management.

Profit/Cost Sharing: See sections 5.8 and 5.9. Profit is to be added to total cost, while shared costs are to be subtracted from total cost, as applicable.

Amount Requested: The amount requested is equal to the sum of the Direct Labor, Overhead, ODCs, G&A and any profit, less any cost sharing. The amount requested cannot exceed \$125,000 for Phase I.

Federal Facilities, Laboratories, and Equipment: If you require the use of Government facilities, laboratories, or equipment, identify the Federal facilities, laboratories or equipment in the text box provided, as well as in part 8 of your technical proposal, and upload a signed statement of availability from the Government agency. Please note that this section SHALL be completed if you certified in Form A that you will require the use of Government facilities. Leave this section BLANK if you DO NOT require the use of Federal facilities, laboratories, or equipment.

Audit Information: Complete the Audit Information section of Form C to indicate if your firm's accounting system has been audited and if the rates from that audit agreement are used for this proposal.

Note: There is a separate "Audit Information" section linked from your Activity Worksheet that must also be completed.

SBIR Check List

For assistance in completing your Phase I proposal, use the following checklist to ensure your submission is complete.

1. **The entire proposal including any supplemental material shall not exceed a total of 23 8.5 x 11 inch pages and follow the format requirements (section 3.2.2).**
2. The proposal and innovation is submitted for one subtopic only (section 3.1).
3. The entire proposal is submitted consistent with the requirements and in the order outlined in section 3.2.
4. The technical proposal contains all eleven parts in order (section 3.2.4).
5. The 1-page briefing chart does not include any proprietary data (section 3.2.6).
6. Certifications in Form A are completed, and agree with the content of the technical proposal.
7. Proposed funding does not exceed \$125,000 (sections 1.4, 5.1.1).
8. Proposed project duration does not exceed 6 months (sections 1.4, 5.1.1).
9. Entire proposal including Forms A, B, and C submitted via the Internet.
10. Form A electronically endorsed by the SBC Official and the PI.
11. **Proposals must be received no later than 5:00 p.m. EDT on Thursday, November 29, 2012 (section 6.3).**

Form A – STTR Cover Sheet

	Subtopic No.	System generated 4-digits
Proposal Number:	--. --	- ----
Topic Title:		
Subtopic Title:		
Proposal Title:		

Firm Name:	Research Institution Name:
Mailing Address:	Mailing Address:
City:	City:
State/Zip:	State/Zip:
Phone:	Phone:
Fax:	Fax:
EIN/Tax ID:	EIN/Tax ID:

ACN (Authorized Contract Negotiator) Name:	
ACN E-mail:	
ACN Phone:	Extension:
DUNS + 4:	
Cage Code:	
Amount Requested: \$_____ (auto-populated upon completion of Budge Form C)	
Duration: _____ months	

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 Technology Transfer (STTR) 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 STTR 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 OFFEROR HAS REVIEWED AND CERTIFIES THAT:

<p>a. During the performance of the contract, the Principal Investigator will spend more than one half of his/her time as an employee of the awardee or the Research Institution (based on a 40 hour workweek). If no, the offeror must request a written deviation from this requirement from the funding agreement officer. Note: The Principal Investigator's tasks cannot be split between two people. Co-PIs are not acceptable. Refer to section 1.5.3.</p>	Yes No																																								
<p>b. Gender of the Principal Investigator</p>	Male Female																																								
<p>c. Is the Principal Investigator a socially and economically disadvantaged individual?</p>	Yes No																																								
<p>d. All, essentially equivalent work, or a portion of the work proposed under this project (check the applicable line):</p> <p>___ Has not been submitted for funding by another Federal agency.</p> <p>___ Has been submitted for funding by another Federal agency but has not been funded under any other Federal grant, contract, subcontract or other transaction. (Complete section i below)</p> <p>___ A portion has been funded by another grant, contract, or subcontract as described in detail in the proposal. Before award, this must be approved in writing by the funding agreement officer. (Complete section ii below)</p> <p>___ Has received funding for essentially equivalent work under this project by any other Federal grant, contract, or subcontract.</p> <p style="margin-left: 20px;">i) If submitted for other Federal funding, provide information on essentially equivalent proposal submissions below:</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="width: 10%;">Proposal No.</th> <th style="width: 30%;">Proposal Title</th> <th style="width: 20%;">Date of Submission</th> <th style="width: 20%;">Soliciting Agency</th> <th style="width: 20%;">(Anticipated) Selection Announcement Date</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table> <p style="margin-left: 20px;">ii) If a portion has been Federally funded by another grant, contract, or contract, provide information on essentially equivalent proposal submissions below:</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="width: 10%;">Contract/ Grant No.</th> <th style="width: 30%;">Proposal Title</th> <th style="width: 20%;">Date of Submission</th> <th style="width: 20%;">Soliciting Agency</th> <th style="width: 20%;">Date of Award</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table>	Proposal No.	Proposal Title	Date of Submission	Soliciting Agency	(Anticipated) Selection Announcement Date																Contract/ Grant No.	Proposal Title	Date of Submission	Soliciting Agency	Date of Award																
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Contract/ Grant No.	Proposal Title	Date of Submission	Soliciting Agency	Date of Award																																					
<p>e. During the performance of the contract, the SBC will perform at least 40% of the applicable percentage of work and the RI will perform at least 30% of the applicable percentage of work*</p>	Yes No																																								

<p>f. During the performance of the contract, the research/research and development will be performed in the United States*</p> <p>* In rare occasions, minor deviations from this requirement may be necessary; however, any minor deviation must be approved in writing by the contracting officer after consultation with the agency STTR Program Manager/Business Manager.</p>	<p>Yes No</p>
<p>g. During the performance of the contract, the research/research and development will be performed at the offeror's facilities by the offeror's employees except as otherwise indicated in the STTR technical proposal</p>	<p>Yes No</p>
<p><i>As described in section 2.17 of the Solicitation, the partnering Research Institution qualifies as a:</i></p>	
<p>h. FFRDC</p>	<p>Yes No</p>
<p>i. Nonprofit Research Institution</p>	<p>Yes No</p>
<p>j. Nonprofit College or University</p>	<p>Yes No</p>
<p><i>As described in Section 3 of this solicitation, the offeror meets the following requirements completely:</i></p>	
<p>k. Research Agreement electronically endorsed by the SBC and RI</p>	<p>Yes No</p>
<p>l. A Signed Allocation of Rights Agreement will be available for the Contracting Officer no more than 10 business days from time of notification of selection for negotiations</p>	<p>Yes No</p>
<p>m. All 11 parts of the technical proposal are included in part order and the page limitation is met</p>	<p>Yes No</p>
<p>n. Subcontracts/consultants proposed?</p> <p>i) If yes, does the proposal comply with the subcontractor/consultant limitation? (section 3.2.4, part 9)</p>	<p>Yes No</p> <p>Yes No N/A</p>
<p>o. Federal facilities, laboratories, or equipment required?</p> <p>i) If yes, is justification for the use uploaded in Form C?</p> <p>ii) If yes, is a signed statement of availability uploaded in Form C?</p>	<p>Yes No</p> <p>Yes No N/A</p> <p>Yes No N/A</p>
<p><i>In accordance with ITAR, 22 CFR 120-130, as applicable:</i></p>	
<p>p. The offeror understands and shall comply with export control regulations</p>	<p>Yes No</p>
<p><i>In accordance with FAR 52.223-13, FAR 52.223-3, 29 CFR 1910.1200(g) and the latest version of Federal Standard No. 313 as applicable, indicate if the following will be used (must comply with Federal regulations):</i></p>	
<p>q. Toxic Chemicals</p>	<p>Yes No</p>
<p>r. Hazardous Materials</p>	<p>Yes No</p>

<i>As referenced in section 1.2 of the Solicitation, indicate if the R&D to be performed is related to:</i>	
s. Renewable Energy	Yes No
t. Manufacturing	Yes No
<i>Disclosure permission:</i>	
u. Will you permit the Government to disclose your name, address, and telephone number of the Business Official of your concern, if your proposal 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
<i>As a representative of the offeror, I certify the following:</i>	
<ul style="list-style-type: none"> — The offeror 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 non-procurement transactions (FAR Subpart 9.4 or 2 C.F.R. part 180); and (6) other administrative penalties including termination of SBIR/STTR awards. 	

ENDORSEMENTS:**Principal Investigator:**

Name: Title:
Phone: E-mail:

Endorsed by: Date:

Corporate/Business Official:

Name: Title:
Phone: E-mail:

Endorsed by: Date:

PROPRIETARY NOTICE (If applicable, see sections 5.5, 5.6)

NOTICE: This 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, provided that a funding agreement is awarded to the offeror as a result of or in connection with the submission of this 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 in pages _____ of this proposal.

Note: Do not mark the entire proposal as proprietary. Form B (page 2 of your proposal submission) cannot contain proprietary data. (See section 3.2.3 of the 2012 Solicitation)

Guidelines for Completing STTR Cover Sheet

Complete Cover Sheet Form A electronically via the Proposal Submission Electronic Handbook.

Proposal Number: This number does not change. The proposal number consists of the four-digit subtopic number and four-digit system-generated number.

Topic Title: Select the topic that this proposal will address. Refer to section 9 for topic descriptions.

Subtopic Title: Select the subtopic that this proposal will address. Refer to section 9 for subtopic descriptions.

Proposal Title: Enter a brief, descriptive title using no more than 80 keystrokes (characters and spaces). Do not use the subtopic title. Avoid words like "development" and "study."

Firm Name: Enter the full name of the firm submitting the proposal. If a joint venture, list the firm chosen to negotiate and receive contracts. If the name exceeds 40 keystrokes, please abbreviate.

Research Institution Name: Enter the full name of the partnering Research Institution.

Mailing Address: Must match CCR address and should be the address where mail is received.

City, State, Zip: City, 2-letter State designation (i.e. TX for Texas), 9-digit Zip code (i.e. 20705-3106)

Phone, Fax: Number including area code

EIN/Tax ID: Employer Identification Number/Taxpayer ID

ACN Name: Enter the name of the Authorized Contract Negotiator from your firm

ACN E-mail: Email address

ACN Phone, Ext.: Number including area code and extension (if applicable)

DUNS + 4: 9-digit Data Universal Number System; a 4-digit suffix is also required if owned by a parent concern. For information on obtaining a DUNS number go to <http://www.dnb.com>.

CAGE Code: Commercial Government and Entity Code that is issued by the Central Contractor Registration (CCR). For information on obtaining a CAGE Code, go to <http://www.ccr.gov>.

Amount Requested: Proposal amount auto-populated from Budget Summary. The amount requested should not exceed \$125,000 (see sections 1.4, 5.1.1).

Duration: Proposed duration in months. The requested duration should not exceed 12 months (see sections 1.4, 5.1.1).

Certifications: Answer Yes or No as applicable for certifications a – u (see the referenced sections for definitions). Where applicable, SBCs should make sure that their certifications on Form A agree with the content of their technical proposal.

- a. The Principal Investigator is required to be “primarily employed” by the Small Business Concern or the Research Institution as defined in section 1.5.3 of the Solicitation.
- b. As required by the SBIR/STTR Policy Directive, the offeror should indicate the gender of the Principal Investigator. This data is collected for statistical purposes only.
- c. As required by the SBIR/STTR Policy Directive, the offeror should indicate if the Principal Investigator is a socially and economically disadvantaged individual as defined in 13 C.F.R. § 124.103 and 124.104. This data is collected for statistical purposes only.

- d. The firm must disclose if any essentially equivalent work has been submitted for funding or funded by another Federal agency. While it is permissible to submit essentially equivalent proposals, it is unlawful to enter into funding agreements requiring essentially equivalent work. If essentially equivalent work under this project has been submitted to other Federal Agencies/programs for funding, then the SBC must provide the proposal number, proposal title, date of submission, soliciting agency, and the (anticipated) selection announcement date in subsection i. If a portion of the work has been funded by another grant, contract, or subcontract, then the SBC must provide the contract/grant number, proposal title, date of submission, awarding agency, date of award in subsection ii.
- e. The SBC is required to perform at least 40% of the work and the RI is required to perform at least 30% of the work. Refer to section 3.2.4, part 9.
- f. R/R&D must be performed in the United States (See sections 1.5.2 and 2.27) except in rare and unique circumstances, which require approval by the Contracting Officer prior to award.
- g. The offeror must certify that during the performance of the contract the R/R&D will be performed at the offeror's facilities by the offeror's employees unless otherwise indicated in the STTR proposal.
- h-j. Indicate whether the Research Institution (RI) qualifies as a FFRDC, Nonprofit Research Institution, or a Nonprofit College/University. (Only one of these should be marked as "Yes").
- k. The Research Agreement must be electronically endorsed by the authorized SBC Official and RI Official. Refer to section 3.2.5 of the Solicitation. Note: Endorsement is performed via the "Endorsement" link located in the Activity Worksheet for each proposal.
- l. Within 10 business days of the notification of selection for negotiation, the offeror must provide to the Contracting Officer a completed Allocation of Rights Agreement (ARA). The ARA shall state the allocation of intellectual property rights with respect to the proposed STTR activity and planned follow-on research, development and/or commercialization. See section 3.2.12 of the Solicitation.
- m. As stated in section 3.2 of the Solicitation, the entire proposal must not exceed the 23-page limitation (technical proposal plus Forms A, B, C, and Research Agreement) and must consist of all eleven (11) required parts.
- n. By answering "Yes", the SBC certifies that subcontracts/consultants (other than the Research Institution) have been proposed and arrangements have been made to perform on the contract, if awarded.
 - i) Proposed subcontractor/consultant business arrangements must not exceed 30 percent of the research and/or analytical work (as determined by the total cost of the proposed subcontracting effort (to include the appropriate OH and G&A) in comparison to the total effort (total contract price including cost sharing, if any, less profit if any). Refer to section 3.2.4, part 9 of the Solicitation.
- o. By answering "Yes", the SBC certifies that Federal furnished facilities, laboratories, or equipment are required to perform the proposed activities. By answering "No", the SBC certifies that no such Federal furnished facilities, laboratories, or equipment is required to perform the proposed activities. See section 3.2.4, part 8 of the Solicitation.
 - i) If proposing to use Federal facilities, laboratories, or equipment a justification statement from the SBC must be uploaded in Form C. Proposals requiring waivers must explain why the waiver is appropriate. Facilities designated as a Federal laboratory are exempt from the waiver requirement.
 - ii) If proposing to use Federal furnished facilities, laboratories, or equipment, a signed statement of availability must be uploaded in Form C that describes the uniqueness of the facility and its availability to the offeror at specified times, signed by the appropriate Government official.

- p. Offerors are responsible for ensuring compliance with export control and International Traffic in Arms (ITAR) regulations. All employees who will work on this contract must be eligible under these regulations or the offeror must have in place a valid export license or technical assistance agreement. Violations of these regulations can result in criminal or civil penalties. For further information on ITAR visit http://www.pmddtc.state.gov/regulations_laws/itar.html. For additional assistance, contact the ARC export control administrator, Mary Williams, at mary.p.williams@nasa.gov. See section 5.12.3.
- q-r. Offeror must indicate by answering “Yes” or “No” as applicable if toxic chemicals and/or hazardous materials will be used. SBCs must be in compliance with federal regulations. Reference FAR 52.223-13 Certification of Toxic Chemical Release Reporting and FAR 52.223-3 Hazardous Material identification and Material Safety Identification.

Offerors must list any hazardous material to be delivered under this contract. The apparently successful offeror agrees to submit, for each item as required prior to award, a Material Safety Data Sheet, meeting the requirements of 29 CFR 1910.1200(g) and the latest version of Federal Standard No. 313, for all hazardous material identified in paragraph (b) of this clause. Data shall be submitted in accordance with Federal Standard No. 313, whether or not the apparently successful offeror is the actual manufacturer of these items. Failure to submit the Material Safety Data Sheet prior to award may result in the apparently successful offeror being considered non-responsible and ineligible for award.
- s. Answer “Yes” if this proposal has a connection to energy efficiency or alternative and renewable energy. This should also be indicated in part 5 (Related R/R&D) of the proposal with a brief explanation of how it is related to energy efficiency or alternative and renewable energy. See section 1.2 of the Solicitation.
- t. Answer “Yes” if this proposal has a connection to manufacturing. This should also be indicated in part 5 (Related R/R&D) of the proposal with a brief explanation of how it is related to manufacturing. See section 1.2 of the Solicitation.
- u. The offeror must indicate if they permit the Government to disclose the name, address, and telephone number of the Business Official of your concern, if the proposal does not result in an award, to appropriate local and State-level economic development organizations that may be interested in contacting the Business Official for further information.

Electronic Endorsement:

Electronic endorsement is performed by the Principal Investigator and the authorized Business Official from the “Endorsement” link located on the Activity Worksheet for each proposal. Electronic endorsement by the Business Official is the final step in the proposal submission process and can only be performed when all required sections of the proposal submission are complete and the Principal Investigator and Research Institution Official have performed their separate electronic endorsements. Once endorsed, the name and date of endorsement will populate under the “Endorsement” section of this form. If any changes are made to the submission after endorsement by the Principal Investigator and/or Business Official, the proposal must be re-endorsed to be considered complete and submitted.

Endorsement of the proposal by the Business Official certifies that all information submitted in connection with this application is true and correct as of the date of submission. 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 non-procurement transactions (FAR Subpart 9.4 or 2 C.F.R. part 180); and (6) other administrative penalties including termination of SBIR/STTR awards.

Form B – STTR Proposal Summary

Proposal Number: Subtopic No. System generated 4-digits
 Subtopic Title: --. -- - ----
 Proposal Title:

Small Business Concern:

Name:
 Address:
 City/State/Zip:
 Phone:

Principal Investigator/Project Manager:

Name:
 Address:
 City/State/Zip:
 Phone: Extension:
 E-mail:

Business Official:

Name:
 Address:
 City/State/Zip:
 Phone: Extension:
 E-mail:

Estimated Technology Readiness Level (TRL) at beginning and end of contract:

Begin: _____
 End: _____

Technology Available (TAV):

All Subtopics listed in this solicitation have Technology Available (TAV) with NASA Intellectual Property. The use of the NASA IP is strictly voluntary. Refer to section 1.6 of the Solicitation for additional information.

Do you plan to use NASA Intellectual Property (IP) under the award? Yes No

If yes, [click here](#) to access the NASA Research License Application that must be completed and appended to your technical proposal.

Technical Abstract: (Limit 2,000 characters, approximately 200 words)

Potential NASA Application(s): (Limit 1,500 characters, approximately 150 words)

Potential Non-NASA Application(s): (Limit 1,500 characters, approximately 150 words)

Technology Taxonomy: (Select only the technologies relevant to this specific proposal)

NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the Agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.

Guidelines for Completing STTR Proposal Summary

Complete Proposal Summary Form B electronically via the Proposal Submission Electronic Handbook.

Proposal Number: Auto-populated with proposal number as shown on Cover Sheet.

Subtopic Title: Auto-populated with subtopic title as shown on Cover Sheet.

Proposal Title: Auto-populated with proposal title as shown on Cover Sheet.

Small Business Concern: Auto-populated with firm information as shown on Cover Sheet.

Research Institution: Auto-populated with RI information as shown on Cover Sheet.

Principal Investigator/Project Manager: Enter the full name of the PI/PM and include all required contact information.

Technology Readiness Level (TRL): Provide the estimated Technology Readiness Level (TRL) at the beginning and end of the contract. See section 2.26 and Appendix B for TRL definitions.

Technology Available (TAV): All Subtopics listed in this solicitation have Technology Available (TAV) with NASA Intellectual Property. Refer to section 1.6 of the Solicitation for more information. The offeror shall answer “Yes” if planning to use NASA IP under the award, and must complete the NASA Research License Application and append it to the technical proposal.

Technical Abstract: Summary of the offeror’s proposed project is limited to 2,000 characters, approximately 200 words, and shall summarize the implications of the approach and the anticipated results of the Phase I. NASA will reject a proposal if the technical abstract is determined to be non-responsive to the subtopic. The abstract must not contain proprietary information and must describe the NASA need addressed by the proposed R/R&D effort.

Potential NASA Application(s): Summary of the direct or indirect NASA applications of the innovation, assuming the goals of the proposed R/R&D are achieved. The response is limited to 1,500 characters, approximately 150 words.

Potential Non-NASA Application(s): Summary of the direct or indirect NASA applications of the innovation, assuming the goals of the proposed R/R&D are achieved. The response is limited to 1,500 characters, approximately 150 words.

Technology Taxonomy: Selections for the technology taxonomy are limited to technologies supported or relevant to the specific proposal. The listing of technologies for the taxonomy is provided in Appendix C.

Form C – STTR Budget Summary

PROPOSAL NUMBER:

SMALL BUSINESS CONCERN:

(1) DIRECT LABOR:

Category	Description	Education	Years of Experience	Hours	Rate	Fringe Rate % (if applicable)	Total
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Document uploaded for labor rate documentation: (file name)

TOTAL DIRECT LABOR:

(1)

\$ _____

(2) OVERHEAD COST;

_____ % of Total Direct Labor or \$ _____

Comments:

Overhead Cost Sources:

OVERHEAD COST:

(2)

\$ _____

(3) OTHER DIRECT COSTS (ODCs):

Materials:

Description: _____

Vendor: _____

Quantity: _____ Cost: _____

Consumable? Yes No

Competitively Sourced? Yes No

Used Exclusively for this Contract? Yes No

Supporting Comments: _____

Supporting Documents: (file name)

Supplies:

Description: _____

Vendor: _____

Quantity: _____ Cost: _____

Consumable? Yes No

Competitively Sourced? Yes No

Used Exclusively for this Contract? Yes No

Supporting Comments: _____

Supporting Documents: (file name)

Equipment:

Description: _____
 Vendor: _____
 Quantity: _____ Cost: _____
 Competitively Sourced? Yes No
 Used Exclusively for this Contract? Yes No
 Supporting Comments: _____
 Supporting Documents: (file name) _____

Other:

Description: _____
 Vendor: _____
 Quantity: _____ Cost: _____
 Competitively Sourced? Yes No
 Used Exclusively for this Contract? Yes No
 Supporting Comments: _____
 Supporting Documents: (file name) _____

Travel:

Location From: _____ Location To: _____
 Number of People: _____ Number of Days: _____
 Purpose of Trip: _____
 Airfare: _____ Car Rental: _____
 Per Diem: _____ Other Costs: _____
 Total Costs: _____
 Sources of Estimates: _____
 Explanation/Justification: _____

Explanation of ODCs:

Provide any additional information on the Other Direct Costs listed above, including the basis used for estimating the costs.

Subcontractor/Consultants:	Total Cost:
_____	_____
_____	_____
_____	_____

Supporting Documents: (file name) _____

(Note: Separate Budget Summaries completed for all proposed Subcontractors/Consultants via the Subcontractors/Consultants section of Form C)

Research Institution:	Total Cost:
_____	_____

(Note: Separate Budget Summary completed for the Research Institution via the Research Institution section of Form C)

	TOTAL OTHER DIRECT COSTS:	
	(3)	\$ _____
(1)+(2)+(3)=(4)	SUBTOTAL:	
	(4)	\$ _____

(5) GENERAL & ADMINISTRATIVE (G&A) COSTS

_____ % of Subtotal or \$ _____

G&A COSTS:
(5)

\$ _____

Comments:

If an audit rate is not available, provide a detailed explanation of the cost base used to develop the G&A rate and if possible, a historical actual G&A rate for the past three years.

G&A Cost Elements:

(4)+(5)=(6)

TOTAL COSTS
(6)

\$ _____

(7) ADD PROFIT or SUBTRACT COST SHARING PROFIT/COST SHARING:
(As applicable)

(7)

\$ _____

Comments:

(6)+(7)=(8)

AMOUNT REQUESTED:
(8)

\$ _____

FEDERAL FACILITIES, LABORATORIES, OR EQUIPMENT:

If you require the use of a Federal facility, laboratory, or equipment, identify it below as well as in part 8 of your technical proposal and upload a signed statement of availability from the Government agency. In addition, a letter of justification should be uploaded. (See certification j on Form A and section 3.2.4, part 8).

AUDIT AGENCY:

If your firm's accounting system has been audited, are the rates from that audit agreement used for this proposal?

- ☐ The rates listed in the negotiated rate agreement were used to prepare the budget summary
☐ Other rates were used to prepare the budget summary
☐ My firm's accounting system has not been audited

If the listed rates are not being used to prepare the budget summary, please provide an explanation:

Guidelines for Preparing STTR Budget Summary

Complete Budget Summary Form C electronically.

The offeror shall electronically submit a price proposal of estimated costs with detailed information for each cost element, consistent with the offeror's cost accounting and estimating system.

This summary does not eliminate the need to fully document and justify the amounts requested in each category. Such documentation should be contained, as appropriate, in the text boxes or via uploads as indicated in the electronic form.

Offerors with questions about the appropriate classification of costs are advised to consult with an experienced accountant that has experience in government contracting and cost accounting principals. Information provided by the Defense Contract Audit Administration in their publication "Information for Contractors" may also be useful. This publication can be found via the following site under publications: <http://www.dcaa.mil/>

Firm: Same as Cover Sheet.

Proposal Number: Same as Cover Sheet.

Direct Labor: Select the appropriate labor category for each person who will be working directly on the proposed research effort and provide the labor description, level of education, years of experience, total number of hours, labor rate, and fringe rate percentage (if applicable). Detail the labor hours used for each year of the proposed research effort separately.

Labor rate documentation should include costs that are included in the fringe rate percentage (if applicable). Provide the breakout rate such as the labor hour rate, health benefits, life insurance etc. Some examples of direct labor include Principal Investigator, Engineer, Scientist, Analyst or Research Assistant/Laboratory Assistant. All listed categories shall be directly related to proposed work to be performed under contract with NASA. Any contributions from non-technical personnel proposed under direct labor shall be explicitly explained. Labor rates that do not compare favorably to comparable state average rates at <http://www.bls.gov> require additional documentation, supporting the proposed rate or salary.

Note: Costs associated with firm executives, accountants or administrative support are typically included in a firm's general and administrative costs. If these costs are being proposed as direct labor then provide the details of how the proposed hours were allocated to this effort and verify that these costs are not also covered in your overhead or G&A rate.

Overhead Cost: Specify current rate and base. Use current rate(s) negotiated with your firm's cognizant Federal-auditing agency, if available. A rate that has not been audited requires a detailed explanation of the cost base used to develop the rate and if possible, historical actual overhead rates for the past three years.

Specify the cost elements of the firm's overhead costs in the text boxes provided. Possible overhead cost elements include insurance, sick leave, and vacation.

Note: If no labor overhead rate is proposed and the proposed direct labor includes all fringe benefits, you may enter "0" for the overhead cost line.

Other Direct Costs (ODCs): Refer to FAR 31.205 – Selected Costs for determination of cost allowability.

Materials and Supplies: Under the Materials and Supplies sections, indicate type, vendor, quantity required, and cost. Identify whether each item is consumable, which year it will be purchased, if it was competitively sourced, and if it will be used exclusively for this contract. Your proposed cost shall be justified and supporting documents should be uploaded. General materials or supplies without adequate explanation of the components, quantity and use of said items are not an acceptable breakdown. In the supporting comments block, provide the basis for the proposed price (vendor quote, competitive quotes, catalog price, estimate, etc.). The Contracting Officer will make the final determination.

Special Tooling, Testing, and Test Equipment: The need for these items, if proposed, will be carefully reviewed. Equipment must be made in the USA to the maximum extent practical. The offeror should provide competitive quotes to support the proposed costs or should justify why only one source is available. Competitive quotes may be signed quotes from vendors or copies of catalogue pages. Normally the costs of any equipment should be quoted on a purchase basis, unless the offeror can demonstrate that lease or rent of the equipment is clearly advantageous to the Government. The Contracting Officer will make the final determination. Upload supporting documentation as necessary. In the supporting comments block provide the basis for the proposed price (vendor quote, competitive quotes, catalog price, estimate etc.). The Contracting Officer will make the final determination.

Travel: All proposed travel must be necessary for the success of the research. Include a detailed accounting of all proposed expenses to include the purpose of proposed trips, number of trips, travelers per trip, as well as meals, hotel, and rental car estimated costs. Sources of estimate should be identified when travel is proposed along with a justification for each trip. Proposed travel costs shall be in accordance with the Federal Travel Regulation <http://www.gsa.gov/federaltravelregulation>.

Subcontracts/Consultants: Subcontracts/Consultants costs are included in the Other Direct Costs total. A separate budget summary must be completed for each subcontract/consultant proposed. Further instructions are provided in the Subcontracts/Consultants section below.

Note: Do not add subcontractors or consultants as a line item under the ODCs section of Form C. It will automatically be added to the ODCs upon completion of the separate Subcontractor/Consultant budget summary form.

Research Institution: Research Institution costs are included in the Other Direct Costs total. A separate budget summary must be completed for the Research Institution. Further instructions are provided in the Research Institution section below.

Note: Do not add the Research Institution as a line item under the ODCs section of Form C. It will automatically be added to the ODCs upon completion of the separate Research Institution budget summary form.

Other: List all other direct costs that are not otherwise included in the categories described above such as rental of facilities, etc.

Note: The purchase of equipment, instrumentation, or facilities under STTR must be justified by the offeror and approved by the Government during contract negotiations. Firms should be prepared to justify all material, supplies, and equipment costs during negotiations. See section 3.2.4, part 8 for further guidance.

Explanation of ODCs: Provide any additional information for the proposed ODCs, including basis for cost estimation, in the text box provided.

Subcontracts/Consultants: List consultants by name and specify, for each, the number of hours and hourly costs. Detailed quotes from subcontractors should be provided in the same format. Note that a subcontract entered into for performance of research or research and development differs from an arrangement with a vendor to provide a service such as machining, analysis with test equipment or use of computer time. The costs of such arrangements with vendors should be covered under Special Tooling, Testing, Test Equipment and Material or under Other Direct Costs. Upon request of the contracting officer, the subcontractor's cost proposals may be sealed or mailed directly for government eyes only.

A letter of commitment shall be uploaded for each proposed subcontractor/consultant from the Subcontractor/Consultant Letter of Commitment section of the subcontractor/consultant budget summary form. If a commitment letter is not available, you must upload alternate documentation that sufficiently substantiates that the subcontractor/consultant is available to perform the proposed work during the proposed timeframe. Note that not providing the information now may delay contract negotiations and award.

Research Institution: Provide detailed budget information for the costs associated with the Research Institution.

General and Administrative (G&A) Costs: Specify a current rate and base to which G&A costs will be applied. If available, use the current rate recommendations from the cognizant Federal-auditing agency. If an audit rate is not available, provide a detailed explanation of the cost base used to develop the rate and if possible, a historical actual G&A rate for the past three years.

Specify the elements of the firm's G&A costs in the text boxes provided. Possible G&A cost elements include rent, utilities, and management.

Profit/Cost Sharing: See sections 5.8 and 5.9. Profit is to be added to total cost, while shared costs are to be subtracted from total cost, as applicable.

Amount Requested: The amount requested is equal to the sum of the Direct Labor, Overhead, ODCs, G&A and any profit, less any cost sharing. The amount requested cannot exceed \$125,000 for Phase I.

Federal Facilities, Laboratories, and Equipment: If you require the use of Government facilities, laboratories, or equipment, identify the Federal facilities, laboratories or equipment in the text box provided, as well as in part 8 of your technical proposal, and upload a signed statement of availability from the Government agency. Please note that this section SHALL be completed if you certified in Form A that you will require the use of Government facilities. Leave this section BLANK if you DO NOT require the use of Federal facilities, laboratories, or equipment.

Audit Information: Complete the Audit Information section of Form C to indicate if your firm's accounting system has been audited and if the rates from that audit agreement are used for this proposal.

Note: There is a separate "Audit Information" section linked from your Activity Worksheet that must also be completed.

Model Research Agreement

By virtue of the signatures of our authorized representatives, _____ (Small Business Concern), and _____ (Research Institution), have agreed to cooperate on the _____ (Proposal Title) Project, in accordance with the proposal being submitted with this agreement.

This agreement shall be binding until the completion of all Phase I activities, at a minimum. If the _____ (Proposal Title) Project is selected to continue into Phase II, the agreement may also be binding in Phase II activities that are funded by NASA, then this agreement shall be binding until those activities are completed. The agreement may also be binding in Phase III activities that are funded by NASA.

After notification of Phase I selection and prior to contract release, we shall prepare and submit, if requested by NASA, an **Allocation of Rights Agreement**, which shall state our rights to the intellectual property and technology to be developed and commercialized by the _____ (Proposal Title) Project. We understand that our contract cannot be approved and project activities may not commence until the **Allocation of Rights Agreement** has been signed and certified to NASA.

Please direct all questions and comments to _____ (Small Business Concern representative) at (Phone Number) _____.

Signature

Name/title

Small Business Concern

Signature

Name/title

Research Institution

Small Business Technology Transfer (STTR) Program Model Allocation of Rights Agreement

This Agreement between _____, a small business concern organized as a _____ under the laws of _____ and having a principal place of business at _____, ("SBC") and _____, a research institution having a principal place of business at _____, ("RI") is entered into for the purpose of allocating between the parties certain rights relating to an STTR project to be carried out by SBC and RI (hereinafter referred to as the "PARTIES") under an STTR funding agreement that may be awarded by _____ NASA _____ to SBC to fund a proposal entitled "_____ submitted, or to be submitted, to by SBC on or about _____, 20____.

1. Applicability of this Agreement.

- (a) This Agreement shall be applicable only to matters relating to the STTR project referred to in the preamble above.
- (b) If a funding agreement for STTR project is awarded to SBC based upon the STTR proposal referred to in the preamble above, SBC will promptly provide a copy of such funding agreement to RI, and SBC will make a sub-award to RI in accordance with the funding agreement, the proposal, and this Agreement. If the terms of such funding agreement appear to be inconsistent with the provisions of this Agreement, the Parties will attempt in good faith to resolve any such inconsistencies.

However, if such resolution is not achieved within a reasonable period, SBC shall not be obligated to award nor RI to accept the sub-award. If a sub-award is made by SBC and accepted by RI, this Agreement shall not be applicable to contradict the terms of such sub-award or of the funding agreement awarded by NASA to SBC except on the grounds of fraud, misrepresentation, or mistake, but shall be considered to resolve ambiguities in the terms of the sub-award.

2. The provisions of this Agreement shall apply to any and all consultants, subcontractors, independent contractors, or other individuals employed by SBC or RI for the purposes of this STTR project.

- (a) Background Intellectual Property.
- (b) "Background Intellectual Property" means property and the legal right therein of either or both parties developed before or independent of this Agreement including inventions, patent applications, patents, copyrights, trademarks, mask works, trade secrets and any information embodying proprietary data such as technical data and computer software.
- (c) This Agreement shall not be construed as implying that either party hereto shall have the right to use Background Intellectual Property of the other in connection with this STTR project except as otherwise provided hereunder.
 - (1) The following Background Intellectual Property of SBC may be used nonexclusively and except as noted, without compensation by RI in connection with research or development activities for this STTR project (if "none" so state):

_____;

- (2) The following Background Intellectual Property of RI may be used nonexclusively and, except as noted, without compensation by SBC in connection with research or development activities for this STTR project (if "none" so state):

- (3) The following Background Intellectual Property of RI may be used by SBC nonexclusively in connection with commercialization of the results of this STTR project, to the extent that such use is reasonably necessary for practical, efficient and competitive commercialization of such results but not for commercialization independent of the commercialization of such results, subject to any rights of the Government therein and upon the condition that SBC pay to RI, in addition to any other royalty including any royalty specified in the following list, a royalty of _____% of net sales or leases made by or under the authority of SBC of any product or service that embodies, or the manufacture or normal use of which entails the use of, all or any part of such Background Intellectual Property (if "none" so state):

3. Project Intellectual Property.

- (a) "Project Intellectual Property" means the legal rights relating to inventions (including Subject Inventions as defined in 37 CFR § 401), patent applications, patents, copyrights, trademarks, mask works, trade secrets and any other legally protectable information, including computer software, first made or generated during the performance of this STTR Agreement.
- (b) Except as otherwise provided herein, ownership of Project Intellectual Property shall vest in the party whose personnel conceived the subject matter, and such party may perfect legal protection in its own name and at its own expense. Jointly made or generated Project Intellectual Property shall be jointly owned by the Parties unless otherwise agreed in writing. The SBC shall have the first option to perfect the rights in jointly made or generated Project Intellectual Property unless otherwise agreed in writing.
- (1) The rights to any revenues and profits, resulting from any product, process, or other innovation or invention based on the cooperative shall be allocated between the SBC and the RI as follows:
- SBC Percent: _____ RI Percent: _____
- (2) Expenses and other liabilities associated with the development and marketing of any product, process, or other innovation or invention shall be allocated as follows: the SBC will be responsible for _____ percent and the RI will be responsible for _____ percent.
- (c) The Parties agree to disclose to each other, in writing, each and every Subject Invention, which may be patentable or otherwise protectable under the United States patent laws in Title 35, United States Code. The Parties acknowledge that they will disclose Subject Inventions to each other and the Agency within two months after their respective inventor(s) first disclose the invention in writing to the person(s) responsible for patent matters of the disclosing Party. All written disclosures of such inventions shall contain sufficient detail of the invention, identification of any statutory bars, and shall be marked confidential, in accordance with 35 U.S.C. § 205.
- (d) Each party hereto may use Project Intellectual Property of the other nonexclusively and without compensation in connection with research or development activities for this STTR project, including inclusion in STTR project reports to the AGENCY and proposals to the AGENCY for continued funding of this STTR project through additional phases.

- (e) In addition to the Government's rights under the Patent Rights clause of 37 CFR § 401.14, the Parties agree that the Government shall have an irrevocable, royalty free, nonexclusive license for any Governmental purpose in any Project Intellectual Property.
- (f) SBC will have an option to commercialize the Project Intellectual Property of RI, subject to any rights of the Government therein, as follows -
 - (1) Where Project Intellectual Property of RI is a potentially patentable invention, SBC will have an exclusive option for a license to such invention, for an initial option period of _____ months after such invention has been reported to SBC. SBC may, at its election and subject to the patent expense reimbursement provisions of this section, extend such option for an additional _____ months by giving written notice of such election to RI prior to the expiration of the initial option period. During the period of such option following notice by SBC of election to extend, RI will pursue and maintain any patent protection for the invention requested in writing by SBC and, except with the written consent of SBC or upon the failure of SBC to reimburse patenting expenses as required under this section, will not voluntarily discontinue the pursuit and maintenance of any United States patent protection for the invention initiated by RI or of any patent protection requested by SBC. For any invention for which SBC gives notice of its election to extend the option, SBC will, within _____ days after invoice, reimburse RI for the expenses incurred by RI prior to expiration or termination of the option period in pursuing and maintaining (i) any United States patent protection initiated by RI and (ii) any patent protection requested by SBC. SBC may terminate such option at will by giving written notice to RI, in which case further accrual of reimbursable patenting expenses hereunder, other than prior commitments not practically revocable, will cease upon RI's receipt of such notice. At any time prior to the expiration or termination of an option, SBC may exercise such option by giving written notice to RI, whereupon the parties will promptly and in good faith enter into negotiations for a license under RI's patent rights in the invention for SBC to make, use and/or sell products and/or services that embody, or the development, manufacture and/or use of which involves employment of, the invention. The terms of such license will include: (i) payment of reasonable royalties to RI on sales of products or services which embody, or the development, manufacture or use of which involves employment of, the invention; (ii) reimbursement by SBC of expenses incurred by RI in seeking and maintaining patent protection for the invention in countries covered by the license (which reimbursement, as well as any such patent expenses incurred directly by SBC with RI's authorization, insofar as deriving from RI's interest in such invention, may be offset in full against up to _____ of accrued royalties in excess of any minimum royalties due RI); and, in the case of an exclusive license, (3) reasonable commercialization milestones and/or minimum royalties.
 - (2) Where Project Intellectual Property of RI is other than a potentially patentable invention, SBC will have an exclusive option for a license, for an option period extending until _____ months following completion of RI's performance of that phase of this STTR project in which such Project Intellectual Property of RI was developed by RI. SBC may exercise such option by giving written notice to RI, whereupon the parties will promptly and in good faith enter into negotiations for a license under RI's interest in the subject matter for SBC to make, use and/or sell products or services which embody, or the development, manufacture and/or use of which involve employment of, such Project Intellectual Property of RI. The terms of such license will include: (i) payment of reasonable royalties to RI on sales of products or services that embody, or the development, manufacture or use of which involves employment of, the Project Intellectual Property of RI and, in the case of an exclusive license, (ii) reasonable commercialization milestones and/or minimum royalties.

- (3) Where more than one royalty might otherwise be due in respect of any unit of product or service under a license pursuant to this Agreement, the parties shall in good faith negotiate to ameliorate any effect thereof that would threaten the commercial viability of the affected products or services by providing in such license(s) for a reasonable discount or cap on total royalties due in respect of any such unit.

4. Follow on Research or Development.

All follow on work, including any licenses, contracts, subcontracts, sublicenses or arrangements of any type, shall contain appropriate provisions to implement the Project Intellectual Property rights provisions of this agreement and insure that the Parties and the Government obtain and retain such rights granted herein in all future resulting research, development, or commercialization work.

5. Confidentiality/Publication.

- (a) Background Intellectual Property and Project Intellectual Property of a party, as well as other proprietary or confidential information of a party, disclosed by that party to the other in connection with this STTR project shall be received and held in confidence by the receiving party and, except with the consent of the disclosing party or as permitted under this Agreement, neither used by the receiving party nor disclosed by the receiving party to others, provided that the receiving party has notice that such information is regarded by the disclosing party as proprietary or confidential. However, these confidentiality obligations shall not apply to use or disclosure by the receiving party after such information is or becomes known to the public without breach of this provision or is or becomes known to the receiving party from a source reasonably believed to be independent of the disclosing party or is developed by or for the receiving party independently of its disclosure by the disclosing party.
- (b) Subject to the terms of paragraph (a) above, either party may publish its results from this STTR project. However, the publishing party will give a right of refusal to the other party with respect to a proposed publication, as well as a _____ day period in which to review proposed publications and submit comments, which will be given full consideration before publication. Furthermore, upon request of the reviewing party, publication will be deferred for up to _____ additional days for preparation and filing of a patent application which the reviewing party has the right to file or to have filed at its request by the publishing party.

6. Liability.

- (a) Each party disclaims all warranties running to the other or through the other to third parties, whether express or implied, including without limitation warranties of merchantability, fitness for a particular purpose, and freedom from infringement, as to any information, result, design, prototype, product or process deriving directly or indirectly and in whole or part from such party in connection with this STTR project.
- (b) SBC will indemnify and hold harmless RI with regard to any claims arising in connection with commercialization of the results of this STTR project by or under the authority of SBC. The PARTIES will indemnify and hold harmless the Government with regard to any claims arising in connection with commercialization of the results of this STTR project.

7. Termination.

- (a) This agreement may be terminated by either Party upon __ days written notice to the other Party. This agreement may also be terminated by either Party in the event of the failure of the other Party to comply with the terms of this agreement.
- (b) In the event of termination by either Party, each Party shall be responsible for its share of the costs incurred through the effective date of termination, as well as its share of the costs incurred after the effective date of termination, and which are related to the termination. The confidentiality, use, and/or nondisclosure obligations of this agreement shall survive any termination of this agreement.

AGREED TO AND ACCEPTED

Small Business Concern

By: _____ Date: _____
Print Name: _____
Title: _____

Research Institution

By: _____ Date: _____
Print Name: _____
Title: _____

STTR Check List

For assistance in completing your Phase I proposal, use the following checklist to ensure your submission is complete.

- 1. The entire proposal including any supplemental material shall not exceed a total of 23 8.5 x 11 inch pages, including the Research Agreement, and follow the format requirements (sections 3.2.2, 3.2.5).**
2. The proposal and innovation is submitted for one subtopic only (Section 3.1).
3. The entire proposal is submitted consistent with the requirements and in the order outlined in section 3.2.
4. The technical proposal contains all eleven parts in order (section 3.2.4).
5. The 1-page briefing chart does not include any proprietary data (section 3.2.6).
6. Certifications in Form A are completed, and agree with the content of the technical proposal.
7. Proposed funding does not exceed \$125,000 (sections 1.4).
8. Proposed project duration does not exceed 12 months (sections 1.4).
9. Research Agreement has been electronically endorsed by both the SBC Official and the RI (sections 3.2.5, 6.2).
10. Entire proposal including Forms A, B, C, and Research Agreement submitted via the Internet.
11. Form A electronically endorsed by the SBC Official and the PI.
- 12. Proposals must be received no later than 5:00 p.m. EDT on Thursday, November 29, 2012 (section 6.3).**
13. Signed Allocation of Rights Agreement available for Contracting Officer at time of selection.

National Aeronautics and Space Administration

SMALL BUSINESS INNOVATION RESEARCH (SBIR) & SMALL BUSINESS TECHNOLOGY TRANSFER (STTR)

Part 2: General Phase II Proposal Instructions and Evaluation Criteria

*The electronic version of this document
is at: <http://sbir.nasa.gov>*

2012 NASA SBIR/STTR Program Solicitations

1. Phase II Program Description

1.1 Introduction

This document provides a general description of the NASA SBIR/STTR Phase II Program and proposal submission requirements. All small business concerns (SBCs) that are awarded and have successfully completed their Phase I contracts are invited to submit Phase II proposals. Receipt of Phase II proposals are due on the last day of performance under SBIR/STTR Phase I contracts, the submission period will be available approximately 6 weeks prior to the contract completion date.

Proposals must be submitted online via the Proposal Submissions Electronic Handbook at <http://sbir.nasa.gov> and include all relevant documentation.

1.2 Phase II Description

Phase II

The purpose of Phase II is the development, demonstration and delivery of the innovation. Only SBCs awarded a Phase I contract are eligible to submit a proposal for a Phase II funding agreement. Phase II projects are chosen as a result of competitive evaluations and based on selection criteria provided in the Phase II Proposal Instructions and Evaluation Criteria.

Maximum value and period of performance for Phase II contracts:

Phase II Contracts	SBIR	STTR
Maximum Contract Value	\$750,000	\$750,000
Period of Performance	24 months	24 months

1.3 Phase II Contract Options

Phase II Enhancement (Phase II-E)

The purpose of the Phase II-E Option is to further encourage the advancement of innovations developed under Phase II contracts via an extension of R/R&D efforts to the current Phase II contract. Eligible firms must secure a third-party investor to partner and invest in enhancing their technology for further research, infusion, and commercialization. Under this option, the NASA SBIR/STTR Program will match, on a dollar-to-dollar basis, up to \$125,000 of non-NASA-SBIR/non-NASA-STTR investments to extend a project from 6-to-12 months. There is a minimum funding requirement for Phase II-E, as eligible firms must secure at least \$25,000 in third party investments. These non-NASA-SBIR/non-NASA-STTR third party investments can come from a NASA project, NASA contractor, or any commercial investor. The total cumulative award for the Phase II contract plus the Phase II-E match is not expected to exceed \$875,000 of SBIR/STTR funding. The non-SBIR/non-STTR contribution is not limited since it is regulated under the guidelines for Phase III awards.

The Phase II-E application may be submitted anytime during the 4th month before the end of the contract period of performance (for example, a 24 month period of performance, the application would be due any time during the 20th month of the period of performance; a 18 month period of performance, the application would be due any time during the 14th month of the period of performance). Also, any additional information regarding the submission of a Phase II-E proposal will be included in the Phase II contracts. Firms interested in executing a Phase II-E option are requested to notify the NASA SBIR/STTR Program of its intent to propose in writing to ARC-SBIR-PMO@mail.nasa.gov, by the end of the 13th month of performance of the Phase II contract. This written notification will be non-binding.

Maximum value and period of performance for the Phase II-E contract option:

Phase II Enhancement	Minimum non-SBIR/STTR Funding Required for Eligibility for Matching in Phase II-E	Corresponding SBIR/STTR Program Contribution	Anticipated Period of Additional Performance
	\$25,000	\$25,000	6-12 Months
	Maximum non-SBIR/STTR Funding to be Matched by SBIR/STTR Program in Phase II-E	Corresponding SBIR/STTR Program Contribution	Anticipated Period of Additional Performance
	\$125,000	\$125,000	6-12 Months

Phase II contracts with a period of performance less than 18 months, will NOT be eligible for a Phase II-E. In addition, to be eligible for this option, the contractor's performance must be on time in accordance with the contract work plan. The number of Phase II- E options to be exercised is subject to the availability of funds and will be selected based on criteria provided in the Phase II contract.

Phase II eXpanded (Phase II-X)

The purpose of the Phase II-X Option is to establish a strong and direct partnership between the NASA SBIR/STTR Program and other NASA projects undertaking the development of new technologies of innovations for future use. Under a Phase II-X option, innovations developed in Phase II are to be advanced via an extension of R/R&D efforts to the current Phase II contract. There are two specific requirements to be met for firms to be eligible for a Phase II-X option. First, eligible firms must secure a NASA program or project (other than the NASA SBIR/STTR Program) as a partner to invest in enhancing their technology for further research or infusion. Second, there is a minimum funding requirement for Phase II-X, as eligible firms must secure at least \$75,000 in NASA program or project funding. Under this option, the NASA SBIR/STTR Program will match, on a 2-for-1 basis, up to \$250,000 of NASA program or project funding, thus enabling a maximum of \$500,000 of SBIR/STTR award funds to be added from the NASA SBIR/STTR Program. Note: A firm may acquire additional, non-NASA, third-party investments as part of a Phase II-X option, but those funds will not be counted in the NASA SBIR/STTR Program's matching calculation. Executing a Phase II-X option is anticipated to extend a Phase II from 12-to-24 months after the completion of Phase II. The total cumulative award for the Phase II contract plus the Phase II-X match is not expected to exceed \$1,250,000 of SBIR/STTR funding. The NASA contribution is not limited since it is regulated under the guidelines for Phase III awards.

The Phase II-X application may be submitted anytime during the 4th month before the end of the contract period of performance (for example, a 24 month period of performance, the application would be due any time during the 20th month of the period of performance; a 18 month period of performance, the application would be due any time during the 14th month of the period of performance). Also, any additional information regarding the submission of a Phase II-X proposal will be included in the Phase II contracts. Firms interested in executing a Phase II-X option are requested to notify the NASA SBIR/STTR Program of its intent to propose in writing to ARC-SBIR-PMO@mail.nasa.gov, by the end of the 13th month of performance of the Phase II contract. This written notification will be non-binding.

Maximum value and period of performance for Phase II- X contract options:

Phase II eXpanded	Minimum Funding Required from non-SBIR/STTR NASA Source for Eligibility for Matching in Phase II-X	Corresponding SBIR/STTR Program Contribution	Anticipated Period of Additional Performance
	\$75,000	\$150,000	12-24 Months
	Maximum Funding Amount from non-SBIR/STTR NASA Source to be Matched in Phase II-X	Corresponding SBIR/STTR Program Contribution	Anticipated Period of Additional Performance
	\$250,000	\$500,000	12-24 Months

Phase II contracts with a period of performance less than 18 months, will NOT be eligible for a Phase II-X. The number of Phase II-X options to be exercised is subject to the availability of funds and will be selected based on criteria provided in the Phase II contract.

Proposing to the Phase II-E or Phase II-X Option

Note: The SBIR/STTR Program will allow firms with a Phase II contract that follows a Phase I contract from this solicitation to submit a proposal for either a Phase II-E contract option or a Phase II-X contract option. Firms are not permitted to submit a proposal for both options. The number of Phase II- E and Phase II-X options to be exercised may be limited by availability of funds and will be selected based on the evaluation criteria.

1.4 Eligibility Requirements

1.4.1 Small Business Concern

Only firms qualifying as SBCs are eligible to participate in these programs. Socially and economically disadvantaged and women-owned SBCs are particularly encouraged to propose.

1.4.2 Place of Performance

R/R&D must be performed in the United States. However, based on a rare and unique circumstance (for example, if a supply or material or other item or project requirement is not available in the United States), NASA may allow a particular portion of the research or R&D work to be performed or obtained in a country outside of the United States. Proposals must clearly indicate if any work will be performed outside the United States. Prior to award, approval by the Contracting Officer for such specific condition(s) must be in writing.

Note: Offerors are responsible for ensuring that all employees who will work on this contract are eligible under export control and International Traffic in Arms (ITAR) regulations. Any employee who is not a U.S. citizen or a permanent resident may be restricted from working on this contract if the technology is restricted under export control and ITAR regulations unless the prior approval of the Department of State or the Department of Commerce is obtained via a technical assistance agreement or an export license. Violations of these regulations can result in criminal or civil penalties.

1.4.3 Principal Investigator (PI) Employment Requirement

The primary employment of the Principal Investigator (PI) shall be with the SBC under the SBIR Program, while under the STTR Program, either the SBC or RI shall employ the PI. Primary employment means that more than 50% of the PI's total employed time (including all concurrent employers, consulting, and self-employed time) is spent with the SBC or RI at time of award and during the entire period of performance. Primary employment with a small business concern precludes full-time employment at another organization. If the PI does not currently meet these primary employment requirements, then the offeror must explain how these requirements will be met if the proposal is selected for contract negotiations that may lead to an award. Co-Principle Investigators are not allowed.

Note: NASA considers a fulltime workweek to be nominally 40 hours and we consider 19.9-hour or more workweek elsewhere to be in conflict with this rule. In rare occasions, minor deviations from this requirement may be necessary; however, any minor deviation must be approved in writing by the contracting officer after consultation with the NASA SBIR/STTR Program Manager/Business Manager.

Requirements	SBIR	STTR
Primary Employment	PI must be with the SBC	PI must be employed with the RI or SBC
Employment Certification	The offeror must certify in the proposal that the primary employment of the PI will be with the SBC at the time of award and during the conduct of the project	The offeror must certify in the proposal that the primary employment of the PI will be with the SBC or the RI at the time of award and during the conduct of the project
Co-PIs	Not Allowed	Not Allowed
Misrepresentation of Qualifications	Shall result in rejection of the proposal or termination of the contract	Shall result in rejection of the proposal or termination of the contract
Substitution of PIs	Shall receive advanced written approval from NASA	Shall receive advanced written approval from NASA

1.5 NASA SBIR/STTR Technology Available (TAV)

All subtopics have the option of using Technology Available (TAV) with NASA IP (defined below), which may also include NASA non-patented software technology requiring a Software Usage Agreement (SUA) or similar permission for use by others. All subtopics address the objective of increasing the commercial application of innovations derived from Federal R&D. While NASA scientists and engineers conduct breakthrough research that leads to innovations, the range of NASA's effort does not extend to commercial product development in any of its intramural research areas. Additional work is often necessary to exploit these NASA technologies for either infusion or commercial viability and likely requires innovation on behalf of the private sector. NASA provides these technologies "as is" and makes no representation or guarantee that additional effort will result in infusion or commercial viability.

The NASA technologies identified in a subtopic or via the IP search tool (<http://technology.nasa.gov>): (1) are protected by NASA-owned patents (NASA Patents), (2) are non-patented NASA-owned or controlled software (NASA software), or (3) are otherwise available for use by the public. In the event offeror requests to use NASA owned or controlled technologies, which are not NASA patents or NASA software, NASA shall consider such request and permit such uses as NASA, in its sole discretion, deems appropriate and permissible. If a proposer elects to use a NASA patent, a non-exclusive, royalty-free research license will be required to use the NASA IP during the SBIR/STTR performance period.

Similarly, if a proposer wishes to use NASA software, the parties will be required to enter into a Software Usage Agreement on a non-exclusive, royalty-free basis in order to use such NASA software for government purposes and "Government-Furnished Computer Software and Related Technical Data" will apply to the contract. As used herein, "NASA IP" refers collectively to NASA patents and NASA software disclaimer. All subtopics include an opportunity to license or otherwise use NASA IP on a non-exclusive, royalty-free basis, for research use under the contract. Use of the NASA IP is strictly voluntary. Whether or not a firm uses NASA IP within their proposed effort will not in any way be a factor in the selection for award. NASA software release is governed by NPR 2210.1C.

Use of NASA Patent

All offerors submitting proposals citing a NASA patent must submit a non-exclusive, royalty-free license application if the use of a NASA patent is desired. The NASA license application is available on the NASA SBIR/STTR website: http://sbir.gsfc.nasa.gov/SBIR/research_license_app.doc. NASA only will grant research licenses to those SBIR/STTR offerors who submitted a license application and whose proposal resulted in an SBIR/STTR award under this solicitation. Such grant of non-exclusive research license will be set forth in the successful offeror's SBIR/STTR contract. License applications will be treated in accordance with Federal patent licensing regulations as provided in 37 CFR Part 404.

SBIR/STTR offerors are notified that no exclusive or non-exclusive commercialization license to make, use or sell products or services incorporating the NASA patent will be granted unless an SBIR/STTR offeror applies for and receives such a license in accordance with the Federal patent licensing regulations at 37 CFR Part 404. Awardees with contracts that identify a specific NASA patent will be given the opportunity to negotiate a non-exclusive commercialization license or, if available, an exclusive commercialization license to the NASA patent.

An SBIR/STTR awardee that has been granted a non-exclusive, royalty-free research license to use a NASA patent under the SBIR/STTR award may, if available and on a non-interference basis, also have access to NASA personnel knowledgeable about the NASA patent. The NASA Intellectual Property Manager (IPM) located at the appropriate NASA Center will be available to assist awardees requesting information about a patent that was identified in the SBIR/STTR contract and, if available and on a non-interference basis, provide access to the inventor or surrogate for the purpose of knowledge transfer.

Note: Access to the inventor for the purpose of knowledge transfer, will require the requestor to enter into a Non-Disclosure Agreement (NDA), the awardee “may” be required to reimburse NASA for knowledge transfer activities.

Use of NASA Software

Software identified and requested under a SBIR/STTR contract shall be treated as Government Purpose Rights. Government purpose releases includes releases to other NASA Centers, Federal government agencies, and recipients who have a government contract. The software may be used for "government purposes" only. The recipients of such software releases are typically U.S. citizens. Non U.S. citizens will not be allowed access to NASA software under the SBIR/STTR contract.

A Software Usage Agreement (SUA) shall be requested after contract award from the appropriate NASA Center Software Release Authority (SRA). The SUA request shall include the NASA software title, version number, requesting firm contract info including recipient name, and SBIR/STTR contract award info. The SUA will expire when the contract ends.

2. Proposal Preparation Instructions and Requirements

2.1 Fundamental Considerations

The object of Phase II is to continue the R/R&D effort from the completed Phase I.

Contract Deliverables

Phase II contracts shall require the delivery of reports that present (1) the work and results accomplished, (2) the scientific, technical and commercial merit and feasibility of the proposed innovation and Phase II results, (3) its relevance and significance to one or more NASA needs, and (4) the progress towards transitioning the proposed innovation and Phase II results into follow-on investment, development, testing and utilization for NASA mission programs and other potential customers. The delivery of a prototype unit, software package, or a complete product or service, for NASA testing and utilization is desirable and, if proposed, must be described and listed as a deliverable in the proposal.

2.2 Phase II Proposal Requirements

2.2.1 General Requirements

The Phase I contract will serve as a request for proposal (RFP) for the Phase II follow-on project. Phase II proposals are more comprehensive than those required for Phase I. Submission of a Phase II proposal is in accordance with Phase I contract requirements and is voluntary. NASA assumes no responsibility for any proposal preparation expenses.

A competitive Phase II proposal will clearly and concisely (1) describe the proposed innovation relative to the state of the art and the market, (2) address Phase I results relative to the scientific, technical merit and feasibility of the proposed innovation and its relevance and significance to the NASA needs, and (3) provide the planning for a focused project that builds upon Phase I results and encompasses technical, market, financial and business factors relating to the development and demonstration of the proposed innovation, and its transition into products and services for NASA mission programs and other potential customers.

2.2.2 Format Requirements

Proposals that do not follow the formatting requirement are subject to rejection during administrative screening.

Page Limitations and Margins

Any page(s) going over the required page limited will be deleted and omitted from the proposal review. A Phase II proposal shall not exceed a total of 50 standard 8 1/2 x 11 inch (21.6 x 27.9 cm) pages. Forms A, B, and C count as one page each regardless of whether the completed forms print as more than one page. Each page shall be numbered consecutively at the bottom. Margins shall be 1.0 inch (2.5 cm). All required items of information must be covered in the proposal and will be included in the page total. The space allocated to each part of the technical content will depend on the project and the offeror's approach.

Each proposal submitted must contain the following items in the order presented:

- (1) Cover Sheet (Form A), electronically endorsed, counts as 1 page towards the 50-page limit.
- (2) Proposal Summary (Form B), counts as 1 page towards the 50-page limit (and must not contain proprietary data).
- (3) Budget Summary (Form C), counts as 1 page towards the 50-page limit.
- (4) Technical Content (11 Parts in order as specified in section 2.2.4, **not to exceed 47 pages for SBIR and 46 pages for STTR**), including all graphics, and starting with a table of contents.
- (5) R/R&D Agreement between the SBC and RI (**STTR only**), counts as 1 page towards the 50-page limit.
- (6) Capital Commitments Addendum Supporting Phase II and Phase III.
- (7) Briefing Chart (Not included in the 50-page limit and must not contain proprietary data).
- (8) NASA Research License Application is not included in the 50-page limit (only if TAV is being proposed).

Note: Letters of general endorsement are not required or desired and will not be considered during the review process. However, if submitted, such letter(s) will count against the page limit.

In addition to the above items, each offeror must submit the following firm level forms, which must be filled out once during each submission period and are applicable to all firm proposals submissions:

- (9) Firm Level Certifications, are not included in the 50-page limit.
- (10) Audit Information, is not included in the 50-page limit.
- (11) Prior Awards Addendum, is not included in the 50-page limit.
- (12) Commercial Metrics Survey, is not included in the 50-page limit.

Type Size

No type size smaller than 10 point shall be used for text or tables, except as legends on reduced drawings. Proposals prepared with smaller font sizes will be rejected without consideration.

Header/Footer Requirements

Header must include firm name, proposal number, and project title. Footer must include the page number and proprietary markings if applicable. Margins can be used for header/footer information.

Classified Information

NASA does not accept proposals that contain classified information.

2.2.3 Forms

All form submissions shall be done electronically, with each form counting as 1 page towards the 50-page limit and accounting for pages 1-3 of the proposal regardless of the length.

2.2.3.1 Cover Sheet (Form A)

A sample Cover Sheet (Form A) is provided in section 6. The offeror shall provide complete information for each item and submit the form, as required in section 5. The proposal project title shall be concise and descriptive of the proposed effort. The title should not use acronyms or words like "Development of" or "Study of." The NASA research topic title must not be used as the proposal title. Form A counts as one page towards the 50-page limit.

2.2.3.2 Proposal Summary (Form B)

A sample Proposal Summary (Form B) is provided in section 6. The offeror shall provide complete information for each item and submit Form B as required in section 5. Form B counts as one page towards the 50-page limit.

Note: Proposal Summary (Form B), including the Technical Abstract, is public information and may be disclosed. Do not include proprietary information on Form B.

2.2.3.3. Budget Summary (Form C)

A sample of the Budget Summary (Form C) is provided in section 6. The offeror shall complete the Budget Summary following the instructions provided with the sample form. The total requested funding for the Phase II effort shall not exceed \$750,000. A text box is provided on the electronic budget form for additional explanation. Information shall be submitted to explain the offeror's plans for use of the requested funds to enable NASA to determine whether the proposed price is fair and reasonable. Form C counts as one page towards the 50-page limit.

Note: The Government is not responsible for any monies expended by the firm before award of any contract.

2.2.4 Technical Proposal

This part of the submission should not contain any budget data and must consist of all eleven (11) parts listed below in the given order. All eleven parts of the technical proposal must be numbered and titled. Parts that are not applicable must be included and marked "Not Applicable." A proposal omitting any part will be considered non-responsive to this Solicitation and will be rejected during administrative screening. The required table of contents is provided below:

Phase II Table of Contents

Part 1: Table of Contents.....	Page 4
Part 2: Identification and Significance of the Innovation and Results of the Phase I Proposal	
Part 3: Technical Objectives	
Part 4: Work Plan	
Part 5: Related R/R&D	
Part 6: Key Personnel	
Part 7: Phase III Efforts, Commercialization and Business Planning	
Part 8: Facilities/Equipment	
Part 9: Subcontracts and Consultants	
Part 10: Potential Post Applications	
Part 11: Essentially Equivalent and Duplicate Proposals and Awards	

Part 1: Table of Contents

The technical proposal shall begin with a brief table of contents indicating the page numbers of each of the parts of the proposal and should start on page 4 because Forms A, B, and C account for pages 1-3.

Part 2: Identification and Significance of the Innovation and Results of the Phase I Proposal

Drawing upon Phase I results, succinctly describe:

- (1) The proposed innovation;
- (2) the relevance and significance of the proposed innovation to a need or needs, within the subtopic;
- (3) the proposed innovation relative to the state of the market, the state of the art, and its feasibility; and
- (4) the capability of the offeror to conduct the proposed R/R&D and to fulfill the commercialization of the proposed innovation.

Part 3: Technical Objectives

Define the specific objectives of the Phase II research and technical approach.

TAV Note: All offerors submitting proposals who are planning to use NASA IP must describe their planned developments with the IP. The NASA Research License Application should be added as an attachment at the end of the proposal and will not count towards the 50-page limit (See paragraph 1.5).

Part 4: Work Plan

Include a detailed description of the Phase II R/R&D plan to meet the technical objectives. The plan should indicate what will be done, where it will be done, and how the R/R&D will be carried out. Discuss in detail the methods planned to achieve each task or objective. Task descriptions, schedules, resource allocations, estimated task hours for each key personnel and planned accomplishments including project milestones shall be included.

STTR: In addition, the work plan will specifically address the percentage and type of work to be performed by the SBC and the RI. The plan will provide evidence that the SBC will exercise management direction and control of the performance of the STTR effort, including situations in which the PI may be an employee of the RI.

Part 5: Related R/R&D

Describe significant current and/or previous R/R&D that is directly related to the proposal including any conducted by the PI or by the offeror. Describe how it relates to the proposed effort and any planned coordination with outside sources. The offeror must persuade reviewers of his or her awareness of key recent R/R&D conducted by others in the specific subject area. As an option, the offer may use this section to include bibliographic references.

Part 6: Key Personnel and Bibliography of Directly Related Work

Identify all key personnel involved in Phase II activities whose expertise and functions are essential to the success of the project. Provide bibliographic information including directly related education and experience.

The PI is considered key to the success of the effort and must make a substantial commitment to the project. The following requirements are applicable:

Functions: The functions of the PI are: planning and directing the project; leading it technically and making substantial personal contributions during its implementation; serving as the primary contact with NASA on the project; and ensuring that the work proceeds according to contract agreements. Competent management of PI functions is essential to project success. The Phase II proposal shall describe the nature of the PI's activities and the amount of time that the PI will personally apply to the project. The amount of time the PI proposes to spend on the project must be acceptable to the Contracting Officer.

Qualifications: The qualifications and capabilities of the proposed PI and the basis for PI selection are to be clearly presented in the proposal. NASA has the sole right to accept or reject a PI based on factors such as education, experience, demonstrated ability and competence, and any other evidence related to the specific assignment.

Eligibility: This part shall also establish and confirm the eligibility of the PI, and indicate the extent to which other proposals recently submitted or planned for submission in the year and existing projects commit the time of the PI concurrently with this proposed activity. Any attempt to circumvent the restriction on PIs working more than half time for an academic or a nonprofit organization by substituting an ineligible PI will result in rejection of the proposal. However, for an STTR the PI can be primarily employed by either the SBC or the RI. Please see section 1.4.3 for further explanation.

Note: If the Phase II PI is different than that proposed under the Phase I, please provide rational for the change.

Part 7: Phase III Efforts, Commercialization and Business Planning

Present a plan for commercialization (Phase III) of the proposed innovation. Commercialization encompasses the transition of technology into products and services for NASA mission programs, other Government agencies and non-Government markets. The commercialization plan, at a minimum, shall address the following areas:

- (1) **Market Feasibility and Competition:** Describe (a) the target market(s) of the innovation and the associated product or service; (b) the competitive advantage(s) of the product or service; (c) key potential customers, including NASA mission programs and prime contractors; (d) projected market size (NASA, other Government and/or non-Government); (e) the projected time to market and estimated market share within five years from market-entry; and (f) anticipated competition from alternative technologies, products and services and/or competing domestic or foreign entities.

- (2) **Commercialization Strategy and Relevance to the Offeror:** Present the commercialization strategy for the innovation and associated product or service and its relationship to the SBC's business plans for the next five years. Infusion into NASA missions and projects is an option for commercialization strategy.
- (3) **Key Management, Technical Personnel and Organizational Structure:** Describe: (a) the skills and experiences of key management and technical personnel in technology commercialization; (b) current organizational structure; and (c) plans and timelines for obtaining expertise and personnel necessary for commercialization.
- (4) **Production and Operations:** Describe product development to date as well as milestones and plans for reaching production level, including plans for obtaining necessary physical resources.
- (5) **Financial Planning:** Delineate private financial resources committed to the development and transition of the innovation into market-ready product or service. Describe the projected financial requirements and the expected or committed capital and funding sources necessary to support the planned commercialization of the innovation. Provide evidence of current financial condition (e.g., standard financial statements including a current cash flow statement).
- (6) **Intellectual Property:** Describe plans and current status of efforts to secure intellectual property rights (e.g., patents, copyrights, trade secrets) necessary to obtain investment, attain at least a temporal competitive advantage, and achieve planned commercialization.

Part 8: Facilities/Equipment

General: Describe available equipment and physical facilities (this should include physical location [where the work is to be performed], square footage, and major equipment) necessary to carry out the proposed Phase II and projected Phase III efforts. Items of equipment or facilities to be purchased (as detailed in the cost proposal) shall be justified under this section.

Use of Federal facilities or equipment: In accordance with the Federal Acquisition Regulations (FAR) Part 45, it is NASA's policy not to provide facilities (capital equipment, tooling, test and computer facilities, etc.) for the performance of work under SBIR/STTR contracts. Generally an SBC will furnish its own facilities to perform the proposed work on the contract. Government-wide SBIR/STTR policies restrict the use of any SBIR/STTR funds for the use of Federal equipment and facilities (except for those facilities designated as a Federal laboratory). This does not preclude an SBC from utilizing a Federal facility or Federal equipment, but any charges for such use may not be paid for with SBIR/STTR funds. In rare and unique circumstances, SBA may issue a case-by-case waiver to this provision after review of an agency's written justification. Federal facilities designated as Federal laboratories are exempt from this waiver requirement (see 15 U.S.C. § 3710a(d) and the SBA SBIR/STTR Policy Directive). Any NASA facility generally would be considered a Federal laboratory; however, requests for things such as office space would be deemed to be a Federal facility requiring a waiver. Additionally, NASA may not and cannot fund the use of the Federal facility (including Federal laboratories) or personnel for the SBIR/STTR project with NASA program or project money.

When a proposed project or product demonstration requires the use of a unique Federal facility that is not designated as a Federal laboratory to be funded by the SBIR/STTR Program, then the offeror must provide a) a letter from the SBC Official explaining why the SBIR/STTR research project requires the use of the Federal facility or personnel, including data that verifies the absence of non-Federal facilities or personnel capable of supporting the research effort, and b) a statement, signed by the appropriate Government official at the facility, verifying that it will be available for the required effort. Proposals requiring waivers must explain why the waiver is appropriate. NASA will provide this explanation to SBA during the Agency waiver process. NASA cannot guarantee that a waiver from this policy can be obtained from SBA. These letters should be uploaded in Form C of your proposal. **Failure to provide this explanation and the site manager's written availability of use may invalidate any proposal selection.**

When a proposed project or product demonstration requires the use of a Federal laboratory then the offeror must provide a letter justifying the use of a Federal laboratory from the SBC official, as well as, a letter from the Government agency that verifies the availability. These letters should be uploaded in Form C of your proposal. **Failure to provide the site manager's written availability of use of the Federal laboratory and the letter of justification from the SBC may invalidate any proposal selection.**

Additionally, any proposer requiring the use of Federal laboratory, property, or facilities must, within ten (10) business days of notification of selection for negotiations, provide to the NASA Shared Services Center Contracting Officer all required documentation, to include, an agreement by and between the Contractor and the appropriate Federal facility, executed by the Government official authorized to approve such use. The Agreement must delineate the terms of use, associated costs, property and facility responsibilities and liabilities.

Part 9: Subcontracts and Consultants

Subject to the restrictions set forth below, the SBC may establish business arrangements with other entities or individuals to participate in performance of the proposed R/R&D effort. The offeror must describe all subcontracting or other business arrangements, and identify the relevant organizations and/or individuals with whom arrangements are planned. The expertise to be provided by the entities must be described in detail, as well as the functions, services, number of hours and labor rates. Offerors are responsible for ensuring that all organizations and individuals proposed to be utilized are actually available for the time periods required. Subcontract costs should be documented in the subcontractor/consultant budget section in Form C and supporting documentation should be uploaded for each (appropriate documentation is specified in Form C). Subcontractors' and consultants' work has the same place of performance restrictions as stated in section 1.4.2. **The following restrictions apply to the use of subcontracts/consultants:**

SBIR Phase II Subcontracts/Consultants	STTR Phase II Subcontracts/Consultants
The proposed subcontracted business arrangements must not exceed 50 percent of the research and/or analytical work (as determined by the total cost of the proposed subcontracting effort (to include the appropriate OH and G&A) in comparison to the total effort (total contract price including cost sharing, if any, less profit if any).	A minimum of 40 percent of the research or analytical work must be performed by the proposing SBC and minimum of 30 percent must be performed by the RI. Any subcontracted business effort other than that performed by the RI, shall not exceed 30 percent of the research and/or analytical work (as determined by the total cost of the subcontracting effort (to include the appropriate OH and G&A) in comparison to the total effort (total contract price including cost sharing, if any, less profit if any).

Example:

Total price to include profit - \$725,000
Profit - \$21,750
Total price less profit - \$725,000 - \$21,750 = \$703,250
Subcontractor cost - \$250,000
G&A - 5%
G&A on subcontractor cost - \$250,000 x 5% = \$12,500
Subcontractor cost plus G&A - \$250,000 + \$12,500 = \$262,500
Percentage of subcontracting effort – subcontractor cost plus G&A / total price less profit
- \$262,500/\$703,250 = 37.3%

For an SBIR Phase II this is acceptable since it is below the limitation of 50%.

For an STTR Phase II this is unacceptable since it is above 30% limitation.

Part 10: Potential Post Applications (Commercialization)

Building upon section 2.2.4, part 7; further specify the potential NASA and commercial applications of the innovation and the associated potential customers; such as NASA mission programs and projects, within target markets. Potential NASA applications include the projected utilization of proposed contract deliverables (e.g., prototypes, test units, software) and resulting products and services by NASA organizations and contractors.

Part 11a: Essentially Equivalent and Duplicate Proposals and Awards

WARNING – While it is permissible with proposal notification to submit identical proposals or proposals containing a significant amount of essentially equivalent work for consideration under numerous Federal program solicitations, it is unlawful to enter into funding agreements requiring essentially equivalent work. Offerors are at risk for submitting essentially equivalent proposals and therefore, are strongly encouraged to disclose these issues to the soliciting agency to resolve the matter prior to award. See Part 11b.

If an applicant elects to submit identical proposals or proposals containing a significant amount of essentially equivalent work under other Federal program solicitations, a statement must be included in each such proposal indicating:

- (1) The name and address of the agencies to which proposals were submitted or from which awards were received.
- (2) Date of proposal submission or date of award.
- (3) Title, number, and date of solicitations under which proposals were submitted or awards received.
- (4) The specific applicable research topics for each proposal submitted for award received.
- (5) Titles of research projects.
- (6) Name and title of principal investigator or project manager for each proposal submitted or award received.

A summary of essentially equivalent work information is also required on Form A.

Part 11b: Related Research and Development Proposals and Awards

All federal agencies have a mandate to reduce waste, fraud, and abuse in federally funded programs. The submission of essentially equivalent work and the acceptance of multiple awards for essentially equivalent work in the SBIR/STTR Program have been identified as an area of abuse and possibly fraud. SBIR/STTR funding agencies and the Office of the Inspector General are actively evaluating proposals and awards to eliminate this problem. Related research and development includes proposals and awards that do not meet the definition of “Essentially Equivalent Work”, but are related to the technology innovation in the proposal being submitted. Related research and development could be interpreted as essentially equivalent work by outside reviewers without additional information. Therefore, if you are submitting closely related proposals or your firm has closely related research and development that is currently or previously funded by NASA or other Federal agencies, it is to your advantage to describe the relationships between this proposal and related efforts clearly delineating why this should not be considered an essentially equivalent work effort. These explanations should not be longer than one page, will not be included in the page count, and will not be part of the technical evaluation of the proposal.

2.2.5 Research Agreement (Applicable for STTR proposals only)

The Research Agreement (different from the Allocation of Rights Agreement) is a single-page document electronically submitted and endorsed by the SBC and Research Institution (RI). A model agreement is provided, or firms can create their own custom agreement. The Research Agreement should be submitted as required in section 5. This agreement counts as one page toward the 50-page limit.

2.2.6 Capital Commitments Addendum Supporting Phase II and Phase III

Describe and document capital commitments from non-SBIR/STTR sources or from internal SBC funds for pursuit of Phase II and Phase III efforts. Offerors for Phase II contracts are strongly urged to obtain non-SBIR/STTR funding support commitments for follow-on Phase III activities and additional support of the Phase II from parties other than the proposing firm. Funding support commitments must show that a specific and substantial amount will be made available to the firm to pursue the stated Phase II and/or Phase III objectives. They must indicate the source, date, and conditions or contingencies under which the funds will be made available. Alternatively, self-commitments of the same type and magnitude that are required from outside sources can be considered. If a Phase III will be funded internally, offerors should describe their financial position.

Evidence of funding support commitments from outside parties must be provided in writing and should accompany the Phase II proposal. Letters of commitment should specify available funding commitments, other resources to be provided, and any contingent conditions. Expressions of technical interest by such parties in the Phase II research or of potential future financial support are insufficient and will not be accepted as support commitments by NASA. Letters of commitment should be added as an addendum to the Phase II proposal. This addendum will not be counted against the 50-page limitation.

2.2.7 Briefing Chart

A one-page briefing chart is required to assist in the ranking and advocacy of proposals prior to selection. Submission of the briefing chart is not counted against the 50-page limit, and must not contain any proprietary data or ITAR restricted data. An example chart is provided in Appendix A. An electronic form will be provided during the submissions process.

2.2.8 Firm Level Certifications

Firm level certifications that are applicable across all proposal submissions submitted to this solicitation must be completed via the “Certifications” section of the Proposal Submission Electronic Handbook. The offeror must answer Yes or No as applicable. An example of the certification can be found in section 6.

Note: The designated firm admin, typically the first person to register your firm, is the only individual authorized to update the certifications.

2.2.9 Audit Information

The SBC shall complete the questions regarding the firm’s rates and upload the Federal agency audit report or related information that is available from the last audit. If your firm has never been audited by a federal agency, then answer “No” to the first question and you do not need to complete the remainder of the form. The “Audit Information” will be used to assist the contracting officer with negotiations if the proposal is selected for award. If the audit provided is not acceptable, they will be advised by the Contracting Officer on what is required to determine reasonable cost and/or rates. There is a separate “Audit Information” section in Forms C that must also be completed. The audit information is not included in the 50-page limit. An electronic form will be provided during the submissions process.

Note: The designated firm admin, typically the first person to register your firm, is the only individual authorized to update the audit information.

2.2.10 Prior Awards Addendum

If the SBC has received more than 15 Phase II awards in the prior 5 fiscal years, submit name of awarding agency, date of award, funding agreement number, amount, topic or subtopic title, follow-on agreement amount, source, and date of commitment and current commercialization status for each Phase II. If your firm has received any SBIR or STTR Phase II awards, even if it has received fewer than 15 in the last 5 years, it is still recommended that you complete this form for those Phase II awards your firm did receive. This information will be useful when completing the Commercialization Metrics Survey, and in tracking the overall success of the SBIR and STTR programs. Any NASA Phase II awards your firm has received will be automatically populated in the electronic form, as are any Phase II awards previously entered by the SBC during prior submissions (you may update the information for these awards). The addendum is not included in the 50-page limit. An electronic form will be provided during the submissions process.

Note: The designated firm admin, typically the first person to register your firm, is the only individual authorized to update the addendum information.

2.2.11 Commercial Metrics Survey

NASA has instituted a comprehensive commercialization survey/data gathering process for firms with prior NASA SBIR/STTR awards. If the SBC has received any Phase III awards resulting from work on any NASA SBIR or STTR awards, provide the related Phase I or Phase II contract number, name of Phase III awarding agency, date of award, funding agreement number, amount, project title, and period of performance. The survey will also ask for firm sales and ownership information, as well as any commercialization success the firm has had as a result of Phase II SBIR or STTR awards. This information will allow firms to demonstrate their ability to carry SBIR/STTR research through to achieve commercial success, and allow agencies to track the overall commercialization success of their SBIR and STTR programs. The survey is not included in the 50-page limit and content should be limited to information requested above. An electronic form will be provided during the submissions process.

Note: Information received from SBIR/STTR awardees completing the survey is kept confidential, and will not be made public except in broad aggregate, with no firm-specific attribution. The Commercialization Metrics Survey is a required part of the proposal submissions process and must be completed via the Proposal Submission Electronic Handbook

2.2.12 Contractor Responsibility Information

No later than 10 business days after the notification of selection for negotiations the offeror shall provide a signed statement from your financial institution(s), on its letterhead, stating whether or not your firm is in good standing and how long you have been with the institution.

2.2.13 Allocation of Rights Agreement (STTR awards only)

No more than 10 business days after the notification of selection for negotiation, the offeror should provide to the Contracting Officer, a completed **Allocation of Rights Agreement (ARA)**, which has been signed by authorized representatives of the SBC, RI and subcontractors and consultants, as applicable. The ARA shall state the allocation of intellectual property rights with respect to the proposed STTR activity and planned follow-on research, development and/or commercialization. A sample ARA is available in section 6 of this Solicitation.

If the ARA form is completed and available at the time of submission, offers should upload it in Form C, which will help to expedite contract negotiations.

3. Method of Selection and Evaluation Criteria

3.1 Phase II Proposals

All Phase II proposals will be evaluated and ranked on a competitive basis. Proposals will be initially screened to determine responsiveness. Proposals determined to be responsive to the administrative requirements of this solicitation and having a reasonable potential of meeting a NASA need, as evidenced by the technical abstract included in the Proposal Summary (Form B), will be technically evaluated by NASA personnel to determine the most promising technical and scientific approaches. Each proposal will be reviewed on its own merit. NASA is under no obligation to fund any proposal or any specific number of proposals in a given topic. It also may elect to fund several or none of the proposed approaches to the same topic or subtopic.

3.1.1 Evaluation Process

The Phase II evaluation process is similar to the Phase I process. Each proposal will be reviewed by NASA scientists and engineers and by qualified experts outside of NASA as needed. In addition, those proposals with high technical merit will be reviewed for commercial merit. NASA may use a peer review panel to evaluate commercial merit. Panel membership may include non-NASA personnel with expertise in business development and technology commercialization.

3.1.2 Phase II Evaluation Criteria

NASA intends to select for award those proposals that best meet the Government's need(s). Note: Past performance will not be a separate evaluation factor but will be evaluated under factors 1 and 4 below. The evaluation of Phase II proposals will apply the following factors described below:

Factor 1: Scientific/Technical Merit and Feasibility

The proposed R/R&D effort will be evaluated on its originality, the feasibility of the innovation, and potential technical value. In addition, past performance of Phase I will be evaluated to determine the degree to which Phase I objectives were met, and whether the Phase I results indicate a Phase II project is appropriate.

Factor 2: Experience, Qualifications and Facilities

The technical capabilities and experience of the PI or project manager, key personnel, staff, consultants and subcontractors, if any, are evaluated for consistency with the research effort and their degree of commitment and availability. The necessary instrumentation or facilities required must show to be adequate and any reliance on external sources, such as Government furnished equipment or facilities, addressed (section 2.2.4, part 8).

Factor 3: Effectiveness of the Proposed Work Plan

The work plan will be reviewed for its comprehensiveness, effective use of available resources, labor distribution, and the proposed schedule for meeting the Phase II objectives. The methods planned to achieve each objective or task should be discussed in detail. The proposed path beyond Phase II for further development and infusion into a NASA mission or program will also be reviewed. Please see Factor 5 for price evaluation criteria.

STTR: The clear delineation of responsibilities of the SBC and RI for the success of the proposed cooperative R/R&D effort will be evaluated. The offeror must demonstrate the ability to organize for effective conversion of intellectual property into products and services of value to NASA and the commercial marketplace.

Factor 4: Commercial Potential and Feasibility

The proposal will be evaluated for the commercial potential and feasibility of the proposed innovation and associated products and services. The offeror's experience and record in technology commercialization, current funding commitments from private or non-SBIR funding sources, existing and projected commitments for Phase III funding, investment, sales, licensing, and other indicators of commercial potential and feasibility will be considered along with the commercialization plan for the innovation. Evaluation of the commercialization plan and the overall proposal will include consideration of the following areas:

- (1) **Commercial Potential and Feasibility of the Innovation:** This includes assessment of (a) the transition of the innovation into a well-defined product or service; (b) a realistic target market niche; (c) a product or service that has strong potential for meeting a well-defined need within the target market; and (d) a commitment of necessary financial, physical, and/or personnel resources.
- (2) **Intent and Commitment of the Offeror:** This includes assessing the commercialization of the innovation for (a) importance to the offeror's current business and strategic planning; (b) reliance on (or lack thereof) Government markets; and (c) adequacy of funding sources necessary to bring technology to identified market.
- (3) **Capability of the Offeror to Realize Commercialization:** This includes assessment of (a) the offeror's past performance, experience, and success in technology commercialization; (b) the likelihood that the offeror will be able to obtain the remaining necessary financial, technical, and personnel-related resources; and (c) the current strength and continued financial viability of the offeror.

Commercialization encompasses the infusion of innovative technology into products and services for NASA mission programs, other Government agencies and non-Government markets.

Factor 5: Price Reasonableness

The offeror's cost proposal will be evaluated for price reasonableness based on the information provided in (Form C). NASA will comply with the FAR and NASA FAR Supplement (NFS) to evaluate the proposed price/cost to be fair and reasonable.

After completion of evaluation for price reasonableness and determination of responsibility the Contracting Officer shall submit a recommendation for award to the Source Selection Official.

Scoring of Factors and Weighting

Factors 1, 2, and 3 will be scored numerically with Factor 1 worth 50 percent and Factors 2 and 3 each worth 25 percent. The sum of the scores for Factors 1, 2, and 3 will comprise the Technical Merit score. Proposals receiving acceptable numerical scores will be evaluated and rated for their commercial potential. The evaluation for Factor 4, Commercial Potential and Feasibility, will be in the form of an adjectival rating (Excellent, Very Good, Average, Below Average, Poor). For Phase II proposals, commercial merit is a critical factor. Factors 1 - 4 will be evaluated and used in the selection of proposals for negotiation. Factor 5 will be evaluated and used in the selection for award.

3.1.3 Selection

Proposals recommended for negotiations will be forwarded to the Program Management Office for analysis and presented to the Source Selection Official and Mission Directorate Representatives. Final selection decisions will consider the recommendations, overall NASA priorities, program balance and available funding, as well as any other evaluations or assessments (particularly pertaining to commercial potential). The Source Selection Official has the final authority for choosing the specific proposals for contract negotiation. Each proposal selected for negotiation will be evaluated for cost/price reasonableness. After completion of evaluation for cost/price reasonableness and a determination of responsibility the Contracting Officer will submit a recommendation for award to the Source Selection Official.

The list of proposals selected for negotiation will be posted on the NASA SBIR/STTR website (<http://sbir.nasa.gov>). All firms will receive a formal notification letter. A Contracting Officer will negotiate an appropriate contract to be signed by both parties before work begins.

3.2 Debriefing of Offerors

After selection for negotiations have been announced, debriefings for proposals will be available to the offeror's corporate official or designee via e-mail. Telephone requests for debriefings will not be accepted. Debriefings are not opportunities to reopen selection decisions. They are intended to acquaint the offeror with perceived strengths and weaknesses of the proposal in order to help offerors identify constructive future action by the offeror. Debriefings will not disclose the identity of the proposal evaluators, proposal scores, the content of, or comparisons with other proposals.

To request debriefings on proposals, offerors must request via e-mail to the SBIR/STTR Program Support Office at ARC-SBIR-PMO@mail.nasa.gov within 60 days after the announcement of selection for negotiation. Late requests will not be honored.

4. Considerations

4.1 Awards

4.1.1 Availability of Funds

All Phase II awards are subject to availability of funds. NASA has no obligation to make any specific number of awards, and may elect to make several or no awards in any specific technical topic or subtopic.

SBIR Contracts	STTR Contracts
NASA anticipates that approximately 35-40 percent of the successfully completed Phase I projects from the SBIR 2012 Solicitation will be selected for Phase II. Phase II agreements will be firm-fixed-price contracts with performance periods not exceeding 24 months and funding not exceeding \$750,000.	NASA anticipates that approximately 35-40 percent of the successfully completed Phase I projects from the STTR 2012 Solicitation will be selected for Phase II. Phase II agreements will be firm-fixed-price contracts with performance periods not exceeding 24 months and funding not exceeding \$750,000.

4.1.2 Contracting

To simplify contract award and reduce processing time, all contractors selected for Phase II contracts should ensure that:

- (1) All information in your proposal is current, e.g., your address has not changed, the proposed PI is the same, etc... If changes have occurred since submittal of your proposal, notify Contracting Officer immediately.
- (2) Your firm is registered in CCR and all information is current. NASA uses the CCR to populate its contract and payment systems; if the information in the CCR is not current your award and payments will be delayed. If updates have been made, notify contracting officer immediately.
- (3) The representations and certifications in ORCA (Online Representations and Certifications Application) are current.
- (4) The VETS 100 report submitted by your firm to the Department of Labor is current and submitted to the Contracting Officer within 10 business days of the notification of selection for negotiation.
- (5) Your firm HAS NOT proposed a Co-Principal Investigator.
- (6) STTR selectees should execute their Allocation of Rights Agreement within 10 business days of the notification of selection for negotiation.
- (7) Your firm has a timely response to all communications from the NSSC Contracting Officer.

From the time of proposal notification of selection for negotiation, until the award of a contract, all communications shall be submitted electronically to NSSC-SBIR-STTR@nasa.gov.

Note: Costs incurred prior to and in anticipation of award of a contract are entirely the risk of the contractor in the event that a contract is not subsequently awarded. A notification of selection for negotiation is not to be misconstrued as an award notification to commence work.

Phase II Model Contract

An example of the Phase II contracts can be found in the in the NASA SBIR/STTR Firm Library: https://sbir.gsfc.nasa.gov/sbir/firm_library/index.html. Note: **Model contracts are subject to change.**

4.2 Phase II Reporting

The technical reports are required as described in the contract and are to be provided to NASA. All required reports shall be submitted electronically via the EHB.

4.3 Release of Proposal Information

In submitting a proposal, the offeror agrees to permit the Government to disclose publicly the information contained on the Proposal Summary (Form B). Other proposal data is considered to be the property of the offeror, and NASA will protect it from public disclosure to the extent permitted by law including the Freedom of Information Act (FOIA).

4.4 Access to Proprietary Data by Non-NASA Personnel

4.4.1 Non-NASA Reviewers

In addition to Government personnel, NASA, at its discretion and in accordance with 1815.207-71 of the NASA FAR Supplement, may utilize qualified individuals from outside the Government in the proposal review process. Any decision to obtain an outside evaluation shall take into consideration requirements for the avoidance of organizational or personal conflicts of interest and the competitive relationship, if any, between the prospective contractor or subcontractor(s) and the prospective outside evaluator. Any such evaluation will be under agreement with the evaluator that the information (data) contained in the proposal will be used only for evaluation purposes and will not be further disclosed.

4.4.2 Non-NASA Access to Confidential Business Information

In the conduct of proposal processing and potential contract administration, the Agency may find it necessary to provide proposal access to other NASA contractor and subcontractor personnel. NASA will provide access to such data only under contracts that contain an appropriate NFS 1852.237-72 Access to Sensitive Information clause that requires the contractors to fully protect the information from unauthorized use or disclosure.

4.5 Proprietary Information in the Proposal Submission

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 as confidential proprietary information. NASA will treat in confidence pages listed as proprietary in the following legend that appears on the Cover Sheet (Form A) of the proposal:

"This 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, provided that a funding agreement is awarded to the offeror as a result of or in connection with the submission of this 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 in pages ____ of this proposal."

Note: Do not label the entire proposal proprietary. The Proposal Summary (Form B), and the Briefing Chart should not contain proprietary information; and any page numbers that would correspond to these must not be designated proprietary in Form B.

Information contained in unsuccessful proposals will remain the property of the applicant. The Government will, however, retain copies of all proposals.

4.6 Cost Sharing

Cost sharing occurs when a contractor proposes to bear some of the burden of reasonable, allocable and allowable contract costs. Cost sharing is permitted, but not required for proposals under this Solicitation. Cost sharing is not an evaluation factor in consideration of your proposal. Cost sharing, if included, should be shown in the budget summary. No profit will be paid on the cost-sharing portion of the contract.

4.7 Profit or Fee

Phase II contracts may include a reasonable profit. The reasonableness of proposed profit is determined by the Contracting Officer during contract negotiations. Reference FAR 15.404-4.

4.8 Joint Ventures and Limited Partnerships

Both joint ventures and limited partnerships are permitted, provided the entity created qualifies as an SBC. A statement of how the workload will be distributed, managed, and charged should be included in the proposal. A copy or comprehensive summary of the joint venture agreement or partnership agreement should be appended to the proposal. This will not count as part of the page limit for the Phase II proposal.

4.9 Addition Information

4.9.1 Evidence of Contractor Responsibility

In addition to the information required to be submitted in section 2.2.12, before award of an SBIR or STTR contract, the Government may request the offeror to submit certain organizational, management, personnel, and financial information to establish responsibility of the offeror. Contractor responsibility includes all resources required for contractor performance, i.e., financial capability, work force, and facilities.

4.10 Required Registrations and Submissions

4.10.1 Central Contractor Registration

Offerors should be aware of the requirement to register in the Central Contractor Registration (CCR) database prior to contract award. **To avoid a potential delay in contract award, offerors are required to register prior to submitting a proposal. Additionally, firms must certify the NAICS code of 541712.**

The CCR database is the primary repository for contractor information required for the conduct of business with NASA. It is maintained by the Department of Defense. To be registered in the CCR database, all mandatory information, which includes the DUNS or DUNS+4 number, and a CAGE code, must be validated in the CCR system. The DUNS number or Data Universal Number System is a 9-digit number assigned by Dun and Bradstreet Information Services (<http://www.dnb.com>) to identify unique business entities. The DUNS+4 is similar, but includes a 4-digit suffix that may be assigned by a parent (controlling) business concern. The CAGE code or Commercial Government and Entity Code is assigned by the Defense Logistics Information Service (DLIS) to identify a commercial or Government entity. If an SBC does not have a CAGE code, one will be assigned during the CCR registration process.

The DoD has established a goal of registering an applicant in the CCR database within 48 hours after receipt of a complete and accurate application via the Internet. However, registration of an applicant submitting an application through a method other than the Internet may take up to 30 days. Therefore, offerors that are not registered should consider applying for registration immediately upon receipt of this solicitation. Offerors and contractors may obtain information on CCR registration and annual confirmation requirements via the Internet at <http://www.ccr.gov> or by calling 888-CCR-2423 (888-227-2423).

4.10.2 52.204-8 Annual Representations and Certifications

Offerors should be aware of the requirement that the Representation and Certifications required from Government contractors must be completed through the Online Representations and Certifications Application (ORCA) website <https://orca.bpn.gov/login.aspx>. FAC 01-26 implements the final rule for this directive and requires that all offerors provide representations and certifications electronically via the BPN website; to update the representations and certifications as necessary, but at least annually, to keep them current, accurate and complete. NASA will not enter into any contract wherein the Contractor is not compliant with the requirements stipulated herein.

4.10.3 52.222-37 Employment Reports on Special Disabled Veterans, Veterans of the Vietnam-Era, and Other Eligible Veterans

In accordance with Title 38, United States Code, Section 4212(d), the U.S. Department of Labor (DOL), Veterans' Employment and Training Service (VETS) collects and compiles data on the Federal Contractor Program Veterans' Employment Report (VETS-100 Report) from Federal contractors and subcontractors who receive Federal contracts that meet the threshold amount of \$100,000. The VETS-100 reporting cycle begins annually on August 1 and ends September 30. Any federal contractor or prospective contractor that has been awarded or will be awarded a federal contract with a value of \$100,000 or greater must have a current VETS 100 report on file. Please visit the DOL VETS 100 website at <http://www.dol.gov/vets/programs/fcp/main.htm>. NASA will not enter into any contract wherein the firm is not compliant with the requirements stipulated herein.

4.10.4 Software Development Standards

Offerors proposing projects involving the development of software should comply with the requirements of NASA Procedural Requirements (NPR) 7150.2, "NASA Software Engineering Requirements" are available online at <http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=7150&s=2>.

4.10.5 Human and/or Animal Subject

Offerors should be aware of the requirement that an approved protocol by a NASA Review Board is required if the proposed work include human or animal subject. An approved protocol shall be provided to the Contracting Officer prior to the initiation of any human and/or animal subject research. Offerors shall identify the use of human or animal subject on Form A. For additional information, contact the NASA SBIR/STTR Program Management Office at ARC-SBIR-PMO@mail.nasa.gov. Reference 14 CFR 1230 and 1232.

4.10.6 HSPD-12

Firms that require access to federally controlled facilities for six consecutive months or more must adhere to the following:

PIV Card Issuance Procedures in accordance with FAR clause 52.204-9 Personal Identity Verification of Contractor Personnel.

Purpose: To establish procedures to ensure that recipients of contracts are subject to essentially the same credentialing requirements as Federal Employees when performance requires physical access to a Federally-controlled facility or access to a Federal information system **for six consecutive months or more**. (Federally - controlled facilities and Federal information system are defined in FAR 2.101(b)(2)).

Background: Homeland Security Presidential Directive 12 (HSPD-12), "Policy for a Common Identification Standard for Federal Employees and Contractors", and Federal Information Processing Standards Publication (FIPS PUB) Number 201, "Personal Identity Verification (PIV) of Federal Employees and Contractors" require agencies to establish and implement procedures to create and use a Government-wide secure and reliable form of identification NLT October 27, 2005. See: <http://csrc.nist.gov/publications/fips/fips201-1/FIPS-201-1-chng1.pdf>. In accordance with the FAR clause 52.204-9 Personal Identity Verification of Contractor Personnel which states in parts contractor shall comply with the requirements of this clause and shall ensure that individuals needing such access shall provide the personal background and biographical information requested by NASA.

If applicable, detailed procedures for the issuance of a PIV credential can be found at the following URL: <http://itcd.hq.nasa.gov/PIV.html>.

4.11 False Statements

Knowingly and willfully making any false, fictitious, or fraudulent statements or representations may be a felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to \$10,000, up to five years in prison, or both. The Office of the Inspector General has full access to all proposals submitted to NASA.

5. Submission of Proposals

5.1 Submission Requirements

NASA uses electronically supported business processes for the SBIR/STTR programs. An offeror must have Internet access and an e-mail address. Paper submissions are not accepted.

The Electronic Handbook (EHB) for submitting proposals is located at <http://sbir.nasa.gov>. The Proposal Submission EHB will guide the firms through the steps for submitting an SBIR/STTR proposal. All EHB submissions are through a secure connection. Communication between NASA's SBIR/STTR programs and the firm is primarily through a combination of EHBs and e-mail.

5.2 Submission Process

SBCs must register in the EHB to begin the submission process. Firms are encouraged to start the proposal process early, to allow for sufficient time to complete the submissions process. It is recommended that the Business Official, or an authorized representative designated by the Business Official, be the first person to register for the SBC. The SBC's Employer Identification Number (EIN)/Taxpayer Identification Number is required during registration.

Note: The designated firm admin, typically the first person to register your firm, is the only individual authorized to update and change the firm level forms (see section 5.2.1 (5)).

For successful proposal submission, SBCs must complete all forms online, upload their technical proposal in an acceptable format, and have the Business Official and Principle Investigator electronically endorse the proposal. Electronic endorsement of the proposal is handled online with no additional software requirements. The term "technical proposal" refers to the part of the submission as described in section 2.2.4.

STTR: The Research Institution is required to electronically endorse the Agreement prior to the SBC endorsement of the completed proposal submission.

5.2.1 What Needs to Be Submitted

The entire proposal including Forms A, B, C, the briefing chart, and other firm level forms must be submitted/completed out via the Submissions EHB located on the NASA SBIR/STTR website. (Note: Other forms of submissions such as postal, paper, fax, diskette, or e-mail attachments are not acceptable).

- (1) Forms A, B, and C are to be completed online.
- (2) The technical proposal is uploaded from your computer via the Internet utilizing secure communication protocol.
- (3) STTR proposers must submit the Research Agreement between the SBC and RI (STTR only).
- (4) Firms must submit a briefing chart online, which is not included in the page count (see sections 2.2.7).
- (5) NASA Research License Application (only if the use of TAV is proposed).
- (6) The certifications, audit information, prior awards addendum, commercialization metrics survey are required and to be completed online. These are not included in the page count.

5.2.2 Technical Proposal Submissions

NASA converts all technical proposal files to PDF format for evaluation. Therefore, NASA requests that technical proposals be submitted in PDF format or MS Word. Note: Embedded animation or video will not be considered for evaluation.

Virus Check

The offeror is responsible for performing a virus check on each submitted technical proposal. As a standard part of entering the proposal into the processing system, NASA will scan each submitted electronic technical proposal for viruses. The detection, by NASA, of a virus on any electronically submitted technical proposal, may cause rejection of the proposal.

5.2.3 Technical Proposal Uploads

Firms will upload their proposals using the Submissions EHB. Directions will be provided to assist users. All transactions via the EHB are encrypted for security. Firms cannot submit security/password protected technical proposal and/or briefing chart files, as reviewers may not be able to open and read the files. An e-mail will be sent acknowledging each successful upload. Please verify the file name and file size in the confirmation email to ensure the correct proposal was uploaded. An example is provided below:

Sample E-mail for Successful Upload of Technical Proposal

Subject: Successful Upload of Technical Proposal

Upload of Technical Document for your NASA SBIR/STTR Proposal No. _____

This message is to confirm the successful upload of your technical proposal document for:

Proposal No. _____

(Uploaded File Name/Size/Date)

Please note that any previous uploads are no longer considered as part of your submission.

This e-mail is NOT A RECEIPT OF SUBMISSION of your entire proposal

IMPORTANT! The Business Official or an authorized representative must electronically endorse the proposal in the Electronic Handbook using the "Endorse Proposal" step. Upon endorsement, you will receive an e-mail that will be your official receipt of proposal submission.

Thank you for your participation in NASA's SBIR/STTR Program.

NASA SBIR/STTR Program Support Office

You may upload the technical proposal multiple times, with each new upload replacing the previous version, but only the final uploaded and electronically endorsed version will be considered for review.

5.3 Deadline for Phase II Proposal Receipt

All Phase II proposal submissions must be received no later than the last day of the Phase I contract, via the NASA SBIR/STTR website (<http://sbir.nasa.gov>). The EHB will be available for Internet submissions approximately 6 weeks prior to completion date of Phase I contracts. Receipt of Phase II proposals are due on the last day of performance under SBIR/STTR Phase I contracts. The EHB will not be available for Internet submissions after this deadline, so firms are also advised to print all forms prior to the deadline since the EHB will not be available. Any proposal received after that date and time shall be considered late and handled according to NASA FAR Supplement 1815.208.

5.4 Acknowledgment of Proposal Receipt

The final proposal submission includes successful completion of Form A (electronically endorsed by the SBC Official), Form B, Form C, the uploaded technical proposal, and the briefing chart. NASA will acknowledge receipt of electronically submitted proposals upon endorsement by the SBC Official to the SBC Official's e-mail address as provided on the proposal cover sheet. If a proposal acknowledgment is not received, the offeror should call NASA SBIR/STTR Program Support Office at 301-937-0888. An example is provided below:

Sample E-mail for Official Confirmation of Receipt of Full Proposal:

Subject: Official Receipt of your NASA SBIR/STTR Proposal No. _____

Confirmation No. _____

*This message is to acknowledge electronic receipt of your NASA SBIR/STTR Proposal No. _____.
Your proposal, including the forms and the technical document, has been received at the NASA SBIR/STTR Support Office.*

SBIR/STTR 2012 Phase II xx.xx-xxxx (Title)

Form A completed on:

Form B completed on:

Form C completed on:

Technical Proposal Uploaded on:

File Name:

File Type:

File Size:

Briefing Chart completed on:

Proposal endorsed electronically by:

This is your official confirmation of receipt. Please save this email for your records, as no other receipt will be provided. The SBIR notification and announcement for negotiation is currently scheduled for January 2014 or June 2014 for STTR, and will be posted via the SBIR/STTR website (<http://sbir.nasa.gov>).

Thank you for your participation in the NASA SBIR/STTR Program.

NASA SBIR/STTR Program Support Office

5.5 Withdrawal of Proposals

Prior to the close of submissions, proposals may be withdrawn via the Proposal Submission Electronic Handbook hosted on the NASA SBIR/STTR website (<http://sbir.nasa.gov>). In order to withdraw a proposal after the deadline, the designated SBC Official must send written notification via email to sbir@reisystems.com.

5.6 Service of Protests

Protests, as defined in Section 33.101 of the FAR, that are filed directly with an agency and copies of any protests that are filed with the General Accounting Office (GAO) shall be served on the Contracting Officer by obtaining written and dated acknowledgement of receipt from the NASA SBIR/STTR Program contact listed below:

Cassandra Williams
NASA Shared Services Center
Building 1111, C Road
Stennis Space Center, MS 39529
Cassandra.Williams-1@nasa.gov

The copy of any protest shall be received within one calendar day of filing a protest with the GAO.

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Firm Certifications

a. The offeror qualifies as a Small Business Concern (SBC)	Yes	No
b. It has no more than 500 employees, including the employees of its affiliates Number of employees: _____	Yes	No
i) Has SBA issued a size determination currently in effect finding that this Small Business Concern exceeds the 500 employee size standard?	Yes	No
c. The firm is owned and operated in the United States	Yes	No
i) 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
If No, explain why: _____		
d. The firm is owned by a faculty member or a student of an institution of higher education as defined in 20 U.S.C. § 1001)	Yes	No
<i>The offeror qualifies as a:</i>		
e. Socially and Economically Disadvantaged SBC	Yes	No
f. Woman-owned SBC	Yes	No
i) Economically Disadvantaged Women-owned SBC	Yes	No
g. HUBZone-owned SBC	Yes	No
h. Veteran-owned SBC	Yes	No
i) Service Disabled Veteran-owned SBC	Yes	No
<i>In accordance with NFS 1852.209-73, the offeror certifies:</i>		
i. It is not the Association of Community Organizations for Reform Now (ACORN) or a subsidiary thereof.	Yes	No
<i>In accordance with NFS 1852.209-75, the offeror certifies that:</i>		
j. It is not a corporation that has had any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability	Yes	No
k. It is not a corporation that was convicted, or had an officer or agent acting on behalf of the corporation convicted, of a felony criminal violation under a Federal law within the preceding 24 months	Yes	No

I understand that providing false information is a criminal offense under Title 18 US Code, Section 1001, False Statements, as well as Title 18 US Code, Section 287, False Claims.

Guidelines for Completing Firm Certifications

Certifications: Firm level certifications that are applicable across all proposal submissions submitted to this solicitation must be completed via the “Certifications” section of the Proposal Submission Electronic Handbook. The offeror must answer Yes or No to certifications (a) through (k) as applicable.

Form A – SBIR Cover Sheet

Proposal Number:	Subtopic No.	System generated 4-digits
Topic Title:	---	-
Subtopic Title:		
Proposal Title:		

Firm Name:
Mailing Address:
City:
State/Zip:
Phone:
Fax:
EIN/Tax ID:

ACN (Authorized Contract Negotiator) Name:	
ACN E-mail:	
ACN Phone:	Extension:
DUNS + 4:	
Cage Code:	
Amount Requested: \$_____ (auto-populated upon completion of Budge Form C)	
Duration: _____ months	

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 OFFEROR HAS REVIEWED AND CERTIFIES THAT

<p>a. During the performance of the contract, the Principal Investigator will spend more than one half of his/her time as an employee of the awardee (based on a 40 hour workweek). If no, the offeror must request a written deviation from this requirement from the funding agreement officer. Note: The Principal Investigator's tasks cannot be split between two people. Co-PIs are not acceptable. Refer to section 1.4.3.</p>	Yes No																																								
<p>b. Gender of the Principal Investigator</p>	Male Female																																								
<p>c. Is the Principal Investigator a socially and economically disadvantaged individual?</p>	Yes No																																								
<p>d. All, essentially equivalent work, or a portion of the work proposed under this project (check the applicable line):</p> <p>___ Has not been submitted for funding by another Federal agency.</p> <p>___ Has been submitted for funding by another Federal agency but has not been funded under any other Federal grant, contract, subcontract or other transaction. (Complete section i below)</p> <p>___ A portion has been funded by another grant, contract, or subcontract as described in detail in the proposal. Before award, this must be approved in writing by the funding agreement officer. (Complete section ii below)</p> <p>___ Has received funding for essentially equivalent work under this project by any other Federal grant, contract, or subcontract.</p> <p style="margin-left: 20px;">i) If submitted for other Federal funding, provide information on essentially equivalent proposal submissions below:</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="width: 10%;">Proposal No.</th> <th style="width: 25%;">Proposal Title</th> <th style="width: 15%;">Date of Submission</th> <th style="width: 15%;">Soliciting Agency</th> <th style="width: 35%;">(Anticipated) Selection Announcement Date</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table> <p style="margin-left: 20px;">ii) If a portion has been Federally funded by another grant, contract, or contract, provide information on essentially equivalent proposal submissions below:</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="width: 10%;">Contract/ Grant No.</th> <th style="width: 25%;">Proposal Title</th> <th style="width: 15%;">Date of Submission</th> <th style="width: 15%;">Soliciting Agency</th> <th style="width: 35%;">Date of Award</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table>	Proposal No.	Proposal Title	Date of Submission	Soliciting Agency	(Anticipated) Selection Announcement Date																Contract/ Grant No.	Proposal Title	Date of Submission	Soliciting Agency	Date of Award																
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Contract/ Grant No.	Proposal Title	Date of Submission	Soliciting Agency	Date of Award																																					
<p>e. During the performance of the contract, the SBC will perform at least half (50 %) of the applicable percentage of work*</p>	Yes No																																								
<p>f. During the performance of the contract, the research/research and development will be performed in the United States*</p> <p style="margin-top: 10px;">* In rare occasions, minor deviations from this requirement may be necessary; however, any minor deviation must be approved in writing by the contracting officer after consultation with the agency SBIR Program Manager/Business Manager.</p>	Yes No																																								

g. During the performance of the contract, the research/research and development will be performed at the offeror's facilities by the offeror's employees except as otherwise indicated in the SBIR technical proposal	Yes	No
<i>As described in Section 2 of this solicitation, the offeror meets the following requirements completely:</i>		
h. All 11 parts of the technical proposal are included in part order and the page limitation is met	Yes	No
i. Subcontracts/consultants proposed?	Yes	No
i) If yes, does the proposal comply with the subcontractor/consultant limitation? (section 2.2.4, part 9)	Yes	No N/A
j. Federal facilities, laboratories, or equipment required?	Yes	No
i) If yes, is justification for the use uploaded in Form C?	Yes	No N/A
ii) If yes, is a signed statement of availability uploaded in Form C?	Yes	No N/A
<i>In accordance with ITAR, 22 CFR 120-130, as applicable:</i>		
k. The offeror understands and shall comply with export control regulations	Yes	No
<i>In accordance with 14 CFR 1230 and 1232 as applicable, indicate if any of the following will be used (must comply with federal regulations):</i>		
l. Human Subject	Yes	No
m. Animal Subject	Yes	No
<i>In accordance with FAR 52.223-13, FAR 52.223-3, 29 CFR 1910.1200(g) and the latest version of Federal Standard No. 313 as applicable, indicate if the following will be used (must comply with Federal regulations):</i>		
n. Toxic Chemicals	Yes	No
o. Hazardous Materials	Yes	No
<i>Indicate if the R&D to be performed is related to:</i>		
p. Renewable Energy	Yes	No
q. Manufacturing	Yes	No
<i>Disclosure permission:</i>		
r. Will you permit the Government to disclose your name, address, and telephone number of the Business Official of your concern, if your proposal 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

<p><i>As a representative of the offeror, I certify the following:</i></p> <ul style="list-style-type: none"> — The offeror 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 non-procurement transactions (FAR Subpart 9.4 or 2 C.F.R. part 180); and (6) other administrative penalties including termination of SBIR/STTR awards. 	
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ENDORSEMENTS:**Principal Investigator:**

Name: _____ Title: _____
Phone: _____ E-mail: _____

Endorsed by: _____ Date: _____

Corporate/Business Official:

Name: _____ Title: _____
Phone: _____ E-mail: _____

Endorsed by: _____ Date: _____

PROPRIETARY NOTICE (If applicable, see sections 4.4, 4.5)

NOTICE: This 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, provided that a funding agreement is awarded to the offeror as a result of or in connection with the submission of this 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 in pages _____ of this proposal.

Note: Do not mark the entire proposal as proprietary. Form B (page 2 of your proposal submission) cannot contain proprietary data. (See section 2.2.3 of the 2012 Solicitation)

Guidelines for Completing SBIR Cover Sheet

Complete Cover Sheet Form A electronically via the Proposal Submission Electronic Handbook.

Proposal Number: This number does not change. The proposal number consists of the four-digit subtopic number and four-digit system-generated number.

Topic Title: Select the topic that this proposal will address. Refer to the Phase I topic descriptions.

Subtopic Title: Select the subtopic that this proposal will address. Refer to the Phase I for subtopic descriptions.

Proposal Title: Enter a brief, descriptive title using no more than 80 keystrokes (characters and spaces). Do not use the subtopic title. Avoid words like "development" and "study."

Firm Name: Enter the full name of the firm submitting the proposal. If a joint venture, list the firm chosen to negotiate and receive contracts. If the name exceeds 40 keystrokes, please abbreviate.

Mailing Address: Must match CCR address and should be the address where mail is received.

City, State, Zip: City, 2-letter State designation (i.e. TX for Texas), 9-digit Zip code (i.e. 20705-3106)

Phone, Fax: Number including area code

EIN/Tax ID: Employer Identification Number/Taxpayer ID

ACN Name: Enter the name of the Authorized Contract Negotiator from your firm

ACN E-mail: Email address

ACN Phone, Ext.: Number including area code and extension (if applicable)

DUNS + 4: 9-digit Data Universal Number System; a 4-digit suffix is also required if owned by a parent concern. For information on obtaining a DUNS number go to <http://www.dnb.com>.

CAGE Code: Commercial Government and Entity Code that is issued by the Central Contractor Registration (CCR). For information on obtaining a CAGE Code, go to <http://www.ccr.gov>.

Amount Requested: Proposal amount auto-populated from Budget Summary. The amount requested should not exceed \$750,000 (see sections 1.2, 4.1.1).

Duration: Proposed duration in months. The requested duration should not exceed 24 months (see sections 1.2, 4.1.1).

Certifications: Answer Yes or No as applicable for certifications a – r (see the referenced sections for definitions). Where applicable, SBCs should make sure that their certifications on Form A agree with the content of their technical proposal.

- a. The Principal Investigator is required to be “primarily employed” by the organization as defined in section 1.4.3 of the Solicitation.
- b. As required by the SBIR/STTR Policy Directive, the offeror should indicate the gender of the Principal Investigator. This data is collected for statistical purposes only.
- c. As required by the SBIR/STTR Policy Directive, the offeror should indicate if the Principal Investigator is a socially and economically disadvantaged individual as defined in 13 C.F.R. § 124.103 and 124.104. This data is collected for statistical purposes only.
- d. The firm must disclose if any essentially equivalent work has been submitted for funding or funded by another Federal agency. While it is permissible to submit essentially equivalent proposals, it is unlawful to enter into funding agreements requiring essentially equivalent work. If essentially equivalent work under this project has been submitted to other Federal Agencies/programs for funding, then the SBC must provide

the proposal number, proposal title, date of submission, soliciting agency, and the (anticipated) selection announcement date is subsection i. If a portion of the work has been funded by another grant, contract, or subcontract, then the SBC must provide the contract/grant number, proposal title, date of submission, awarding agency, date of award in subsection ii.

- e. The SBC is required to perform at least half (50%) of the work. Refer to section 2.2.4, part 9.
- f. R/R&D must be performed in the United States (see section 1.4.2 of this Solicitation) except in rare and unique circumstances which require approval by the Contracting Officer prior to award.
- g. The offeror must certify that during the performance of the contract the R/R&D will be performed at the offeror's facilities by the offeror's employees unless otherwise indicated in the SBIR application.
- h. As stated in section 2.2 of the Solicitation, the entire proposal must not exceed the 50-page limitation and must consist of all eleven (11) required parts.
- i. By answering "Yes", the SBC certifies that subcontracts/consultants have been proposed and arrangements have been made to perform on the contract, if awarded.
 - i) Proposed subcontractor/consultant business arrangements must not exceed 50 percent of the research and/or analytical work (as determined by the total cost of the proposed subcontracting effort (to include the appropriate OH and G&A) in comparison to the total effort (total contract price including cost sharing, if any, less profit if any). Refer to section 2.2.4, part 9 of the Solicitation.
- j. By answering "Yes", the SBC certifies that Federal furnished facilities, laboratories, or equipment are required to perform the proposed activities. By answering "No", the SBC certifies that no such Federal furnished facilities, laboratories, or equipment is required to perform the proposed activities. See section 2.2.4 part 8 of the Solicitation.
 - i) If proposing to use Federal facilities, laboratories, or equipment a justification statement from the SBC must be uploaded in Form C. Proposals requiring waivers must explain why the waiver is appropriate. Facilities designated as a Federal laboratory are exempt from the waiver requirement.
 - ii) If proposing to use Federal furnished facilities, laboratories, or equipment, a signed statement of availability must be uploaded in Form C that describes the uniqueness of the facility and its availability to the offeror at specified times, signed by the appropriate Government official.
- k. Offerors are responsible for ensuring compliance with export control and International Traffic in Arms (ITAR) regulations. All employees who will work on this contract must be eligible under these regulations or the offeror must have in place a valid export license or technical assistance agreement. Violations of these regulations can result in criminal or civil penalties. For further information on ITAR visit http://www.pmddtc.state.gov/regulations_laws/itar.html. For additional assistance, contact the ARC export control administrator, Mary Williams, at mary.p.williams@nasa.gov.
- l-m. Offeror must indicate by answering "Yes" or "No" as applicable if human and/or animal subjects will be used. SBCs must be in compliance with federal regulations. Offerors should be aware of the requirement that an approved protocol by a NASA Review Board is required if the proposed work include human or animal subject. An approved protocol shall be provided to the Contracting Officer before an award can be made. Offerors shall identify the use of human or animal subject on Form A. For additional information, contact the NASA SBIR/STTR Program Management Office at ARC-SBIR-PMO@mail.nasa.gov. Reference 14 CFR 1230 and 1232. (See section 4.10.5)

- n-o. Offeror must indicate by answering “Yes” or “No” as applicable if toxic chemicals and/or hazardous materials will be used. SBCs must be in compliance with federal regulations. Reference FAR 52.223-13 Certification of Toxic Chemical Release Reporting and FAR 52.223-3 Hazardous Material identification and Material Safety Identification.

Offerors must list any hazardous material to be delivered under this contract. The apparently successful offeror agrees to submit, for each item as required prior to award, a Material Safety Data Sheet, meeting the requirements of 29 CFR 1910.1200(g) and the latest version of Federal Standard No. 313, for all hazardous material identified in paragraph (b) of this clause. Data shall be submitted in accordance with Federal Standard No. 313, whether or not the apparently successful offeror is the actual manufacturer of these items. Failure to submit the Material Safety Data Sheet prior to award may result in the apparently successful offeror being considered non-responsible and ineligible for award.

- p. Answer “Yes” if this proposal has a connection to energy efficiency or alternative and renewable energy. This should also be indicated in part 5 (Related R/R&D) of the proposal with a brief explanation of how it is related to energy efficiency or alternative and renewable energy.
- q. Answer “Yes” if this proposal has a connection to manufacturing. This should also be indicated in part 5 (Related R/R&D) of the proposal with a brief explanation of how it is related to manufacturing.
- r. The offeror must indicate if they permit the Government to disclose the name, address, and telephone number of the Business Official of your concern, if the proposal does not result in an award, to appropriate local and State-level economic development organizations that may be interested in contacting the Business Official for further information.

Electronic Endorsement:

Electronic endorsement is performed by the Principal Investigator and the authorized Business Official from the “Endorsement” link located on the Activity Worksheet for each proposal. Electronic endorsement by the Business Official is the final step in the proposal submission process and can only be performed when all required sections of the proposal submission are complete and the Principal Investigator has performed his/her separate electronic endorsement. Once endorsed, the name and date of endorsement will populate under the “Endorsement” section of this form. If any changes are made to the submission after endorsement by the Principal Investigator and/or Business Official, the proposal must be re-endorsed to be considered complete and submitted.

Endorsement of the proposal by the Business Official certifies that all information submitted in connection with this application is true and correct as of the date of submission. 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 non-procurement transactions (FAR Subpart 9.4 or 2 C.F.R. part 180); and (6) other administrative penalties including termination of SBIR/STTR awards.

Form B – SBIR Proposal Summary

Proposal Number: Subtopic No. System generated 4-digits
 --.--- - -----
 Subtopic Title:
 Proposal Title:

Small Business Concern:

Name:
 Address:
 City/State/Zip:
 Phone:

Principal Investigator/Project Manager:

Name:
 Address:
 City/State/Zip:
 Phone: Extension:
 E-mail:

Business Official:

Name:
 Address:
 City/State/Zip:
 Phone: Extension:
 E-mail:

Estimated Technology Readiness Level (TRL) at beginning and end of contract:

Begin: _____
 End: _____

Technology Available (TAV):

All subtopics listed in this solicitation have Technology Available (TAV) with NASA Intellectual Property. The use of the NASA IP is strictly voluntary. Refer to section 1.5 of the Solicitation for additional information.

Do you plan to use NASA Intellectual Property (IP) under the award? Yes No

If yes, [click here](#) to access the NASA Research License Application that must be completed and appended to your technical proposal.

Technical Abstract: (Limit 2,000 characters, approximately 200 words)

Potential NASA Application(s): (Limit 1,500 characters, approximately 150 words)

Potential Non-NASA Application(s): (Limit 1,500 characters, approximately 150 words)

Technology Taxonomy: (Select only the technologies relevant to this specific proposal)

NASA's technology taxonomy has been developed by the SBIR/STTR Program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.

Guidelines for Completing SBIR Proposal Summary

Complete Proposal Summary Form B electronically via the Proposal Submission Electronic Handbook.

Proposal Number: Auto-populated with proposal number as shown on Cover Sheet.

Subtopic Title: Auto-populated with subtopic title as shown on Cover Sheet.

Proposal Title: Auto-populated with proposal title as shown on Cover Sheet.

Small Business Concern: Auto-populated with firm information as shown on Cover Sheet.

Principal Investigator/Project Manager: Enter the full name of the PI/PM and include all required contact information.

Business Official: Auto-populated with Business Official contact information as shown on Cover Sheet.

Technology Readiness Level (TRL): Provide the estimated Technology Readiness Level (TRL) at the beginning and end of the contract. See Appendix B for TRL definitions.

Technology Available (TAV): All subtopics listed in this solicitation have Technology Available (TAV) with NASA Intellectual Property. Refer to section 1.5 of the Solicitation for more information. The offeror shall answer “Yes” if planning to use NASA IP under the award, and must complete the NASA Research License Application and append it to the technical proposal.

Technical Abstract: Summary of the offeror’s proposed project is limited to 2,000 characters, approximately 200 words, and shall summarize the implications of the approach and the anticipated results of the Phase II. NASA will reject a proposal if the technical abstract is determined to be non-responsive to the subtopic. The abstract must not contain proprietary information and must describe the NASA need addressed by the proposed R/R&D effort.

Potential NASA Application(s): Summary of the direct or indirect NASA applications of the innovation, assuming the goals of the proposed R/R&D are achieved. The response is limited to 1,500 characters, approximately 150 words.

Potential Non-NASA Application(s): Summary of the direct or indirect NASA applications of the innovation, assuming the goals of the proposed R/R&D are achieved. The response is limited to 1,500 characters, approximately 150 words.

Technology Taxonomy: Selections for the technology taxonomy are limited to technologies supported or relevant to the specific proposal. The listing of technologies for the taxonomy is provided in Appendix C.

Form C – SBIR Budget Summary

PROPOSAL NUMBER:

SMALL BUSINESS CONCERN:

(2) DIRECT LABOR:

Category	Description	Education	Years of Experience	Hours	Rate	Fringe Rate % (if applicable)	Total
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Document uploaded for labor rate documentation: (file name)

TOTAL DIRECT LABOR:

(1)

\$ _____

(2) OVERHEAD COST;

_____ % of Total Direct Labor or \$ _____

Comments:

Overhead Cost Sources:

OVERHEAD COST:

(2)

\$ _____

(3) OTHER DIRECT COSTS (ODCs):

Materials:

Description: _____

Vendor: _____

Quantity: _____ Cost: _____

Consumable? Yes No

Competitively Sourced? Yes No

Used Exclusively for this Contract? Yes No

Supporting Comments: _____

Supporting Documents: (file name)

Supplies:

Description: _____

Vendor: _____

Quantity: _____ Cost: _____

Consumable? Yes No

Competitively Sourced? Yes No

Used Exclusively for this Contract? Yes No

Supporting Comments: _____

Supporting Documents: (file name)

Equipment:

Description: _____
 Vendor: _____
 Quantity: _____ Cost: _____
 Competitively Sourced? Yes No
 Used Exclusively for this Contract? Yes No
 Supporting Comments: _____
 Supporting Documents: (file name) _____

Other:

Description: _____
 Vendor: _____
 Quantity: _____ Cost: _____
 Competitively Sourced? Yes No
 Used Exclusively for this Contract? Yes No
 Supporting Comments: _____
 Supporting Documents: (file name) _____

Travel:

Location From: _____ Location To: _____
 Number of People: _____ Number of Days: _____
 Purpose of Trip: _____
 Airfare: _____ Car Rental: _____
 Per Diem: _____ Other Costs: _____
 Total Costs: _____
 Sources of Estimates: _____
 Explanation/Justification: _____

Explanation of ODCs:

Provide any additional information on the Other Direct Costs listed above, including the basis used for estimating the costs.

Subcontractor/Consultants:	Total Cost:
_____	_____
_____	_____
_____	_____

Supporting Documents: (file name) _____

(Note: Separate Budget Summaries completed for all proposed Subcontractors/Consultants via the Subcontractors/Consultants section of Form C)

	TOTAL OTHER DIRECT COSTS:	
	(3)	\$ _____
(1)+(2)+(3)=(4)	SUBTOTAL:	
	(4)	\$ _____

(5) GENERAL & ADMINISTRATIVE (G&A) COSTS

_____ % of Subtotal or \$ _____

G&A COSTS:
(5)

\$ _____

Comments:

G&A Cost Elements:

(4)+(5)=(6)

TOTAL COSTS
(6)

\$ _____

(7) ADD PROFIT or SUBTRACT COST SHARING PROFIT/COST SHARING:
(As applicable)

(7)

\$ _____

Comments:

(6)+(7)=(8)

AMOUNT REQUESTED:
(8)

\$ _____

PHASE II DELIVERABLES:

SBCs will be required to submit mandatory deliverables such as progress reports, final report and New Technology Report as per their contract. If your firm is proposing any additional deliverables, list them below:

Deliverable	Quantity	Project Deliverable Milestone
_____	_____	_____
_____	_____	_____
_____	_____	_____

FEDERAL FACILITIES, LABORATORIES, OR EQUIPMENT:

If you require the use of a Federal facility, laboratory, or equipment, identify it below as well as in part 8 of your technical proposal and upload a signed statement of availability from the Government agency. In addition, a letter of justification should be uploaded. (See certification j on Form A and section 2.2.4, part 8).

AUDIT AGENCY:

If your firm's accounting system has been audited, are the rates from that audit agreement used for this proposal?

- ☐ The rates listed in the negotiated rate agreement were used to prepare the budget summary
☐ Other rates were used to prepare the budget summary
☐ My firm's accounting system has not been audited

If the listed rates are not being used to prepare the budget summary, please provide an explanation:

Guidelines for Preparing SBIR Budget Summary

Complete Budget Summary Form C electronically.

The offeror shall electronically submit a price proposal of estimated costs with detailed information for each cost element, consistent with the offeror's cost accounting and estimating system.

This summary does not eliminate the need to fully document and justify the amounts requested in each category. Such documentation should be contained, as appropriate, in the text boxes or via uploads as indicated in the electronic form.

Offerors with questions about the appropriate classification of costs are advised to consult with an experienced accountant that has experience in government contracting and cost accounting principles. Information provided by the Defense Contract Audit Administration in their publication "Information for Contractors" may also be useful. This publication can be found via the following site under publications: <http://www.dcaa.mil/>

Firm: Same as Cover Sheet.

Proposal Number: Same as Cover Sheet.

Direct Labor: Select the appropriate labor category for each person who will be working directly on the proposed research effort and provide the labor description, level of education, years of experience, total number of hours, labor rate, and fringe rate percentage (if applicable). Detail the labor hours used for each year of the proposed research effort separately.

Labor rate documentation should include costs that are included in the fringe rate percentage (if applicable). Provide the breakout rate such as the labor hour rate, health benefits, life insurance etc. Some examples of direct labor include Principal Investigator, Engineer, Scientist, Analyst or Research Assistant/Laboratory Assistant. All listed categories shall be directly related to proposed work to be performed under contract with NASA. Any contributions from non-technical personnel proposed under direct labor shall be explicitly explained. Labor rates that do not compare favorably to comparable state average rates at <http://www.bls.gov> require additional documentation, supporting the proposed rate or salary.

Note: Costs associated with firm executives, accountants or administrative support are typically included in a firm's general and administrative costs. If these costs are being proposed as direct labor then provide the details of how the proposed hours were allocated to this effort and verify that these costs are not also covered in your overhead or G&A rate.

Overhead Cost: Specify current rate and base. Use current rate(s) negotiated with your firm's cognizant Federal-auditing agency, if available. A rate that has not been audited requires a detailed explanation of the cost base used to develop the rate and if possible, historical actual overhead rates for the past three years.

Specify the cost elements of the firm's overhead costs in the text boxes provided. Possible overhead cost elements include insurance, sick leave, and vacation.

Note: If no labor overhead rate is proposed and the proposed direct labor includes all fringe benefits, you may enter "0" for the overhead cost line.

Other Direct Costs (ODCs): Refer to FAR 31.205 – Selected Costs for determination of cost allowability.

Materials and Supplies: Under the Materials and Supplies sections, indicate type, vendor, quantity required, and cost. Identify whether each item is consumable, which year it will be purchased, if it was competitively sourced, and if it will be used exclusively for this contract. Your proposed cost shall be justified and supporting documents should be uploaded. General materials or supplies without adequate explanation of the components, quantity and use of said items are not an acceptable breakdown. In the supporting comments block, provide the basis for the proposed price (vendor quote, competitive quotes, catalog price, estimate etc...). The Contracting Officer will make the final determination.

Special Tooling, Testing, and Test Equipment: The need for these items, if proposed, will be carefully reviewed. Equipment must be made in the USA to the maximum extent practical. The offeror should provide competitive quotes to support the proposed costs or should justify why only one source is available. Competitive quotes may be signed quotes from vendors or copies of catalogue pages. Normally the costs of any equipment should be quoted on a purchase basis, unless the offeror can demonstrate that lease or rent of the equipment is clearly advantageous to the government. The Contracting Officer will make the final determination. Upload supporting documentation as necessary. In the supporting comments block provide the basis for the proposed price (vendor quote, competitive quotes, catalog price, estimate etc.). The Contracting Officer will make the final determination.

Travel: All proposed travel must be necessary for the success of the research. Include a detailed accounting of all proposed expenses to include the purpose of proposed trips, number of trips, travelers per trip, as well as meals, hotel, and rental car estimated costs. Sources of estimate should be identified when travel is proposed along with a justification for each trip. Proposed travel costs shall be in accordance with the Federal Travel Regulation <http://www.gsa.gov/federaltravelregulation>.

Subcontracts/Consultants: Subcontracts/Consultants costs are included in the Other Direct Costs total. A separate budget summary must be completed for each subcontract/consultant proposed. Further instructions are provided in the Subcontracts/Consultants section below.

Note: Do not add subcontractors or consultants as a line item under the ODCs section of Form C. It will automatically be added to the ODCs upon completion of the separate Subcontractor/Consultant budget summary form.

Other: List all other direct costs that are not otherwise included in the categories described above such as rental of facilities, etc.

Note: The purchase of equipment, instrumentation, or facilities under SBIR/STTR must be justified by the offeror and approved by the Government during contract negotiations. Firms should be prepared to justify all material, supplies, and equipment costs during negotiations. See section 2.2.4, part 8 for further guidance.

Explanation of ODCs: Provide any additional information for the proposed ODCs, including basis for cost estimation, in the text box provided.

Subcontracts/Consultants: List consultants by name and specify, for each, the number of hours and hourly costs. Detailed quotes from subcontractors should be provided in the same format. Note that a subcontract entered into for performance of research or research and development differs from an arrangement with a vendor to provide a service such as machining, analysis with test equipment or use of computer time. The costs of such arrangements with vendors should be covered under Special Tooling, Testing, Test Equipment and Material or under Other Direct Costs. Upon request of the contracting officer, the subcontractor's cost proposals may be sealed or mailed directly for government eyes only.

A letter of commitment shall be uploaded for each proposed subcontractor/consultant from the Subcontractor/Consultant Letter of Commitment section of the subcontractor/consultant budget summary form. If a commitment letter is not available, you must upload alternate documentation that sufficiently substantiates that the subcontractor/consultant is available to perform the proposed work during the proposed timeframe. Note that not providing the information now may delay contract negotiations and award.

General and Administrative (G&A) Costs: Specify a current rate and base to which G&A costs will be applied. If available, use the current rate recommendations from the cognizant Federal-auditing agency. If an audit rate is not available, provide a detailed explanation of the cost base used to develop the rate and if possible, a historical actual G&A rate for the past three years.

Specify the elements of the firm's G&A costs in the text boxes provided. Possible G&A cost elements include rent, utilities, and management.

Profit/Cost Sharing: See sections 4.6 and 4.7. Profit is to be added to total cost, while shared costs are to be subtracted from total cost, as applicable.

Amount Requested: The amount requested is equal to the sum of the Direct Labor, Overhead, ODCs, G&A and any profit, less any cost sharing. The amount requested cannot exceed \$750,000 for Phase II.

Federal Facilities, Laboratories, and Equipment: If you require the use of Government facilities, laboratories, or equipment, identify the Federal facilities, laboratories or equipment in the text box provided, as well as in Part 8 of your technical proposal, and upload a signed statement of availability from the Government agency. Please note that this section SHALL be completed if you certified in Form A that you will require the use of Federal facilities. Leave this section BLANK if you DO NOT require the use of Federal facilities, laboratories, or equipment.

Audit Information: Complete the Audit Information section of Form C to indicate if your firm's accounting system has been audited and if the rates from that audit agreement are used for this proposal.

Note: There is a separate "Audit Information" section linked from your Activity Worksheet that must also be completed.

SBIR Check List

For assistance in completing your Phase II proposal, use the following checklist to ensure your submission is complete.

1. **The entire proposal including any supplemental material shall not exceed a total of 50 8.5 x 11 inch pages and the format requirements (section 2.2.2).**
2. The proposal and innovation is submitted for one subtopic only.
3. The entire proposal is submitted consistent with the requirements and in the order outlined in section 2.2.
4. The technical proposal contains all eleven parts in order (section 2.2.4).
5. The 1-page briefing chart does not include any proprietary data (section 2.2.7).
6. Certifications in Form A are completed, and agree with the content of the technical proposal.
7. Proposed funding does not exceed \$750,000 (sections 1.2, 4.1.1).
8. Proposed project duration does not exceed 24 months (sections 1.2, 4.1.1).
9. Entire proposal including Forms A, B, and C submitted via the Internet.
10. Form A electronically endorsed by the SBC Official and the PI.
11. **Phase II proposal submissions will be due after the last day of the Phase I contract (section 5.3).**

Form A – STTR Cover Sheet

	Subtopic No.	System generated 4-digits
Proposal Number:	--. --	- ----
Topic Title:		
Subtopic Title:		
Proposal Title:		

Firm Name:	Research Institution Name:
Mailing Address:	Mailing Address:
City:	City:
State/Zip:	State/Zip:
Phone:	Phone:
Fax:	Fax:
EIN/Tax ID:	EIN/Tax ID:

ACN (Authorized Contract Negotiator) Name:	
ACN E-mail:	
ACN Phone:	Extension:
DUNS + 4:	
Cage Code:	
Amount Requested: \$_____ (auto-populated upon completion of Budge Form C)	
Duration: ____ months	

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 Technology Transfer (STTR) 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 STTR 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 OFFEROR HAS REVIEWED AND CERTIFIES THAT:

<p>a. During the performance of the contract, the Principal Investigator will spend more than one half of his/her time as an employee of the awardee or the Research Institution (based on a 40 hour workweek). If no, the offeror must request a written deviation from this requirement from the funding agreement officer. Note: The Principal Investigator's tasks cannot be split between two people. Co-PIs are not acceptable. Refer to section 1.4.3.</p>	<p>Yes No</p>																																								
<p>b. Gender of the Principal Investigator</p>	<p>Male Female</p>																																								
<p>c. Is the Principal Investigator a socially and economically disadvantaged individual?</p>	<p>Yes No</p>																																								
<p>d. All, essentially equivalent work, or a portion of the work proposed under this project (check the applicable line):</p> <p>___ Has not been submitted for funding by another Federal agency.</p> <p>___ Has been submitted for funding by another Federal agency but has not been funded under any other Federal grant, contract, subcontract or other transaction. (Complete section i below)</p> <p>___ A portion has been funded by another grant, contract, or subcontract as described in detail in the proposal. Before award, this must be approved in writing by the funding agreement officer. (Complete section ii below)</p> <p>___ Has received funding for essentially equivalent work under this project by any other Federal grant, contract, or subcontract.</p> <p style="margin-left: 20px;">i) If submitted for other Federal funding, provide information on essentially equivalent proposal submissions below:</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="width: 10%;">Proposal No.</th> <th style="width: 30%;">Proposal Title</th> <th style="width: 15%;">Date of Submission</th> <th style="width: 15%;">Soliciting Agency</th> <th style="width: 30%;">(Anticipated) Selection Announcement Date</th> </tr> </thead> <tbody> <tr><td>_____</td><td>_____</td><td>_____</td><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td><td>_____</td><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td><td>_____</td><td>_____</td><td>_____</td></tr> </tbody> </table> <p style="margin-left: 20px;">ii) If a portion has been Federally funded by another grant, contract, or contract, provide information on essentially equivalent proposal submissions below:</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="width: 10%;">Contract/ Grant No.</th> <th style="width: 30%;">Proposal Title</th> <th style="width: 15%;">Date of Submission</th> <th style="width: 15%;">Soliciting Agency</th> <th style="width: 30%;">Date of Award</th> </tr> </thead> <tbody> <tr><td>_____</td><td>_____</td><td>_____</td><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td><td>_____</td><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td><td>_____</td><td>_____</td><td>_____</td></tr> </tbody> </table>	Proposal No.	Proposal Title	Date of Submission	Soliciting Agency	(Anticipated) Selection Announcement Date	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	Contract/ Grant No.	Proposal Title	Date of Submission	Soliciting Agency	Date of Award	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	<p>Yes No</p>
Proposal No.	Proposal Title	Date of Submission	Soliciting Agency	(Anticipated) Selection Announcement Date																																					
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<p>e. During the performance of the contract, the SBC will perform at least 40% of the applicable percentage of work and the RI will perform at least 30% of the applicable percentage of work*</p>	<p>Yes No</p>																																								

<p>f. During the performance of the contract, the research/research and development will be performed in the United States*</p> <p>* In rare occasions, minor deviations from this requirement may be necessary; however, any minor deviation must be approved in writing by the contracting officer after consultation with the agency STTR Program Manager/Business Manager.</p>	<p>Yes No</p>
<p>g. During the performance of the contract, the research/research and development will be performed at the offeror's facilities by the offeror's employees except as otherwise indicated in the STTR technical proposal</p>	<p>Yes No</p>
<p><i>The partnering Research Institution qualifies as a:</i></p>	
<p>h. FFRDC</p>	<p>Yes No</p>
<p>i. Nonprofit Research Institution</p>	<p>Yes No</p>
<p>j. Nonprofit College or University</p>	<p>Yes No</p>
<p><i>As described in section 2 of this solicitation, the offeror meets the following requirements completely:</i></p>	
<p>k. Research Agreement electronically endorsed by the SBC and RI</p>	<p>Yes No</p>
<p>l. A Signed Allocation of Rights Agreement will be available for the Contracting Officer no more than 10 business days from time of notification of selection for negotiations</p>	<p>Yes No</p>
<p>m. All 11 parts of the technical proposal are included in part order and the page limitation is met</p>	<p>Yes No</p>
<p>n. Subcontracts/consultants proposed?</p> <p>i) If yes, does the proposal comply with the subcontractor/consultant limitation? (section 2.2.4, part 9)</p>	<p>Yes No</p> <p>Yes No N/A</p>
<p>o. Federal facilities, laboratories, or equipment required?</p> <p>ii) If yes, is justification for the use uploaded in Form C?</p> <p>iii) If yes, is a signed statement of availability uploaded in Form C?</p>	<p>Yes No</p> <p>Yes No N/A</p> <p>Yes No N/A</p>
<p><i>In accordance with ITAR, 22 CFR 120-130, as applicable:</i></p>	
<p>p. The offeror understands and shall comply with export control regulations</p>	<p>Yes No</p>
<p><i>In accordance with 14 CFR 1230 and 1232 as applicable, indicate if any of the following will be used (must comply with federal regulations):</i></p>	
<p>q. Human Subject</p>	<p>Yes No</p>
<p>r. Animal Subject</p>	<p>Yes No</p>

<p><i>In accordance with FAR 52.223-13, FAR 52.223-3, 29 CFR 1910.1200(g) and the latest version of Federal Standard No. 313 as applicable, indicate if the following will be used (must comply with Federal regulations):</i></p>	
s. Toxic Chemicals	Yes No
t. Hazardous Materials	Yes No
<p><i>Indicate if the R&D to be performed is related to:</i></p>	
u. Renewable Energy	Yes No
v. Manufacturing	Yes No
<p><i>Disclosure permission:</i></p>	
w. Will you permit the Government to disclose your name, address, and telephone number of the Business Official of your concern, if your proposal 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
<p><i>As a representative of the offeror, I certify the following:</i></p>	
<p>— The offeror will notify the Federal agency immediately if all or a portion of the work proposed is subsequently funded by another Federal agency.</p>	
<p>— I understand that the information submitted may be given to Federal, State and local agencies for determining violations of law and other purposes.</p>	
<p>— 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 non-procurement transactions (FAR Subpart 9.4 or 2 C.F.R. part 180); and (6) other administrative penalties including termination of SBIR/STTR awards.</p>	

ENDORSEMENTS:

Principal Investigator:

Name:	Title:
Phone:	E-mail:

Endorsed by:	Date:
--------------	-------

Corporate/Business Official:

Name:	Title:
Phone:	E-mail:

Endorsed by:	Date:
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PROPRIETARY NOTICE (If applicable, see sections 4.4, 4.5)

NOTICE: This 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, provided that a funding agreement is awarded to the offeror as a result of or in connection with the submission of this 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 in pages _____ of this proposal.

Note: Do not mark the entire proposal as proprietary. Form B (page 2 of your proposal submission) cannot contain proprietary data. (See section 2.2.3 of the 2012 Solicitation)

Guidelines for Completing STTR Cover Sheet

Complete Cover Sheet Form A electronically via the Proposal Submission Electronic Handbook.

Proposal Number: This number does not change. The proposal number consists of the four-digit subtopic number and four-digit system-generated number.

Topic Title: Select the topic that this proposal will address. Refer to the Phase I for topic descriptions.

Subtopic Title: Select the subtopic that this proposal will address. Refer to the Phase I for subtopic descriptions.

Proposal Title: Enter a brief, descriptive title using no more than 80 keystrokes (characters and spaces). Do not use the subtopic title. Avoid words like "development" and "study."

Firm Name: Enter the full name of the firm submitting the proposal. If a joint venture, list the firm chosen to negotiate and receive contracts. If the name exceeds 40 keystrokes, please abbreviate.

Research Institution Name: Enter the full name of the partnering Research Institution.

Mailing Address: Must match CCR address and should be the address where mail is received.

City, State, Zip: City, 2-letter State designation (i.e. TX for Texas), 9-digit Zip code (i.e. 20705-3106)

Phone, Fax: Number including area code

EIN/Tax ID: Employer Identification Number/Taxpayer ID

ACN Name: Enter the name of the Authorized Contract Negotiator from your firm

ACN E-mail: Email address

ACN Phone, Ext.: Number including area code and extension (if applicable)

DUNS + 4: 9-digit Data Universal Number System; a 4-digit suffix is also required if owned by a parent concern. For information on obtaining a DUNS number go to <http://www.dnb.com>.

CAGE Code: Commercial Government and Entity Code that is issued by the Central Contractor Registration (CCR). For information on obtaining a CAGE Code, go to <http://www.ccr.gov>.

Amount Requested: Proposal amount auto-populated from Budget Summary. The amount requested should not exceed \$750,000 (see sections 1.2, 4.1.1).

Duration: Proposed duration in months. The requested duration should not exceed 24 months (see sections 1.2, 4.1.1).

Certifications: Answer Yes or No as applicable for certifications a – w (see the referenced sections for definitions). Where applicable, SBCs should make sure that their certifications on Form A agree with the content of their technical proposal.

- a. The Principal Investigator is required to be “primarily employed” by the organization or the Research Institution as defined in section 1.4.3 of the Solicitation.
- b. As required by the SBIR/STTR Policy Directive, the offeror should indicate the gender of the Principal Investigator. This data is collected for statistical purposes only.
- c. As required by the SBIR/STTR Policy Directive, the offeror should indicate if the Principal Investigator is a socially and economically disadvantaged individual as defined in 13 C.F.R. § 124.103 and 124.104. This data is collected for statistical purposes only.

- d. The firm must disclose if any essentially equivalent work has been submitted for funding or funded by another Federal agency. While it is permissible to submit essentially equivalent proposals, it is unlawful to enter into funding agreements requiring essentially equivalent work. If essentially equivalent work under this project has been submitted to other Federal agencies/programs for funding, then the SBC must provide the proposal number, proposal title, date of submission, soliciting agency, and the (anticipated) selection announcement date in subsection i. If a portion of the work has been funded by another grant, contract, or subcontract, then the SBC must provide the contract/grant number, proposal title, date of submission, awarding agency, date of award in subsection ii.
- e. The SBC is required to perform at least 40% of the work and the RI is required to perform at least 30% of the work. Refer to section 2.2.4, part 9.
- f. R/R&D must be performed in the United States (see section 1.2.2 of this Solicitation) except in rare and unique circumstances which require approval by the Contracting Officer prior to award.
- g. The offeror must certify that during the performance of the contract the R/R&D will be performed at the offeror's facilities by the offeror's employees unless otherwise indicated in the STTR proposal.
- h-j. Indicate whether the Research Institution (RI) qualifies as a FFRDC, Nonprofit Research Institution, or a Nonprofit College/University. (Only one of these should be marked as "Yes").
- k. The Research Agreement must be electronically endorsed by the authorized SBC Official and RI Official. Refer to section 2.2.5 of the Solicitation. Note: Endorsement is performed via the "Endorsement" link located in the Activity Worksheet for each proposal.
- l. Within 10 business days of the notification of selection for negotiation, the offeror must provide to the Contracting Officer a completed Allocation of Rights Agreement (ARA). The ARA shall state the allocation of intellectual property rights with respect to the proposed STTR activity and planned follow-on research, development and/or commercialization. See section 2.2.13 of the Solicitation.
- m. As stated in section 2.2 of the Solicitation, the entire proposal must not exceed the 50-page limitation and must consist of all eleven (11) required parts.
- n. By answering "Yes", the SBC certifies that subcontracts/consultants (other than the Research Institution) have been proposed and arrangements have been made to perform on the contract, if awarded.
 - i) Proposed subcontractor/consultant business arrangements must not exceed 30 percent of the research and/or analytical work (as determined by the total cost of the proposed subcontracting effort (to include the appropriate OH and G&A) in comparison to the total effort (total contract price including cost sharing, if any, less profit if any). Refer to Section 2.2.4, part 9 of the Solicitation.
- o. By answering "Yes", the SBC certifies that Federal furnished facilities, laboratories, or equipment are required to perform the proposed activities. By answering "No", the SBC certifies that no such Federal furnished facilities, laboratories, or equipment is required to perform the proposed activities. See section 2.2.4, part 8 of the Solicitation.
 - i) If proposing to use Federal facilities, laboratories, or equipment a justification statement from the SBC must be uploaded in Form C. Proposals requiring waivers must explain why the waiver is appropriate. Facilities designated as a Federal laboratory are exempt from the waiver requirement.
 - ii) If proposing to use Federal furnished facilities, laboratories, or equipment, a signed statement of availability must be uploaded in Form C that describes the uniqueness of the facility and its availability to the offeror at specified times, signed by the appropriate Government official.

- p. Offerors are responsible for ensuring compliance with export control and International Traffic in Arms (ITAR) regulations. All employees who will work on this contract must be eligible under these regulations or the offeror must have in place a valid export license or technical assistance agreement. Violations of these regulations can result in criminal or civil penalties. For further information on ITAR visit http://www.pmddtc.state.gov/regulations_laws/itar.html. For additional assistance, contact the ARC export control administrator, Mary Williams, at mary.p.williams@nasa.gov.

 - q-r. Offeror must indicate by answering “Yes” or “No” as applicable if human and/or animal subjects will be used. SBCs must be in compliance with federal regulations. Offerors should be aware of the requirement that an approved protocol by a NASA Review Board is required if the proposed work include human or animal subject. An approved protocol shall be provided to the Contracting Officer before an award can be made. Offerors shall identify the use of human or animal subject on Form A. For additional information, contact the NASA SBIR/STTR Program Management Office at ARC-SBIR-PMO@mail.nasa.gov. Reference 14 CFR 1230 and 1232. (See section 4.10.5)

 - s-t. Offeror must indicate by answering “Yes” or “No” as applicable if toxic chemicals and/or hazardous materials will be used. SBCs must be in compliance with federal regulations. Reference FAR 52.223-13 Certification of Toxic Chemical Release Reporting and FAR 52.223-3 Hazardous Material identification and Material Safety Identification.
- Offerors must list any hazardous material to be delivered under this contract. The apparently successful offeror agrees to submit, for each item as required prior to award, a Material Safety Data Sheet, meeting the requirements of 29 CFR 1910.1200(g) and the latest version of Federal Standard No. 313, for all hazardous material identified in paragraph (b) of this clause. Data shall be submitted in accordance with Federal Standard No. 313, whether or not the apparently successful offeror is the actual manufacturer of these items. Failure to submit the Material Safety Data Sheet prior to award may result in the apparently successful offeror being considered non-responsible and ineligible for award.
- u. Answer “Yes” if this proposal has a connection to energy efficiency or alternative and renewable energy. This should also be indicated in part 5 (Related R/R&D) of the proposal with a brief explanation of how it is related to energy efficiency or alternative and renewable energy.

 - v. Answer “Yes” if this proposal has a connection to manufacturing. This should also be indicated in part 5 (Related R/R&D) of the proposal with a brief explanation of how it is related to manufacturing.

 - w. The offeror must indicate if they permit the Government to disclose the name, address, and telephone number of the Business Official of your concern, if the proposal does not result in an award, to appropriate local and State-level economic development organizations that may be interested in contacting the Business Official for further information.

Electronic Endorsement:

Electronic endorsement is performed by the Principal Investigator and the authorized Business Official from the “Endorsement” link located on the Activity Worksheet for each proposal. Electronic endorsement by the Business Official is the final step in the proposal submission process and can only be performed when all required sections of the proposal submission are complete and the Principal Investigator and Research Institution Official have performed their separate electronic endorsements. Once endorsed, the name and date of endorsement will populate under the Endorsement section of this form. If any changes are made to the submission after endorsement by the Principal Investigator and/or Business Official, the proposal must be re-endorsed to be considered complete and submitted.

Endorsement of the proposal by the Business Official certifies that all information submitted in connection with this application is true and correct as of the date of submission. 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 non-procurement transactions (FAR Subpart 9.4 or 2 C.F.R. part 180); and (6) other administrative penalties including termination of SBIR/STTR awards.

Form B – STTR Proposal Summary

Subtopic No. System generated 4-digits
 Proposal Number: - - . - - - - - - -
 Subtopic Title:
 Proposal Title:

Small Business Concern:

Name:
 Address:
 City/State/Zip:
 Phone:

Principal Investigator/Project Manager:

Name:
 Address:
 City/State/Zip:
 Phone: Extension:
 E-mail:

Business Official:

Name:
 Address:
 City/State/Zip:
 Phone: Extension:
 E-mail:

Estimated Technology Readiness Level (TRL) at beginning and end of contract:

Begin: _____
 End: _____

Technology Available (TAV):

All subtopics listed in this solicitation have Technology Available (TAV) with NASA Intellectual Property. The use of the NASA IP is strictly voluntary. Refer to section 1.5 of the Solicitation for additional information.

Do you plan to use NASA Intellectual Property (IP) under the award? Yes No

If yes, [click here](#) to access the NASA Research License Application that must be completed and appended to your technical proposal.

Technical Abstract: (Limit 2,000 characters, approximately 200 words)

Potential NASA Application(s): (Limit 1,500 characters, approximately 150 words)

Potential Non-NASA Application(s): (Limit 1,500 characters, approximately 150 words)

Technology Taxonomy: (Select only the technologies relevant to this specific proposal)

NASA's technology taxonomy has been developed by the SBIR/STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.

Guidelines for Completing STTR Proposal Summary

Complete Proposal Summary Form B electronically via the Proposal Submission Electronic Handbook.

Proposal Number: Auto-populated with proposal number as shown on Cover Sheet.

Subtopic Title: Auto-populated with subtopic title as shown on Cover Sheet.

Proposal Title: Auto-populated with proposal title as shown on Cover Sheet.

Small Business Concern: Auto-populated with firm information as shown on Cover Sheet.

Research Institution: Auto-populated with RI information as shown on Cover Sheet.

Principal Investigator/Project Manager: Enter the full name of the PI/PM and include all required contact information.

Technology Readiness Level (TRL): Provide the estimated Technology Readiness Level (TRL) at the beginning and end of the contract. See Appendix B for TRL definitions.

Technical Abstract: Summary of the offeror's proposed project is limited to 2,000 characters, approximately 200 words, and shall summarize the implications of the approach and the anticipated results of the Phase II. NASA will reject a proposal if the technical abstract is determined to be non-responsive to the subtopic. The abstract must not contain proprietary information and must describe the NASA need addressed by the proposed R/R&D effort.

Potential NASA Application(s): Summary of the direct or indirect NASA applications of the innovation, assuming the goals of the proposed R/R&D are achieved. The response is limited to 1,500 characters, approximately 150 words.

Potential Non-NASA Application(s): Summary of the direct or indirect NASA applications of the innovation, assuming the goals of the proposed R/R&D are achieved. The response is limited to 1,500 characters, approximately 150 words.

Technology Taxonomy: Selections for the technology taxonomy are limited to technologies supported or relevant to the specific proposal. The listing of technologies for the taxonomy is provided in Appendix C.

Form C – STTR Budget Summary

PROPOSAL NUMBER:

SMALL BUSINESS CONCERN:

(1) DIRECT LABOR:

Category	Description	Education	Years of Experience	Hours	Rate	Fringe Rate % (if applicable)	Total
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Document uploaded for labor rate documentation: (file name)

TOTAL DIRECT LABOR:

(1)

\$ _____

(2) OVERHEAD COST;

_____ % of Total Direct Labor or \$ _____

Comments:

Overhead Cost Sources:

OVERHEAD COST:

(2)

\$ _____

(3) OTHER DIRECT COSTS (ODCs):

Materials:

Description: _____

Vendor: _____

Quantity: _____ Cost: _____

Consumable? Yes No

Competitively Sourced? Yes No

Used Exclusively for this Contract? Yes No

Supporting Comments: _____

Supporting Documents: (file name)

Supplies:

Description: _____

Vendor: _____

Quantity: _____ Cost: _____

Consumable? Yes No

Competitively Sourced? Yes No

Used Exclusively for this Contract? Yes No

Supporting Comments: _____

Supporting Documents: (file name)

Equipment:

Description: _____
 Vendor: _____
 Quantity: _____ Cost: _____
 Competitively Sourced? Yes No
 Used Exclusively for this Contract? Yes No
 Supporting Comments: _____
 Supporting Documents: (file name) _____

Other:

Description: _____
 Vendor: _____
 Quantity: _____ Cost: _____
 Competitively Sourced? Yes No
 Used Exclusively for this Contract? Yes No
 Supporting Comments: _____
 Supporting Documents: (file name) _____

Travel:

Location From: _____ Location To: _____
 Number of People: _____ Number of Days: _____
 Purpose of Trip: _____
 Airfare: _____ Car Rental: _____
 Per Diem: _____ Other Costs: _____
 Total Costs: _____
 Sources of Estimates: _____
 Explanation/Justification: _____

Explanation of ODCs:

Provide any additional information on the Other Direct Costs listed above, including the basis used for estimating the costs.

Subcontractor/Consultants:	Total Cost:
_____	_____
_____	_____
_____	_____

Supporting Documents: (file name) _____

(Note: Separate Budget Summaries completed for all proposed Subcontractors/Consultants via the Subcontractors/Consultants section of Form C)

Research Institution:	Total Cost:
_____	_____

(Note: Separate Budget Summary completed for the Research Institution via the Research Institution section of Form C)

	TOTAL OTHER DIRECT COSTS:	
	(3)	\$ _____
(1)+(2)+(3)=(4)	SUBTOTAL:	
	(4)	\$ _____

(5) GENERAL & ADMINISTRATIVE (G&A) COSTS

_____ % of Subtotal or \$ _____

G&A COSTS:**(5)**

\$ _____

Comments:

If an audit rate is not available, provide a detailed explanation of the cost base used to develop the G&A rate and if possible, a historical actual G&A rate for the past three years.

G&A Cost Elements:

(4)+(5)=(6)**TOTAL COSTS****(6)**

\$ _____

(7) ADD PROFIT or SUBTRACT COST SHARING PROFIT/COST SHARING:**(As applicable)****(7)**

\$ _____

Comments:**(6)+(7)=(8)****AMOUNT REQUESTED:****(8)**

\$ _____

PHASE II DELIVERABLES:

SBCs will be required to submit mandatory deliverables such as progress reports, final report and New Technology Report as per their contract. If your firm is proposing any additional deliverables, list them below:

Deliverable	Quantity	Project Deliverable Milestone
_____	_____	_____
_____	_____	_____
_____	_____	_____

FEDERAL FACILITIES, LABORATORIES, OR EQUIPMENT:

If you require the use of a Federal facility, laboratory or equipment, identify it below as well as in part 8 of your technical proposal and upload a signed statement of availability from the Government agency. In addition, a letter of justification should be uploaded. (See certification j on Form A and section 2.2.4, part 8).

AUDIT AGENCY:

If your firm's accounting system has been audited, are the rates from that audit agreement used for this proposal?

- ☐ The rates listed in the negotiated rate agreement were used to prepare the budget summary
☐ Other rates were used to prepare the budget summary
☐ My firm's accounting system has not been audited

If the listed rates are not being used to prepare the budget summary, please provide an explanation:

Guidelines for Preparing STTR Budget Summary

Complete Budget Summary Form C electronically.

The offeror shall electronically submit a price proposal of estimated costs with detailed information for each cost element, consistent with the offeror's cost accounting and estimating system.

This summary does not eliminate the need to fully document and justify the amounts requested in each category. Such documentation should be contained, as appropriate, in the text boxes or via uploads as indicated in the electronic form.

Offerors with questions about the appropriate classification of costs are advised to consult with an experienced accountant that has experience in government contracting and cost accounting principals. Information provided by the Defense Contract Audit Administration in their publication "Information for Contractors" may also be useful. This publication can be found via the following site under publications: <http://www.dcaa.mil/>

Firm: Same as Cover Sheet.

Proposal Number: Same as Cover Sheet.

Direct Labor: Select the appropriate labor category for each person who will be working directly on the proposed research effort and provide the labor description, level of education, years of experience, total number of hours, labor rate, and fringe rate percentage (if applicable). Detail the labor hours used for each year of the proposed research effort separately.

Labor rate documentation should include costs that are included in the fringe rate percentage (if applicable). Provide the breakout rate such as the labor hour rate, health benefits, life insurance etc. Some examples of direct labor include Principal Investigator, Engineer, Scientist, Analyst or Research Assistant/Laboratory Assistant. All listed categories shall be directly related to proposed work to be performed under contract with NASA. Any contributions from non-technical personnel proposed under direct labor shall be explicitly explained. Labor rates that do not compare favorably to comparable state average rates at <http://www.bls.gov> require additional documentation, supporting the proposed rate or salary.

Note: Costs associated with firm executives, accountants or administrative support are typically included in a firm's general and administrative costs. If these costs are being proposed as direct labor then provide the details of how the proposed hours were allocated to this effort and verify that these costs are not also covered in your overhead or G&A rate.

Overhead Cost: Specify current rate and base. Use current rate(s) negotiated with your firm's cognizant Federal-auditing agency, if available. A rate that has not been audited requires a detailed explanation of the cost base used to develop the rate and if possible, historical actual overhead rates for the past three years.

Specify the cost elements of the firm's overhead costs in the text boxes provided. Possible overhead cost elements include insurance, sick leave, and vacation.

Note: If no labor overhead rate is proposed and the proposed direct labor includes all fringe benefits, you may enter "0" for the overhead cost line.

Other Direct Costs (ODCs): Refer to FAR 31.205 – Selected Costs for determination of cost allowability.

Materials and Supplies: Under the Materials and Supplies sections, indicate type, vendor, quantity required, and cost. Identify whether each item is consumable, which year it will be purchased, if it was competitively sourced, and if it will be used exclusively for this contract. Your proposed cost shall be justified and supporting documents should be uploaded. General materials or supplies without adequate explanation of the components, quantity and use of said items are not an acceptable breakdown. In the supporting comments block, provide the basis for the proposed price (vendor quote, competitive quotes, catalog price, estimate, etc.). The Contracting Officer will make the final determination.

Special Tooling, Testing, and Test Equipment: The need for these items, if proposed, will be carefully reviewed. Equipment must be made in the USA to the maximum extent practical. The offeror should provide competitive quotes to support the proposed costs or should justify why only one source is available. Competitive quotes may be signed quotes from vendors or copies of catalogue pages. Normally the costs of any equipment should be quoted on a purchase basis, unless the offeror can demonstrate that lease or rent of the equipment is clearly advantageous to the government. The Contracting Officer will make the final determination. Upload supporting documentation as necessary. In the supporting comments block provide the basis for the proposed price (vendor quote, competitive quotes, catalog price, estimate, etc.). The Contracting Officer will make the final determination.

Travel: All proposed travel must be necessary for the success of the research. Include a detailed accounting of all proposed expenses to include the purpose of proposed trips, number of trips, travelers per trip, as well as meals, hotel, and rental car estimated costs. Sources of estimate should be identified when travel is proposed along with a justification for each trip. Proposed travel costs shall be in accordance with the Federal Travel Regulation <http://www.gsa.gov/federaltravelregulation>.

Subcontracts/Consultants: Subcontracts/Consultants costs are included in the Other Direct Costs total. A separate budget summary must be completed for each subcontract/consultant proposed. Further instructions are provided in the Subcontracts/Consultants section below.

Note: Do not add subcontractors or consultants as a line item under the ODCs section of Form C. It will automatically be added to the ODCs upon completion of the separate Subcontractor/Consultant budget summary form.

Research Institution: Research Institution costs are included in the Other Direct Costs total. A separate budget summary must be completed for the Research Institution. Further instructions are provided in the Research Institution section below.

Note: Do not add the Research Institution as a line item under the ODCs section of Form C. It will automatically be added to the ODCs upon completion of the separate Research Institution budget summary form.

Other: List all other direct costs that are not otherwise included in the categories described above such as rental of facilities, etc.

Note: The purchase of equipment, instrumentation, or facilities under SBIR/STTR must be justified by the offeror and approved by the government during contract negotiations. Firms should be prepared to justify all material, supplies, and equipment costs during negotiations. See section 2.2.4, part 8 for further guidance.

Explanation of ODCs: Provide any additional information for the proposed ODCs, including basis for cost estimation, in the text box provided.

Subcontracts/Consultants: List consultants by name and specify, for each, the number of hours and hourly costs. Detailed quotes from subcontractors should be provided in the same format. Note that a subcontract entered into for performance of research or research and development differs from an arrangement with a vendor to provide a service such as machining, analysis with test equipment or use of computer time. The costs of such arrangements with vendors should be covered under Special Tooling, Testing, Test Equipment and Material or under Other Direct Costs. Upon request of the contracting officer, the subcontractor's cost proposals may be sealed or mailed directly for government eyes only.

A letter of commitment shall be uploaded for each proposed subcontractor/consultant from the Subcontractor/Consultant Letter of Commitment section of the subcontractor/consultant budget summary form. If a commitment letter is not available, you must upload alternate documentation that sufficiently substantiates that the subcontractor/consultant is available to perform the proposed work during the proposed timeframe. Note that not providing the information now may delay contract negotiations and award.

Research Institution: Provide detailed budget information for the costs associated with the Research Institution.

General and Administrative (G&A) Costs: Specify a current rate and base to which G&A costs will be applied. If available, use the current rate recommendations from the cognizant Federal-auditing agency. If an audit rate is not available, provide a detailed explanation of the cost base used to develop the rate and if possible, a historical actual G&A rate for the past three years.

Specify the elements of the firm's G&A costs in the text boxes provided. Possible G&A cost elements include rent, utilities, and management.

Profit/Cost Sharing: See sections 4.6 and 4.7. Profit is to be added to total cost, while shared costs are to be subtracted from total cost, as applicable.

Amount Requested: The amount requested is equal to the sum of the Direct Labor, Overhead, ODCs, G&A and any profit, less any cost sharing. The amount requested cannot exceed \$750,000 for Phase II.

Federal Facilities, Laboratories, and Equipment: If you require the use of Federal facilities, laboratories, or equipment, identify the Federal facilities, laboratories or equipment in the text box provided, as well as in part 8 of your technical proposal, and upload a signed statement of availability from the Government agency. Please note that this section SHALL be completed if you certified in Form A that you will require the use of Federal facilities. Leave this section BLANK if you DO NOT require the use of Federal facilities, laboratories, or equipment.

Audit Information: Complete the Audit Information section of Form C to indicate if your firm's accounting system has been audited and if the rates from that audit agreement are used for this proposal.

Note: There is a separate "Audit Information" section linked from your Activity Worksheet that must also be completed.

Model Research Agreement

By virtue of the signatures of our authorized representatives, _____ (Small Business Concern), and _____ (Research Institution), have agreed to cooperate on the _____ (Proposal Title) Project, in accordance with the proposal being submitted with this agreement.

This agreement shall be binding until the completion of all Phase I activities, at a minimum. If the _____ (Proposal Title) Project is selected to continue into Phase II, the agreement may also be binding in Phase II activities that are funded by NASA, then this agreement shall be binding until those activities are completed. The agreement may also be binding in Phase III activities that are funded by NASA.

After notification of Phase I selection and prior to contract release, we shall prepare and submit, if requested by NASA, an **Allocation of Rights Agreement**, which shall state our rights to the intellectual property and technology to be developed and commercialized by the _____ (Proposal Title) Project. We understand that our contract cannot be approved and project activities may not commence until the **Allocation of Rights Agreement** has been signed and certified to NASA.

Please direct all questions and comments to _____ (Small Business Concern representative) at (Phone Number) _____.

Signature

Name/title

Small Business Concern

Signature

Name/title

Research Institution

Small Business Technology Transfer (STTR) Program Model Allocation of Rights Agreement

This Agreement between _____, a small business concern organized as a _____ under the laws of _____ and having a principal place of business at _____, ("SBC") and _____, a research institution having a principal place of business at _____, ("RI") is entered into for the purpose of allocating between the parties certain rights relating to an STTR project to be carried out by SBC and RI (hereinafter referred to as the "PARTIES") under an STTR funding agreement that may be awarded by _____ NASA _____ to SBC to fund a proposal entitled " _____ " submitted, or to be submitted, to by SBC on or about _____, 20____.

8. Applicability of this Agreement.

- (a) This Agreement shall be applicable only to matters relating to the STTR project referred to in the preamble above.
- (b) If a funding agreement for STTR project is awarded to SBC based upon the STTR proposal referred to in the preamble above, SBC will promptly provide a copy of such funding agreement to RI, and SBC will make a sub-award to RI in accordance with the funding agreement, the proposal, and this Agreement. If the terms of such funding agreement appear to be inconsistent with the provisions of this Agreement, the Parties will attempt in good faith to resolve any such inconsistencies.

However, if such resolution is not achieved within a reasonable period, SBC shall not be obligated to award nor RI to accept the sub-award. If a sub-award is made by SBC and accepted by RI, this Agreement shall not be applicable to contradict the terms of such sub-award or of the funding agreement awarded by NASA to SBC except on the grounds of fraud, misrepresentation, or mistake, but shall be considered to resolve ambiguities in the terms of the sub-award.

9. The provisions of this Agreement shall apply to any and all consultants, subcontractors, independent contractors, or other individuals employed by SBC or RI for the purposes of this STTR project.

- (d) Background Intellectual Property.
- (e) "Background Intellectual Property" means property and the legal right therein of either or both parties developed before or independent of this Agreement including inventions, patent applications, patents, copyrights, trademarks, mask works, trade secrets and any information embodying proprietary data such as technical data and computer software.
- (f) This Agreement shall not be construed as implying that either party hereto shall have the right to use Background Intellectual Property of the other in connection with this STTR project except as otherwise provided hereunder.
 - (1) The following Background Intellectual Property of SBC may be used nonexclusively and except as noted, without compensation by RI in connection with research or development activities for this STTR project (if "none" so state):

_____;

- (2) The following Background Intellectual Property of RI may be used nonexclusively and, except as noted, without compensation by SBC in connection with research or development activities for this STTR project (if "none" so state):

- (3) The following Background Intellectual Property of RI may be used by SBC nonexclusively in connection with commercialization of the results of this STTR project, to the extent that such use is reasonably necessary for practical, efficient and competitive commercialization of such results but not for commercialization independent of the commercialization of such results, subject to any rights of the Government therein and upon the condition that SBC pay to RI, in addition to any other royalty including any royalty specified in the following list, a royalty of _____% of net sales or leases made by or under the authority of SBC of any product or service that embodies, or the manufacture or normal use of which entails the use of, all or any part of such Background Intellectual Property (if "none" so state):

10. Project Intellectual Property.

- (g) "Project Intellectual Property" means the legal rights relating to inventions (including Subject Inventions as defined in 37 CFR § 401), patent applications, patents, copyrights, trademarks, mask works, trade secrets and any other legally protectable information, including computer software, first made or generated during the performance of this STTR Agreement.
- (h) Except as otherwise provided herein, ownership of Project Intellectual Property shall vest in the party whose personnel conceived the subject matter, and such party may perfect legal protection in its own name and at its own expense. Jointly made or generated Project Intellectual Property shall be jointly owned by the Parties unless otherwise agreed in writing. The SBC shall have the first option to perfect the rights in jointly made or generated Project Intellectual Property unless otherwise agreed in writing.
- (1) The rights to any revenues and profits, resulting from any product, process, or other innovation or invention based on the cooperative shall be allocated between the SBC and the RI as follows:
- SBC Percent: _____ RI Percent: _____
- (2) Expenses and other liabilities associated with the development and marketing of any product, process, or other innovation or invention shall be allocated as follows: the SBC will be responsible for _____ percent and the RI will be responsible for _____ percent.
- (i) The Parties agree to disclose to each other, in writing, each and every Subject Invention, which may be patentable or otherwise protectable under the United States patent laws in Title 35, United States Code. The Parties acknowledge that they will disclose Subject Inventions to each other and the Agency within two months after their respective inventor(s) first disclose the invention in writing to the person(s) responsible for patent matters of the disclosing Party. All written disclosures of such inventions shall contain sufficient detail of the invention, identification of any statutory bars, and shall be marked confidential, in accordance with 35 U.S.C. § 205.
- (j) Each party hereto may use Project Intellectual Property of the other nonexclusively and without compensation in connection with research or development activities for this STTR project, including inclusion in STTR project reports to the AGENCY and proposals to the AGENCY for continued funding of this STTR project through additional phases.

- (k) In addition to the Government's rights under the Patent Rights clause of 37 CFR § 401.14, the Parties agree that the Government shall have an irrevocable, royalty free, nonexclusive license for any Governmental purpose in any Project Intellectual Property.
- (l) SBC will have an option to commercialize the Project Intellectual Property of RI, subject to any rights of the Government therein, as follows -
- (1) Where Project Intellectual Property of RI is a potentially patentable invention, SBC will have an exclusive option for a license to such invention, for an initial option period of _____ months after such invention has been reported to SBC. SBC may, at its election and subject to the patent expense reimbursement provisions of this section, extend such option for an additional _____ months by giving written notice of such election to RI prior to the expiration of the initial option period. During the period of such option following notice by SBC of election to extend, RI will pursue and maintain any patent protection for the invention requested in writing by SBC and, except with the written consent of SBC or upon the failure of SBC to reimburse patenting expenses as required under this section, will not voluntarily discontinue the pursuit and maintenance of any United States patent protection for the invention initiated by RI or of any patent protection requested by SBC. For any invention for which SBC gives notice of its election to extend the option, SBC will, within _____ days after invoice, reimburse RI for the expenses incurred by RI prior to expiration or termination of the option period in pursuing and maintaining (i) any United States patent protection initiated by RI and (ii) any patent protection requested by SBC. SBC may terminate such option at will by giving written notice to RI, in which case further accrual of reimbursable patenting expenses hereunder, other than prior commitments not practically revocable, will cease upon RI's receipt of such notice. At any time prior to the expiration or termination of an option, SBC may exercise such option by giving written notice to RI, whereupon the parties will promptly and in good faith enter into negotiations for a license under RI's patent rights in the invention for SBC to make, use and/or sell products and/or services that embody, or the development, manufacture and/or use of which involves employment of, the invention. The terms of such license will include: (i) payment of reasonable royalties to RI on sales of products or services which embody, or the development, manufacture or use of which involves employment of, the invention; (ii) reimbursement by SBC of expenses incurred by RI in seeking and maintaining patent protection for the invention in countries covered by the license (which reimbursement, as well as any such patent expenses incurred directly by SBC with RI's authorization, insofar as deriving from RI's interest in such invention, may be offset in full against up to _____ of accrued royalties in excess of any minimum royalties due RI); and, in the case of an exclusive license, (3) reasonable commercialization milestones and/or minimum royalties.
 - (2) Where Project Intellectual Property of RI is other than a potentially patentable invention, SBC will have an exclusive option for a license, for an option period extending until _____ months following completion of RI's performance of that phase of this STTR project in which such Project Intellectual Property of RI was developed by RI. SBC may exercise such option by giving written notice to RI, whereupon the parties will promptly and in good faith enter into negotiations for a license under RI's interest in the subject matter for SBC to make, use and/or sell products or services which embody, or the development, manufacture and/or use of which involve employment of, such Project Intellectual Property of RI. The terms of such license will include: (i) payment of reasonable royalties to RI on sales of products or services that embody, or the development, manufacture or use of which involves employment of, the Project Intellectual Property of RI and, in the case of an exclusive license, (ii) reasonable commercialization milestones and/or minimum royalties.

- (3) Where more than one royalty might otherwise be due in respect of any unit of product or service under a license pursuant to this Agreement, the parties shall in good faith negotiate to ameliorate any effect thereof that would threaten the commercial viability of the affected products or services by providing in such license(s) for a reasonable discount or cap on total royalties due in respect of any such unit.

11. Follow on Research or Development.

All follow on work, including any licenses, contracts, subcontracts, sublicenses or arrangements of any type, shall contain appropriate provisions to implement the Project Intellectual Property rights provisions of this agreement and insure that the Parties and the Government obtain and retain such rights granted herein in all future resulting research, development, or commercialization work.

12. Confidentiality/Publication.

- (c) Background Intellectual Property and Project Intellectual Property of a party, as well as other proprietary or confidential information of a party, disclosed by that party to the other in connection with this STTR project shall be received and held in confidence by the receiving party and, except with the consent of the disclosing party or as permitted under this Agreement, neither used by the receiving party nor disclosed by the receiving party to others, provided that the receiving party has notice that such information is regarded by the disclosing party as proprietary or confidential. However, these confidentiality obligations shall not apply to use or disclosure by the receiving party after such information is or becomes known to the public without breach of this provision or is or becomes known to the receiving party from a source reasonably believed to be independent of the disclosing party or is developed by or for the receiving party independently of its disclosure by the disclosing party.
- (d) Subject to the terms of paragraph (a) above, either party may publish its results from this STTR project. However, the publishing party will give a right of refusal to the other party with respect to a proposed publication, as well as a _____ day period in which to review proposed publications and submit comments, which will be given full consideration before publication. Furthermore, upon request of the reviewing party, publication will be deferred for up to _____ additional days for preparation and filing of a patent application which the reviewing party has the right to file or to have filed at its request by the publishing party.

13. Liability.

- (c) Each party disclaims all warranties running to the other or through the other to third parties, whether express or implied, including without limitation warranties of merchantability, fitness for a particular purpose, and freedom from infringement, as to any information, result, design, prototype, product or process deriving directly or indirectly and in whole or part from such party in connection with this STTR project.
- (d) SBC will indemnify and hold harmless RI with regard to any claims arising in connection with commercialization of the results of this STTR project by or under the authority of SBC. The PARTIES will indemnify and hold harmless the Government with regard to any claims arising in connection with commercialization of the results of this STTR project.

14. Termination.

- (c) This agreement may be terminated by either Party upon __ days written notice to the other Party. This agreement may also be terminated by either Party in the event of the failure of the other Party to comply with the terms of this agreement.
- (d) In the event of termination by either Party, each Party shall be responsible for its share of the costs incurred through the effective date of termination, as well as its share of the costs incurred after the effective date of termination, and which are related to the termination. The confidentiality, use, and/or nondisclosure obligations of this agreement shall survive any termination of this agreement.

AGREED TO AND ACCEPTED

Small Business Concern

By: _____ Date: _____
Print Name: _____
Title: _____

Research Institution

By: _____ Date: _____
Print Name: _____
Title: _____

STTR Check List

For assistance in completing your Phase II proposal, use the following checklist to ensure your submission is complete.

- 1. The entire proposal including any supplemental material shall not exceed a total of 25 8.5 x 11 inch pages, including the Research Agreement, and follow the format requirements (sections 2.2.2, 2.2.5).**
2. The proposal and innovation is submitted for one subtopic only.
3. The entire proposal is submitted consistent with the requirements and in the order outlined in section 2.2.
4. The technical proposal contains all eleven parts in order (section 2.2.4).
5. The 1-page briefing chart does not include any proprietary data (section 2.2.7).
6. Certifications in Form A are completed, and agree with the content of the technical proposal.
7. Proposed funding does not exceed \$750,000 (section 1.2, 4.1.1).
8. Proposed project duration does not exceed 24 months (section 1.2, 4.1.1).
9. Research Agreement has been electronically endorsed by both the SBC Official and the RI (sections 2.2.5, 5.2).
10. Entire proposal including Forms A, B, C, and Research Agreement submitted via the Internet
11. Form A electronically endorsed by the SBC Official and the PI.
- 12. Phase II proposal submissions will be due after the last day of the Phase I contract (section 5.3).**
13. Signed Allocation of Rights Agreement, available for the Contracting Officer at the time of selection.

9. Research Topics for SBIR and STTR

9.1 SBIR Research Topics

Introduction

The SBIR Program Solicitation topics and subtopics are developed by the NASA Mission Directorates and Centers in coordination with the NASA SBIR/STTR programs.

There are three Mission Directorates (MDs):

Aeronautics Research
Human Exploration and Operations
Science

9.1.1 AERONAUTICS RESEARCH

NASA's Aeronautics Research Mission Directorate (ARMD) expands the boundaries of aeronautical knowledge for the benefit of the Nation and the broad aeronautics community, which includes the Agency's partners in academia, industry, and other government agencies. ARMD is conducting high-quality, cutting-edge research at the fundamental level and integrated systems level to support current and emerging applications as well as revolutionary concepts and technologies that could one day enable radical change to both the airspace system and the aircraft that fly within it, facilitating a safer, more environmentally friendly, and more efficient air transportation system. At the same time, we are ensuring that aeronautics research and critical core competencies continue to play a vital role in support of NASA's goals for both manned and robotic space exploration.

ARMD is also directly addressing fundamental research challenges that must be overcome in order to implement the Next Generation Air Transportation System (NextGen). NextGen is the name given to a new National Airspace System that proposes to transform America's air traffic control system from an aging ground-based system to a satellite-based system. NextGen technology will provide advanced levels of automated support to air navigation service providers and aircraft operators enabling shortened routes for time and fuel savings, reduced traffic delays, increased capacity, and permitting controllers to monitor and manage aircraft with greater safety margins. This transformation has the aim of reducing gridlock, both in the sky and at airports. In conjunction with expanding air traffic management capabilities, research is being conducted to help address substantial noise, emissions, efficiency, performance, and safety challenges that are required to ensure vehicles can support the NextGen vision.

NASA's Aeronautics Research Mission Directorate (ARMD) supports the Agency's goal (Goal 4) to advance aeronautics research for societal benefit. The ARMD research plans directly support the National Aeronautics Research and Development Policy and accompanying Executive Order signed by the President on December 20, 2006.

Beginning in 2012, ARMD will issue more focused solicitations by rotating subtopics every other year. The reduction in the scope of the solicitation does not imply a change in interest in a given area. For example, in 2012 we are soliciting proposals for airframe noise reduction and efficiency improvement (through drag reduction). In 2013 we plan to solicit proposals for air engine noise and efficiency reductions. Then in 2014 we will return to airframe noise and efficiency improvement.

(<http://www.aeronautics.nasa.gov/>)

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TOPIC: A1 Aviation Safety

The Aviation Safety Program conducts fundamental research and technology development of known and predicted safety concerns as the nation transitions to the Next Generation Air Transportation System (NextGen). Future challenges to maintaining aviation safety arise from expected significant increases in air traffic, continued operation of legacy vehicles, introduction of new vehicle concepts, increased reliance on automation, and increased operating complexity. Further design challenges also exist where safety barriers may prevent the technical innovations necessary to achieve NextGen capacity and efficiency goals. The program seeks capabilities furthering the practice of proactive safety management and design methodologies and solutions to predict and prevent safety issues, to monitor for them in-flight and mitigate against them should they occur, to analyze and design them out of complex system behaviors, and to constantly analyze designs and operational data for potential hazards. AvSP's top ten technical challenges are:

- Assurance of Flight Critical Systems.
- Discovery of Precursors to Safety Incidents.
- Assuring Safe Human-Systems Integration.
- Prognostic Algorithm Design for Safety Assurance.
- Vehicle Health Assurance.
- Crew-System Interactions and Decisions.
- Loss of Control Prevention, Mitigation, and Recovery.
- Engine Icing.
- Airframe Icing.
- Atmospheric Hazard Sensing & Mitigation.

AvSP includes three research projects:

- The System-wide Safety Assurance Technologies Project provides knowledge.
- Concepts and methods to proactively manage increasing complexity in the design and operation of vehicles.
- Air transportation systems, including advanced approaches to enable improved and cost-effective verification and validation of flight-critical systems.

The Vehicle Systems Safety Technologies Project identifies risks and provides knowledge to avoid, detect, mitigate, and recover from hazardous flight conditions, and to maintain vehicle airworthiness and health. The Atmospheric Environment Safety Technologies Project investigates sources of risk and provides technology needed to help ensure safe flight in and around atmospheric hazards. NASA seeks highly innovative proposals that will complement its work in science and technologies that build upon and advance the Agency's unique safety-related research capabilities vital to aviation safety. Additional information is available at (http://www.aeronautics.nasa.gov/programs_avsafe.htm).

A1.01 Aviation External Hazard Sensor Technologies

Lead Center: LaRC

Participating Center(s): DFRC, GRC

NASA is concerned with the prevention of encounters with hazardous in-flight conditions and the mitigation of their effects when they do occur. Hazardous flight conditions of particular interest are: wake vortices, clear-air turbulence, in-flight icing, lightning, and low visibility. NASA is interested in new and innovative methods for detection, identification, evaluation, and monitoring of in-flight hazards to aviation. In the case of lightning, interest is centered on the mitigation and in-flight measurement of lightning damage, particularly to composite aircraft.

NASA seeks to foster research and development that leads to innovative new technologies and methods, or significant improvements in existing technologies, for in-flight hazard avoidance and mitigation. Technologies may take the form of tools, models, techniques, procedures, substantiated guidelines, prototypes, and devices. Proposed products may be for retrofit into current aircraft or for installation in future aircraft. Both manned and unmanned aircraft are of interest.

A key objective of the NASA Aviation Safety Program is to support the research of technology, systems, and methods that will facilitate transformation of the National Airspace System to Next Generation Air Transportation System (NextGen) (information available at www.jpdo.gov). The general approach to the development of airborne sensors for NextGen is to encourage the development of multi-use, adaptable, and effective sensors that will have a strong benefit to safety. The greatest impact will result from improved sensing capability in the terminal area, where higher density and more reliable operations are required for NextGen.

Under this subtopic, proposals are invited that explore new and improved sensors and sensor systems for the detection and monitoring of hazards to aircraft before they are encountered. With regard to hazardous lightning conditions, the emphasis is not on remote detection, but rather on developing systems that make aircraft more robust in a lightning environment or provide in-flight damage assessment or other hazard mitigating benefits. The scope of this subtopic does not include human factors and focused development of human interfaces, including displays and alerts. Primary emphasis is on airborne applications, but in some cases the development of ground-based sensor technology may be supported. Approaches that use multiple sensors in combination to improve hazard detection and quantification of hazard levels are also of interest.

Areas of particular interest to NASA at this time are described in more detail below. The list and details are provided as encouragement but are not intended to exclude other proposals that fit the scope of this subtopic.

Turbulence and Wake Vortex

- *Remote detection of kinetic air hazards* - The class of hazards including wake vortices, turbulence, and other hazards associated with air motion is referred to as kinetic air hazards. Within this class, wakes and turbulence are the highest priorities; however, NASA is particularly interested in sensor systems that can detect multiple hazards and thus provide greater utility. For example, air data systems are at times disabled by icing, and a multi-function, multi-hazard sensor that includes a robust alternative air data source would be a great asset in such conditions.
- *Airborne detection of wake vortices* - Airborne detection of wake vortices is considered challenging due to the fact that detection must be possible in nearly all weather conditions, in order to be practical, and because of the size and nature of the phenomena. In particular, NASA is interested in the ability to detect and measure wake vortex hazards for arbitrary viewing angles.
- *Airborne detection of turbulence* - NASA has made a major investment in the development of new and enhanced technologies to enable detection of turbulence to improve aviation safety. Progress has been made in efforts to quantify hazard levels from convectively induced turbulence events and to make these quantitative assessments available to civil and commercial aviation. NASA is interested in expanding these prior efforts to take advantage of the newly developing turbulence monitoring technologies, particularly those focused on clear air turbulence (CAT). NASA welcomes proposals that explore the methods, algorithms and quantitative assessment of turbulence for the purpose of increasing aviation safety and augmenting currently available data in support of NextGen operations.

Lightning

- *Lightning Strike Protection* - NASA is investigating means for mitigating damage to aircraft, with a particular interest in protecting composite aircraft. Currently, an electrically-conductive screen protects composite aircraft by functioning as a Faraday shield and is intended to confine lightning and electromagnetic effects to the outside or outermost skin of the aircraft. The lightning strike protection system, hereafter referred to as the LSP, is incorporated in the coatings, layers, and structure that comprise the skin of the aircraft. NASA is most interested in LSP solutions that will be cost effective and lightweight.
- *Mitigation of lightning strike damage* - NASA is seeking solutions that will provide better protection from lightning damage by directing attachment points or lightning currents to safe or less hazardous areas and by reducing the susceptibility of the aircraft to thermal or other damage due to strikes.
- *In-flight lightning damage measurement and assessment* - A typical commercial aircraft is struck by lightning about once per year. At this time, composite aircraft that are struck in-flight are inspected upon

landing for a damage assessment. Such assessments may be time-consuming and difficult. Innovations that will provide a measurement or damage detection system in the LSP are solicited. The objective would be to achieve a capability to have damage detection and assessment capability in the aircraft that will provide immediate information to the flight crew after a lightning attachment.

A1.02 Inflight Icing Hazard Mitigation Technology

Lead Center: GRC

NASA is concerned with the prevention of encounters with hazardous in-flight conditions and the mitigation of their effects when they do occur. Under this subtopic, proposals are invited that explore new and dramatically improved technologies related to inflight airframe and engine icing hazards for manned and unmanned vehicles. Technologies of interest should address the detection, measurement, and/or the mitigation of the hazards of flight into supercooled liquid water clouds and flight into regions of high ice crystal density. With these emphases in mind, products and technologies that can be made affordable and capable of retrofit into the current aviation system and aircraft, as well as for use in the future are sought.

Areas of interest include, but are not limited to:

- Non-destructive 3-D ice density measurements of ice accretions on wind tunnel wing models. NASA has a need for non-optical methods to digitize ice shapes with rough external surfaces and internal voids as can occur with accretions on highly swept wings for comparison to computational simulations. Current methods based upon scanning with line-of-sight, visible-spectrum digitization methods have been found inadequate for many of these very complex ice shapes.
- Remote and in-situ technologies that can accurately quantify the super-cooled liquid water environment in the volume surrounding an airport. Of primary interest are remote sensing technologies that can, by themselves or with other instruments, quantify the temperature, liquid water content, and cloud droplet size spectrum to allow the production of a 3-D icing hazard map of the terminal airspace. Low-cost, expendable in-situ instruments are also of interest for validating and calibrating these remotely sensed measurements.

A1.03 Flight Deck Interface Technologies for NextGen

Lead Center: LaRC

Public benefits derived from continued growth in the transport of passengers and cargo are dependent on the improvement of the intrinsic safety attributes of current and future air vehicles that will operate in NextGen. The Aviation Safety Program (AvSP) is addressing this challenge by conducting cutting-edge fundamental and applied research that will yield innovative algorithms, tools, concepts and technologies from the discipline level up to the subsystem and system level. As a part of the AvSP, the Vehicle System Safety Technology (VSST) Project has initiated a Technical Challenge (TC) toward the improvement of Crew Decision-Making and response in complex situations (CDM), in current-day and NextGen operations.

To address this TC, NASA seeks innovative flight deck interface research and technology that address the following major topic areas:

- The flight crew's needs for situation awareness/information in current-day and emerging NextGen operations. Research and technology development focused on novel display technologies and display methods that allow for new means of NextGen information portrayal and creating visual and aural interface methods to provide hazard and aircraft state awareness and protection during terminal maneuvering area operations.
- The development of flight deck interface technologies that assure pilot awareness and appropriate engagement (balancing awareness and workload) in current-day and emerging NextGen operations. Research and technology development to proactively address the potential impact of changing roles and responsibilities between the Air Navigation Services Providers (ANSP) and pilots as well as between the human and automation, and the robustness of these interfaces when responding to unexpected events.
- Integrated information management systems that assure the information needed by flight crews to make critical decisions is complete and not misleading. Research and technology development to better manage

flight deck information during NextGen “Net-Centric” operations without overloading or underwhelming the operators/users.

- Understanding demographics and proficiency that impact human (pilot) decision-making. Research and technology development which addresses emerging pilot demographics and pilot proficiency standards to improve pilot decision-making and interactions with other human and automation

A1.04 Vehicle Level Diagnostics

Lead Center: LaRC

Participating Center(s): ARC, DFRC, GRC

This SBIR subtopic augments on-going activities in the Vehicle Systems Safety Technology (VSST) project within NASA's Aviation Safety Program. Specifically, this subtopic addresses the "Maintain Vehicle Safety between Major Inspections" (MVS) technical challenge. The MVS technical challenge concentrates on capabilities to maintain vehicle safety between major inspection intervals with an emphasis on the subsystems of airframe, avionics, and propulsion. NASA is seeking proposals to combine information from, and within, the various subsystems to perform overall vehicle level diagnostics. The objective of this work is to provide an infrastructure to assess the health state of aircraft through the integration of full vehicle sensors and diagnostic information. Partnering with organizations that can provide relevant data is encouraged.

A1.05 Data Mining and Knowledge Discovery

Lead Center: ARC

The fulfillment of the SSAT project's goal requires the ability to transform vast amounts of data produced by aircraft and associated systems and people into actionable knowledge that will aid in detection, causal analysis, and prediction at levels ranging from the aircraft-level, to the fleet-level, and ultimately to the level of the national airspace. For this topic, we are especially interested in automated discovery of previously unknown precursors to aviation safety incidents involving human – automation interaction. We expect to gain knowledge on latent deficiencies in crew training, communication, and operations that is of paramount importance to future SSAT project goals and objectives. The incorporation of human performance will be invaluable to the success of this effort, and as such it will be important to use heterogeneous data from varied sources that are matched on a per-flight basis with flight-recorded data, such as radar track data, airport information, weather data, flight crew schedule information, maintenance information, and Air Safety Reports. This topic will develop revolutionary and first-of-a-kind methods and tools that incorporate the limitations of human performance throughout the design lifecycle of human-automation systems to increase safety and reduce validation costs in NextGen.

The focus of this effort will be on the fleet level or above. As such, the successful proposal will develop validated data mining and machine learning based methods to uncover systemic human-automation interaction issues that manifest at a much broader level than those incidents that occur within a single flight or for a single aircraft. Simulated data that is representative of the interactions between humans and automation found on flight systems and on data from real world aircraft and supporting ground-based systems should be used. The total of the data set under study should be at least 10 TB in size, and exhibit appropriate statistical and operational complexities found in real world human automation interactions. Furthermore, a deep knowledge of human-automation interaction from the human-factors perspective as well as the ability to create novel machine learning and data mining algorithms should be clearly demonstrated.

A1.06 Assurance of Flight-Critical Systems

Lead Center: ARC

Participating Center(s): LaRC

The purpose of this subtopic is to invest in mid- and long-term research to establish rigorous, systematic, scalable, and repeatable verification and validation methods for flight-critical systems, with a deliberate focus on safety for NextGen (<http://www.jpdo.gov>). This subtopic targets NextGen safety activities and interests encompassing vehicles, vehicle systems, airspace, airspace concept of operations, and air traffic technologies, such as communication or guidance and navigation. Methods for assessing issues with technology, human performance and human-systems integration are all included in this sub-topic, nothing that multi-disciplinary research is required that does not focus on one type of component or phenomenon to the exclusion of other important drivers of safety.

Proposals are sought for the development of:

- Safety-case methods and supporting technologies capable of analyzing the system-wide safety properties suitable for civil aviation vehicles and for complex concepts of operation involving airborne systems, ground systems, human operators and controllers.
- Technologies and mathematical models that enable rigorous, comprehensive analysis of novel integrated, and distributed, systems interacting through various mechanisms such as communication networks and human-automation and human-human interaction.
- Techniques, tools and policies to enable efficient and accurate analysis of safety aspects of software-intensive systems, ultimately reducing the cost of software V&V to the point where it no longer inhibits many safety innovations and NextGen developments.
- Tools and techniques that can facilitate the use of formal methods in V&V throughout the lifecycle such as graphical-based development environments (e.g., eclipse plug-ins for static analyzers, model checkers, or theorem provers) or tools facilitating translation from design formats used in industry to formal languages supporting automated reasoning.

This subtopic is intended to address those flight-critical systems that directly conduct flight operations by controlling the aircraft, such as on-board avionics and flight deck systems, and safety-critical ground-based functions such as air traffic control and systems for communication, navigation and surveillance. It is not intended to cover V&V of computational models of physical systems (e.g., CFD codes or finite element analysis).

In Phase II, a functional system shall be delivered to NASA for its retention and ownership.

TOPIC: A2 Air Traffic Management Research and Development (ATM R&D)

Air Traffic Management Research and Development (ATM R&D) NASA has two Programs conducting ATM R&D. The Airspace Systems Program (ASP) is investing in the development, validation and transfer of advanced innovative concepts, technologies and procedures to support the development of the Next Generation Air Transportation System (NextGen). The Integrated Systems Research Program (ISRP) is conducting research at an integrated system-level on promising concepts and technologies and exploring, assessing or demonstrating their benefits in a relevant environment. All the investments include coordination with other NASA Programs and partnerships with other government agencies and joint activities with the U.S. aeronautics industry and academia.

ASP develops and demonstrates future concepts, capabilities, and technologies that will enable major increases in air traffic management effectiveness, flexibility, and efficiency, while maintaining safety, to meet capacity and mobility requirements of NextGen. ISRP explores and assesses new vehicle concepts and enabling technologies through system-level experimentation and focuses specifically on maturing and integrating technologies in major vehicle systems/subsystems for accelerated transition to practical application. One of ISRP's projects is the Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS). The project's primary goal is to address technology development in five areas to reduce the technical barriers related to the safety and operational challenges of routine UAS operations in the NAS. These areas include seamless integration of separation assurance/sense and avoid interoperability, evaluating the workload impact to human UAS operators, demonstration of secure UAS command and control datalink, document requirements for and to create an appropriate test environment for evaluating UAS concepts.

The A2 topic area solicits concepts that can reduce the technical barriers related to the safety and operational challenges of routine UAS operations in the NAS.

Proposers interested in developing and validating innovative ATM concepts, technologies, and procedures to support the Next Generation Air Transportation System (NextGen) should refer to Select Topic E2.01, Air Traffic Management Research and Development.

A2.01 Unmanned Aircraft Systems Integration into the National Airspace System Research

Lead Center: DFRC

Participating Center(s): ARC, GRC, LaRC

The following subtopic is in support of the Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project under the Integrated Systems Research Program (ISRP). There is an increasing need to fly UAS in the NAS to perform missions of vital importance to National Security and Defense, Emergency Management, Science, and to enable commercial applications. The UAS Integration in the NAS Project is structured under the following technical challenges:

- Airspace Integration - validate technologies and procedures for UAS to remain an appropriate distance from other aircraft, and to safely and routinely interoperate with NAS and NextGen Air Traffic Services (ATS).
- Standards/Regulations - validate minimum system and operational performance standards and certification requirements and procedures for UAS to safely operate in the NAS.
- Relevant Test Environment - develop an adaptable, scalable, and schedulable relevant test environment for validating concepts and technologies for UAS to safely operate in the NAS. The Federal Aviation Administration (FAA) regulations are built upon the condition of a pilot being in an aircraft.

There exist few, if any, regulations specifically addressing UAS today. The primary user of UAS to date has been the military. The technologies and procedures to enable seamless operation and integration of UAS in the NAS need to be developed, validated, and employed by the FAA through rule making and policy development.

The Project goal is to capitalize on NASA's unique capabilities and competencies by utilizing integrated system level tests in a relevant environment to eliminate or reduce critical technical barriers of integrating UAS into the NAS. The project is further broken down into five subprojects: Separation Assurance/Sense and Avoid Interoperability (SSI); Communications; Human Systems Integration; Certification; and Integrated Test and Evaluation. The fifth sub-project, Integrated Test and Evaluation, is responsible for developing a live, virtual, and constructive test environment for the other four subprojects. The first phase of the project includes the following:

- Conduct initial modeling, simulation, and flight testing.
- Complete early subproject-focused deliverables (spectrum requirements, comparative analysis of certification methodologies, etc.).
- Validate the key technical elements identified by this project.

The second phase includes the following:

- Conduct systems-level, integrated testing of concepts and/or capabilities that address barriers to routine access to the NAS.
- Provide methodologies for development of airworthiness requirements and data to support development of certification standards and regulatory guidance.
- Develop a body of evidence (including validated data, algorithms, analysis, and recommendations) to support key decision makers in establishing policy, procedures, standards and regulations, enabling routine UAS access in the NAS.

This solicitation seeks proposals, but is not limited, to develop:

- *Certified control and non-payload communications (CNPC) system* - Current civil UAS operations are significantly constrained by the lack of a standardized, certified control and non-payload communications (CNPC) system. The UAS CNPC system is to provide communications functions between the Unmanned Aircraft (UA) and the UA ground control station for such applications as: telecommands; non-payload telemetry; navigation aid data; air traffic control (ATC) voice relay; air traffic services (ATS) data relay; sense and avoid data relay; airborne weather radar data; and non-payload situational awareness video. New and innovative approaches to providing terrestrial and space-based high-bandwidth CNPC systems that are

inexpensive, small, low latency, reliable, and secure offer opportunities for quantum jumps in UAS utility and capabilities. Of particular interest are:

- Technologies for High power C-band amplifiers and highly linear C-band power amplifiers/linearization of high power C-band amplifiers.
 - Miniaturization of C-band radio components/systems.
- *A “Synthetic Vision System” for a ground control station (GCS)* - Integration of display technology that presents the visual environment external to the unmanned aircraft using computer-generated imagery in a manner analogous to how it would appear to the pilot in a manned aircraft. A “synthetic vision system” displays critical features of the environment external to the aircraft through a computer-generated image of the external scene topography using terrain and obstacle databases. Several research and technological developments have made synthetic vision systems possible. Fundamentally, these systems require only precise ownship location, a database, available graphics and computing capability and display media. In terms of safety benefits, synthetic vision may help to reduce many accident precursors including: Loss of awareness of vertical/ lateral path, terrain traffic, etc. Operational benefits may include transition from instruments to visual flight, non-normal and emergency situations, virtual visual self-spacing and station keeping capability, etc. SVS have been extensively studied and there is a vast body of knowledge on their application to manned aviation. Special interest is in the integration of a SVS into a UA ground control station to support operator in the loop, sense and avoid (SAA) functions for UAS operations in the NAS. Guidelines for sense and avoid requirements and functions are currently being developed by standards organizations (e.g., RTCA SC-203) and the FAA.
- *Weather information systems for GCS* - On-board, real-time graphic aviation weather information products have been developed and successfully implemented for manned cockpits. Their use is now widespread and their safety impact widely recognized. The applicability of such products for operators and ground control pilots to enhance situation awareness and improve mission planning and execution is of interest to NASA. Systems such as the NASA developed Aviation Weather Information (AWIN) system that included software, data and data-link applications, color weather graphics such as composite-radar mosaic, lightning-strike data, wind data, satellite images and forecasts could be integrated into a ground control station to provide pilots with weather awareness before and during mission execution. Improved weather awareness should allow aircrews to avoid most weather-related problems through both pre-flight and en-route planning. While the use of these systems has been explored for military UAS operations, their applicability to civil and public operations has not yet been explored.
- *Operator Displays for Sense and Avoid Systems* - While guidelines for the integration of UAS operations in the NAS are being developed new SAA systems are being designed to provide the ground control pilot with situation awareness and the ability to execute required ATC procedures. SAA systems provide UAS with the capability to avoid collisions and remain well clear of other aircraft by means of sensor systems and equipment specifically designed for this purpose. SAA systems consist of surveillance sensors, data communications, threat detection and/or resolution logic and the display of traffic information and/or resolution guidance/advice. Of interest is the development of display technologies to enable ground control pilots to participate in any phase of the SAA process as indicated by operator procedures. These new technologies should utilize the vast experience and body of knowledge developed over the years for airborne/ground separation assurance systems, TCAS displays, and cockpit displays of traffic information. In addition, these new displays will exhibit unique and very challenging new problems associated with the nature of unmanned systems as well as the communication latencies and potential safety risks of failure conditions. Human factors considerations should be applied in the design of these systems.
- *Lost Communication Link Procedures and Operations* - The procedures followed by unmanned aircraft and their pilots when the command and control link is lost with the ground station are not standardized and frequently do not take into account ATC regulations. Each UAS appears to have custom-designed procedures for “lost link” despite the existence of well-established rules for pilots to follow when communication capability is lost. Research should establish a desired set of procedures to be followed that parallel the existing requirements, but departing from those where necessary to meet critical safety considerations. These procedures may be codified in technologies used by the unmanned aircraft or the pilot in the ground control station to maximize the predictability of the UAS’ actions from an ATC perspective.
- *Safety Analysis and Methodologies* - UAS operations are untried in the civil NAS. Unlike other aircraft, there is not an extensive record of civil operations upon which to forecast the safety of UAS operations in the NAS. The introduction of UAS into the NAS raises many safety issues and concerns. Typically,

anytime a new capability is added into the NAS, an Operational Safety Assessment (OSA) is performed by the FAA, to determine whether that introduction of new capability will enhance or detract from the safety of the NAS. As these UAS represent a wholly new operational system, traditional approaches cannot suffice. Research is needed to identify and develop new safety analysis approaches, as well as prognostic indicators and potential new safety metrics.

TOPIC: A3 Air Vehicle Technologies

The Vehicle Systems Technology topic solicits cutting-edge research in aeronautics to overcome technology barriers and challenges in developing highly efficient aircraft systems of the future, with limited impact to the environment. The primary objective is the development of innovative design tools, capabilities and technologies that provide design and system solutions and capabilities to meet the national goals in cleaner environment, reduced noise and highly energy efficient and revolutionary aircraft for the next generation (NextGen) air transportation system.

This topic solicits physics-based, multidisciplinary design, analysis and optimization tools and capabilities to facilitate assessment of new vehicle designs and their potential performance characteristics. These tools and capabilities will enable the best design solutions to meet the performance and environmental requirements and challenges, and technology innovations of future air vehicles. It also solicits research in revolutionary aircraft concepts; lightweight high strength structures and materials; more efficient propulsion systems; advanced concepts for high lift and low drag aircraft that meet the performance, efficiency and environmental requirements of future aircraft, and the goals of NextGen.

Beginning in FY12, this topic covers aircraft technologies formerly covered by the Fundamental Aeronautics topic as well as ground and flight test technologies formerly covered by the Aeronautics Test topic. The re-structuring will emphasize development of tools, technologies, test techniques, and knowledge to meet metrics derived from a definitive set of Technical Challenges responsive to the goals of the National Aeronautics Research and Development Plan (2010) and the NASA Strategic Plan (2011).

- *Fixed Wing Vehicles* - Technologies and concepts for subsonic transport aircraft, propulsion system energy efficiency and environmental compatibility supported by enabling tools and methods. Targeted challenges include drag and weight reduction for fuselages and high aspect ratio wings, quiet high performance high-lift and propulsion systems, high performance clean, alternative-fuel burning gas generators, paradigm-changing hybrid-electric propulsion systems, innovative propulsion-airframe integration concepts.
- *Rotary Wing Vehicles* - Advanced Efficient Propulsion (multi-speed lightweight rotorcraft drive trains and variable speed efficient engines), Advanced Concepts and Configurations (aerodynamically efficient rotorcraft, NextGen configurations, and multi-fidelity design and analysis tools), and Community and Passenger Acceptance (NextGen operations and standards, and comfort and safety).
- *High Speed* - Focused on supersonic research, design, and boom mitigation techniques to achieve low boom strength and other elements that will help enable a low-boom experimental aircraft; System Integration Assessment; Supersonic Cruise Efficiency – Propulsion; Supersonic Cruise Efficiency–Airframe; Sonic Boom Modeling; and Jet Noise Research.
- *Aeronautical Sciences* - Broad, cross-cutting discipline research (e.g., some CFD and structures & materials research) that is pervasive across flight regimes, helps develop some low-level concepts and ideas, and provides program-level systems analysis capability to assess balance and impact of program-wide investments.
- *Aeronautics Test Technologies* - Focused on instrumentation, test measurement technology, test techniques, and facility development that apply to NASA aeronautics facilities to help in sustaining and improving our test capabilities at four NASA Centers: Ames Research Center, Dryden Flight Research Center, Glenn Research Center, and Langley Research Center. Classes of facilities include low speed, transonic, and supersonic wind tunnels, air-breathing engine test facilities, the Western Aeronautical Test Range (WATR), support and test bed aircraft, and simulation and loads laboratories.

A3.01 Structural Efficiency - Airframe **Lead Center: LaRC**

Materials and Structural Concepts for Aeroelastically-Tailored Aircraft Wings

The Fixed Wing and High Speed projects are focused on development of enabling technologies and advanced concepts for subsonic and supersonic cruise transport category aircraft, respectively, demonstrated to TRL 4-6 in the 2025 time frame. Both projects require simultaneous reduction of weight and drag to achieve their respective performance objectives. For subsonic transport aircraft, lift-induced drag is approximately 40% of the total drag at cruise and can be directly addressed via increased wing aspect ratio. For supersonic flight, speed requirements dictate highly swept wings with a very thin airfoil section. Both of these wing geometries, with higher aspect ratio or thinner airfoil section, result in more flexible structure that can exhibit aeroelastic instability and thus require more complicated aeroelastic design, analysis and control. The traditional solution to these aeroelastic issues has been primarily to stiffen the wing by adding additional structure, thus creating a weight penalty. Solutions that favorably modify the aeroelastic response of thin or high aspect ratio wings with no or little weight increase are needed. Furthermore, maneuverability of the vehicle is dependent upon the control authority achievable by wing-located control surfaces in traditional aircraft designs, and possibly actively tailorable portions of wings in more integrated aircraft designs. Designing the wing to have desired aeroelastic characteristics makes the wing amenable to minimal-input active control solutions to further modify the aeroelastic response. Using a building block approach in this research topic, the current solicitation focuses on materials and structural concepts for aeroelastically-tailored aircraft wings, while the more complex aeroservoelastic solution will be the subject of a future solicitation.

This solicitation topic seeks innovative materials and/or structural concepts and technologies for lightweight wings with aeroelastic tailoring, such as tailored bending and torsional stiffness as an example. Proposals should involve novel materials, processes and structural concepts with significant potential to improve the structural efficiency and reduce specific weight. Laboratory scale approaches may be proposed for proof of concept, but must be scalable to application across a broad range of fixed wing aircraft sizes and speeds.

Tailored stiffness may include spatial or temporal variations in stiffness achieved by a combination of passive stiffness tailoring of anisotropic or functionally graded materials, novel structural topologies, or active integrated elements to change structural and/or material properties. The use of existing design and analysis tools and techniques to the greatest extent possible is encouraged, as it is not the intent of this solicitation to develop new computational tools. Specifically, the following concepts and technologies are sought:

- Materials and processing routes to fabricate engineered materials with tailored material properties along all three axes.
- Aeroelastically-tailored structural concepts by which desired static or dynamic aeroelastic responses can be achieved.

Phase I: Identify candidate material systems and structural concepts that enable aeroelastic tailoring of wing structure for reduced weight, for example, variable bending and torsional stiffness. Assess the feasibility and benefits of the proposed concept, including scale-up, necessary material property quantification, and design trade studies. The studies must include quantification of expected structural weight benefits. Identify limiting factors and recommendations for further technology development to address the shortfalls. For novel material systems and structural concepts requiring development, conduct initial proof of concept computational studies and/or element tests.

Phase II: Perform scale-up of materials and processes as necessary, and produce a detailed structural design and hardware build of a subscale wing suitable for laboratory testing to assess structural performance of the concept. Structural testing of the subscale wing will be performed subsequently by NASA and is beyond the scope of the Phase II effort.

A3.02 Quiet Performance

Lead Center: LaRC

Innovative technologies and methods are necessary for the design and development of efficient, environmentally acceptable aircraft. In support of the Fundamental Aeronautics Program, improvements in noise prediction, measurement methods and control are needed for subsonic, transonic and supersonic vehicles targeted specifically at airframe noise sources and the interaction of airframe and engine noise. Innovations in the following specific areas are solicited:

- Fundamental and applied computational fluid dynamics techniques for aeroacoustic analysis, which can be adapted for design codes.
- Prediction of aerodynamic noise sources including those from airframe and sources which arise from significant interactions between airframe and propulsion systems.
- Prediction of sound propagation from the aircraft through a complex atmosphere to the ground. This should include interaction between noise sources and the airframe and its flow field.
- Innovative source identification techniques for airframe (e.g., landing gear, high lift systems) noise sources, including turbulence details related to flow-induced noise typical of separated flow regions, vortices, shear layers, etc.
- Concepts for active and passive control of aeroacoustic noise sources for conventional and advanced aircraft configurations, including adaptive flow control technologies, and noise control technology and methods that are enabled by advanced aircraft configurations, including integrated airframe-propulsion control methodologies.
- Development of synthesis and auditory display technologies for subjective assessments of aircraft community and interior noise, including sonic boom.

A3.03 Low Emissions/Clean Power

Lead Center: GRC

Proposals are sought which support electric propulsion of transport aircraft, which includes various hybrid electric concepts, such as gas turbine engine-battery combinations and turboelectric propulsion (turbine prime mover with electric distribution of power to propulsors). Turboelectric propulsion for aircraft applications will require high specific power (hp/lb or kW/kg) and high efficiency components. Cryogenic and superconducting components will be required to achieve high specific power and high efficiency. The cryogenic components include fully superconducting generators and motors (i.e., superconducting stators as well as rotors), cryogenic inverters and active rectifiers, and cryocoolers. Proposals related to the superconducting machines may include aspects of the machines themselves as well as low AC loss superconducting materials for the stator windings. Generators with at least 10 MW capacity and motors of 2 to 3 MW capacity are of interest. Technology is sought that can contribute to superconducting machines with specific power more than 10 hp/lb. Superconducting wires with filaments less than 10 micrometers in diameter are of interest. Ideas are also sought for achieving 2-3X increase in specific power for non-cryogenic motors through a multidisciplinary approach utilizing advanced motor designs, better materials, and new structural concepts. Ideas are also sought to address challenges related to high voltage power transmission in future hybrid electric aircraft. New modeling and simulation tools for hybrid electric aircraft propulsion systems are also of interest.

A3.04 Aerodynamic Efficiency - Drag Reduction Technology

Lead Center: LaRC

The challenge of energy-efficient flight has at its foundation aerodynamic efficiency, and at the foundation of aerodynamic efficiency is low drag. Drag can be broadly decomposed into four components: viscous or skin friction drag, lift-induced drag, wave or compressibility drag, and excrescence drag due to various protruding items such as antennae, wipers, lights, etc. The relative impact of these four forces depends upon the targeted flight regime and vehicle-specific design requirements. The first force, however, viscous skin friction, stands out as particularly significant across most classes of flight vehicles and effective measures for its control would have a major impact on flight efficiency. In particular, supersonic, low-boom flight and new generations of energy-efficient subsonic transport airplanes including high L/D strut-braced designs, the blended wing body (BWB), the so called “double-

bubble” designs and other concepts with large expanses of surface area would benefit from effective viscous drag control.

Viscous skin friction can be classified as either laminar or turbulent. While the laminar case and its attendant laminar flow control (LFC) techniques remain important scientific and technological disciplines, the goal of high Reynolds number flight efficiency requires that the turbulent case receive renewed attention. In place of the first-principles-derived theoretical framework of the laminar flow stability problem, in the turbulence case we have a wide collection of experimental observations, data correlations, various CFD approaches requiring turbulence closure models and, at low Reynolds numbers, full direct numerical simulation of the Navier-Stokes equations (DNS). While such experimental and CFD-derived knowledge, has greatly increased our understanding of turbulent boundary layer physics over the past decades, key relationships between wall layer and outer layer dynamics essential to a full understanding remain to be identified and verified.

Inadequacies in our understanding of boundary layer turbulence increase reliance upon a more qualitative, physics-guided approach to discovery. For example, the experimental observation of reduced skin friction in the corners of triangular cross-section pipes led to the discovery of drag-reducing V-groove riblets (subsequently also associated with the skin of certain shark species). The quasi-periodic, low-speed streak structures observed in the near-wall layer of turbulent boundary layers led to the implementation of mechanically controlled spanwise waves or lateral oscillations of the wall to disrupt the processes associated with low speed streak bursting. Similar observations have either been made or suggested with respect to the stabilizing influence of convex and in-plane curvature; long length-to-diameter ratio particulates; passive, active and reactive wall motion; manipulation of the wall layer by various geometrical devices (e.g., vortex generators (VG) and large eddy breakup devices (LEBU)), and various weakly ionized gas (WIG) and magnetohydrodynamic/electrohydrodynamic (MHD/EHD) concepts. This solicitation is offered in this spirit of innovation based on experimental or computational observations guided by a basic, though not necessarily complete, physical understanding of the turbulent processes.

In order to stimulate innovation in the area of turbulent viscous drag reduction, proposals are sought subject to the following guidelines:

- Proposals shall address passive, active, or reactive concepts for external, attached, fully developed, turbulent boundary layer viscous drag reduction in air.
- Experimental, hardware-based proposals and theoretical/computational proposals based on realizable hardware are preferred.
- All practical physical concepts are acceptable including but not limited to: mechanical/electro-mechanical actuators, weakly-ionized-gas (WIG) concepts, laser/microwave energy deposition, MHD/EHD devices, surface microstructure/geometry, embedded mechanical devices (VG's, LEBU's), wall mass transpiration, heat transfer, wall motion, wall curvature effects and pressure gradient (vehicle shaping).
- Significant enhancements or refinements of existing concepts and technologies are acceptable.
- First order assessment or technically plausible discussion of any net system energy saving claims shall be provided.
- Proof-of-concept experimental demonstrations are encouraged for Phase I where applicable but are not required.
- Target conditions are flight-relevant Reynolds numbers at either high subsonic ($0.7 < M < 0.9$) or low supersonic ($M < \sim 3$) speeds. Proposals at lower Mach and Reynolds numbers shall provide discussion of a developmental path towards flight-relevant conditions but not necessarily inclusive of actual flight.

A3.05 Controls/Dynamics - Propulsion Systems

Lead Center: GRC

Participating Center(s): DFRC

Propulsion controls and dynamics research is being done under various projects in the Fundamental Aeronautics Program (FAP). For turbine engines, work on Distributed Engine Control (DEC) and Model-Based Engine Control (MBEC) is currently being done under the Subsonic Fixed Wing (SFW) project, and Active Combustion Control research is currently being done under the Supersonics (SUP) project. These 3 efforts are expected to transition to the new Aeronautics Sciences (AS) project in FY13. Aero-Propulso-Servo-Elasticity (APSE) research will continue

under the SUP project. Research activity on Controls/Dynamics for electric propulsion systems is expected to be initiated in FY13 under the reformulated Fixed Wing (FW) project. Propulsion control and dynamics technologies that help achieve the goals of FAP, in terms of: reducing emissions; increasing fuel efficiency; tool and technology development and validation to address challenges in High Speed flight; and enabling fast, efficient design and analysis of advanced aviation systems, are of interest. Proposed activities that are compatible with current propulsion controls and dynamics activities supported by the FAP will be given preference. Following technologies are of specific interest:

- High Efficiency Robust Engine Control* - Typical current operating engine control logic is designed using SISO (Single Input Single Output) PI (Proportional+Integral) control. The control logic is designed to provide minimum guaranteed performance while maintaining adequate safety margins throughout the engine operating life. Additionally, the control logic provides control of variables of interest such as Thrust, Stall Margin etc. indirectly since these variables cannot be measured or are not measured in flight because of restrictions on sensor cost/placement/reliability etc. All this results in highly conservative control design with resulting loss in efficiency. NASA is currently conducting research in Model-Based Engine Control (MBEC) where-in an on-board real-time engine model, tuned to reflect current engine condition, is used to generate estimate of quantities of interest that are to be regulated or limited and these estimates are used to provide direct control of Thrust etc. Alternate methods such as Model Predictive Control, Adaptive Control, direct non-linear control, etc. which will achieve the same objectives as the current MBEC approach while providing practical application of the control logic in terms of operation with sensor noise, operation across varying atmospheric conditions, operation across varying engine health condition over the operating life, and real-time operation within engine control hardware limits, are of interest. The emphasis is on practical application of existing control methods rather than theoretical derivation of totally new concepts. Control design approaches that can accommodate small to medium engine component faults and can still provide desired performance with safe operation are of special interest. The pre-requisite for proposals for engine control design methods is that the NASA C-MAPSS40k (Commercial Modular Aero-Propulsion System Simulation for 40,000 lb class thrust engine) be used for control design and evaluation. This simulation can only be used by U.S. citizens since it is subject to export control laws. Methods for real-time engine parameter identification using flight data are also of interest by themselves.
- Distributed Engine Control* - Current engine control architectures impose limitations on the insertion of new control capabilities primarily due to weight penalties and reliability issues related to complex wiring harnesses. Obsolescence management is also a primary concern in these systems because of the unscheduled cost impact and recertification issues over the engine life cycle. NASA in collaboration with AFRL (Air Force Research Lab) has been conducting research in developing technologies to enable Distributed Engine Control (DEC) architectures. The current need is to develop a DEC test-bed which can be used to investigate a wide range of issues such as system robustness, stability and performance of various DEC architectures, the development of network communications requirements, network performance evaluation, robustness of DEC architectures to data transmission faults and impact on system performance. The tools just described must be compatible with the NASA C-MAPSS40k simulation software and easily integrated into the Hardware-in-the-Loop research facility currently being developed under a separate contract. Restrictions on access to these technologies require that any proposed effort will be limited to work being done by U.S. citizens.
- Active Combustion Control* - The overall objective is to develop all aspects of control systems to enable safe operation of low emissions combustors throughout the engine operating envelope. Low emission combustors are prone to thermo-acoustic instabilities. So far NASA research in this area has focused on modulating the main or pilot fuel flow to suppress such instability. Advanced, ultra-low emissions combustors utilize multi-point (multi-location) injection to achieve a homogeneous, lean fuel/air mixture. There is new interest in using precise control of fuel flow in such a manner as to suppress or avoid thermo-acoustic instabilities. Miniature fuel metering devices (and possibly also fuel flow measurement devices) are needed that can be physically distributed to be close to the multi-point fuel injector in order to enable the control system to accurately place a given proportion of the overall fuel flow to each of the fuel injection locations.
- Aero-Propulso-Servo-Elasticity (APSE)* - The objective of NASA research effort in APSE is to develop a comprehensive dynamic propulsion system model that can be utilized for thrust dynamics and integrated APSE vehicle controls and performance studies, like vehicle ride quality and vehicle stability under typical vehicle maneuvering and atmospheric disturbances, for supersonic vehicles. Innovative approaches to

dynamic modeling of supersonic external compression inlets; parallel flow path modeling of the compression and whole propulsion system to accurately model the distortion effects of flexible modes, maneuvering and atmospheric disturbances; and integration of dynamic propulsion models with aircraft simulations incorporating flexible modes, are of interest.

- *Electric Propulsion Systems* -The objective is to achieve the required increase in the specific power of high efficiency electric components to make a 10 mega-watt onboard power generation and/or utilization feasible for propulsion. Specific areas of interest are: advanced electric power control systems for energy management of battery and fuel cell systems including potentiostatic sensor array to determine battery state-of-charge (SOC) and battery cycle affected state lifetimes; advanced phase angle control systems for electric motors; and advanced power control systems for effective management of large multi-motor arrays designated for use in newer turbo-electric aircraft and embedded boundary layer electric propulsion systems.

A3.06 Physics-Based Conceptual Design Tools

Lead Center: GRC

Participating Center(s): LaRC

Conceptual design and analysis of unconventional vehicle concepts and technologies is needed for technology portfolio investment planning, development of advanced concepts to provide technology pull and independent technical assessment of new concepts. The aerospace flight vehicle conceptual design phase is the most important step in the product development sequence, because of its predefining function. However, the conceptual design phase is the least well understood part of the entire flight vehicle design process, owing to its high level of abstraction and associated risk, its multidisciplinary design complexity, its permanent shortage of available design information and its chronic time pressure to find solutions. Often, the important primary aerospace vehicle design decisions at the conceptual design level (e.g., overall configuration selection) are still made using simple analyses and heuristics. Progress has been made recently in incorporating more physics-based analysis tools in the conceptual design process, especially in the aerodynamics area, and NASA has developed a capability that integrates several analysis tools and models in engineering architectures, such as ModelCenter and OpenMDAO. However, gaps still remain in many disciplines.

Developing higher order, high fidelity tools suitable for conceptual design is a difficult challenge. The first issue is analysis turnaround time. To perform the configuration trades and optimization typical of conceptual design, runtimes measured in seconds or minutes, instead of hours or days, are required. However, rapid analysis turn around time alone is insufficient. To be suitable for conceptual design, tools and methods are needed which accurately predict the “as-built” characteristics. Because it is not possible to model every detail of the design and account for all the underlying physics in the problem formulation, it is difficult to predict the “as-built” characteristics with physics-based methods alone. What is usually required is a combination of these methods with some semi-empirical corrections. Ignoring this aspect can lead to higher order tools which are lower fidelity (less accurate) than the lower order tools they are intended to replace. Another challenge in conceptual design is a lack of detailed design information. Lower order, empirical-based methods typically used in the past for conceptual design often require only gross design parameters as inputs. It is, therefore, not necessary to know design details to obtain a reasonable estimate of the design’s performance. High-order, physics-based methods currently require detailed design knowledge to be useful. For example, whereas semi-empirical drag prediction tools provide estimates for wing drag without needing full 3-D geometry including an airfoil design, such detail is necessary to successfully utilize CFD tools. This gap in the analysis capability and the maturity of the design being analyzed limits the usefulness of the high order analysis in conceptual design. Physics-based tools for conceptual design must be developed which are consistent with the amount of design knowledge that is available at the conceptual design stage.

NASA continues to investigate the potential of advanced, innovative propulsion and aircraft to improve fuel efficiency (i.e, reduce CO₂ emissions) and to reduce the environmental footprint (noise and NO_x) of future generations of commercial transports across the flight speed regime. As such, the agency’s systems analysts need to have the best design/analysis tools possible. The intention of this sub-topic is to solicit proposals for robust, physics-based tools enabling unconventional configurations to be addressed in the conceptual design process. Specifically for 2012, the solicitation will center on new tools and methods that pertain to the propulsion system. Modeling areas where enhanced capabilities are desired include the following:

- Electric/Turbo-electric performance & weight estimation methodologies. Some examples:
 - Electric component performance/weight estimation.
 - Electric grid performance and analysis.
 - Thermal management analysis.
- Enhanced propulsion system performance & weight methodologies. Some examples:
 - Turbomachinery loss modeling.
 - “Rapid” boundary layer ingestion performance.
 - Physics-based component weight estimation.
 - Engine controls & accessories weight/volume.
- High order environmental tools. Some examples:
 - Sonic boom modeling.
 - Combustion emission indices generation.
 - Advanced (beyond ANOPP) acoustics models.
 - Reduced order atmospheric chemistry/global mixing.

A3.07 Rotorcraft

Lead Center: ARC

Participating Center(s): GRC, LaRC

The challenge of the Rotary Wing thrust of the NASA Fundamental Aeronautics Program is to develop and validate tools, technologies and concepts to overcome key barriers for rotary wing vehicles. Technologies of particular interest are as follows:

- *Modeling and Analysis for Conceptual Design and Sizing* -Tools are sought that enable rotorcraft conceptual design and sizing for a wide range of missions. Such tools should also enable systems studies to assess technology benefits. These tools typically model the various rotorcraft components using lower fidelity, approximate and/or empirically based models, and improvements in these tools can be made through developing more accurate rotorcraft component models that are appropriate for conceptual design. The development of methodologies, tools and techniques that include rotorcraft handling qualities during conceptual design is of particular interest with topics including: flight control architecture and handling qualities measures; rotorcraft configuration and data requirements; and methods for integration into conceptual design and sizing codes and analyses. Additional topics of interest include, but are not limited to: engine and drive system models over large rotor speed ranges; auto generation of airfoil tables and analysis and optimization of airfoil sections; noise estimation methods for rotor, engine and drive systems; and airspace performance analysis tools for rotorcraft.
- *Advanced Turbohaft Engines with Variable-Speed Power-Turbine Capability* -Research (modeling, computational work, experiments) that addresses variable-speed power turbine (VSPT) and gas-generator aerothermodynamic, mechanical, and materials challenges is sought. The Rotary Wing Project of the Fundamental Aeronautics Program performs research and development of engine/driveline technologies to enable large civil tilt-rotor vehicles with variable-speed-rotor capability. Options for achieving main-rotor speed variability include a variable-speed transmission and/or a variable-speed power turbine. Key challenges for turboshaft engines of future rotary wing vehicles include high-efficiency power-turbine performance over a wide variable-speed range ($50\% < \text{NPT} < 100\%$), and high overall-pressure-ratio gas generators needed for fuel-efficient engines. Key VSPT aerodynamic challenges include attainment of high efficiency at high turbine work factors associated with operation at lower shaft speeds, management of loss levels over large (e.g., 50 to 60 deg.) incidence-angle swings associated with 50% speed change, and operation at low unit Reynolds numbers at cruise. VSPT mechanical challenges are associated with potential response of shaft and blade modes to critical speeds within the 50% VSPT speed range. Technologies for advanced gas generators—low- and high-pressure compressor and turbine turbomachinery are required as well. In addition to aerodynamic challenges associated with the relative impact of boundary-layers, clearances, leakages, and blade tolerances at low-corrected flow size shared with the high-pressure compressor stages, the high- and low-pressure turbines impose challenges associated with cooling, and incorporation of advance materials (e.g., ceramic matrix composites) in the small turbine sizes.

Proposals on other rotorcraft technologies will also be considered as resources and priorities allow, but the primary emphasis of the solicitation will be on the above two identified technical areas.

A3.08 Propulsion Efficiency - Turbomachinery Technology

Lead Center: GRC

There is a critical need for advanced turbomachinery and heat transfer concepts, methods and tools to enable NASA to reach its goals under the Fundamental Aeronautics Program. These goals include dramatic reductions in aircraft fuel burn, noise, and emissions, as well as an ability to achieve mission requirements for, Subsonic, Rotary Wing, and High Speed Project flight regimes and fundamental research under the Aeronautical Sciences Project. Turbomachinery includes rotating machinery in the high and low pressure spools, transition ducts, purge and bleed flows, casing and hub. In the compression system, advanced concepts and technologies are required to enable higher overall pressure ratio, high stage loading and wider operating range while maintaining or improving aerodynamic efficiency. Such improvements will enable reduced weight and part count, and will enable advanced variable cycle engines for various missions. In the turbine, the very high cycle temperatures demanded by advanced engine cycles place a premium on the cooling technologies required to ensure adequate life of the turbine component. Reduced cooling flow rates and/or increased cycle temperatures enabled by these technologies have a dramatic impact on the engine performance.

Proposals are sought in the turbomachinery and heat transfer area to provide the following specific items:

- Advanced instrumentation to enable time-accurate, detailed measurement of unsteady velocities, pressures and temperatures in three-dimensional flowfields such as found in turbomachinery components and transition ducts. This may include instrumentation and measurement systems capable of operating in conditions up to 900 °F and in the presence of shock-blade row interactions, as well as in high speed, transonic cascades. The instrumentation methods may include measurement probes, non-intrusive optical methods and post-processing techniques that advance the state-of-the-art in turbomachinery unsteady flowfield measurement for purposes of accurately resolving these complex flowfield. Instrumentation enabling measurements and characterization of unsteady turbulent flows at combustor exit temperatures that can be implemented in warm test rigs and actual engines is also included. Instrumentation specific to turbomachinery and heat transfer should be proposed under this subtopic.
- Advanced turbomachinery active and passive flow control concepts to enable increased high stage loading in single and multi-stage axial compressors while maintaining or improving aerodynamic efficiency and operability. Technologies are sought that would reduce dependence on traditional range extending techniques (such as variable inlet guide vane and variable stator geometry) in compression systems. These may include flow control techniques near the compressor end walls and on the rotor and stator blade surfaces. Technologies are sought to reduce turbomachinery sensitivity to tip clearance leakage effects where clearance to chord ratios may be on the order of 5% or above. Technologies are sought to eliminate flow separation in low pressure turbines and transition ducts, improve off-design operation and enable variable cycle operation.
- Novel turbine cooling concepts are sought to enable very high turbine cooling effectiveness especially considering the manufacturability of such concepts. These concepts may include film cooling concepts, internal cooling concepts, and innovative methods to couple the film and internal cooling designs. Concepts proposed should have the potential to be produced with current or forthcoming manufacturing techniques. The availability of advanced manufacturing techniques may actually enable improved cooling designs beyond the current state-of-the-art. Concepts are also sought for the cooling of ceramic-based turbine materials such as ceramic matrix composite (CMC) vanes and blades.
- Computational technologies allowing accurate predictions of turbomachinery flows and heat transfer including active and passive flow control features. Advanced turbulence and LES models that can account for complex three-dimensional flows common in turbomachinery. Models of flow control devices that enable incorporating them in RANS based CFD codes. Particular interest is in CFD method based on overset moving grids that will enable flexibility in studies of small features as cooling holes and active and passive flow control devices.

A3.09 Ground and Flight Test Techniques and Measurement Technologies

Lead Center: DFRC

NASA is committed to effective support and execution of flight research. This includes developing test techniques that improve the control of in-flight test conditions, expanding measurement and analysis methodologies, and improving test data acquisition and management with sensors and systems that have fast response, low volume, minimal intrusion, and high accuracy and reliability. By using state-of-the-art flight test techniques along with novel measurement and data acquisition technologies, NASA will be able to conduct flight research more effectively and also meet the challenges presented by NASA's cutting edge research and development programs. NASA's Aeronautical Test Program (ATP) supports a variety of flight regimes and vehicle types ranging from civil transports, low-speed, to high-altitude long-endurance to supersonic and access-to-space. Therefore, this solicitation can cover a wide range of flight conditions and craft.

NASA also requires improved measurement and analysis techniques for acquisition of real-time, in-flight data used to determine aerodynamic, structural, flight control, and propulsion system performance characteristics. These data will also be used to provide test conductors the information to safely expand the flight and test envelopes of aerospace vehicles and components. This requirement includes the development of sensors to enhance the monitoring of test aircraft safety and atmospheric conditions during flight testing.

Flight research and test capability proposals should be relevant to the following NASA aeronautical test facilities: Western Aeronautical Test Range, Aero-Structures Flight Loads Laboratory, Flight Research Simulation Laboratory, and Research Test Bed Aircraft. Proposals should address innovative methods and technologies to extend the health, maintainability and test capabilities of these flight research support facilities. Areas of interest include:

- Multi-disciplinary nonlinear dynamic systems prediction, modeling, identification, simulation, and control of aerospace vehicles.
- Test techniques for conducting in-flight boundary layer flow visualization, shock wave propagation, Schlieren photography, near and far-field sonic boom determination, atmospheric modeling.
- Active flow control techniques for performance and acoustic noise reduction.
- Intelligent health monitoring for hybrid or all electric distributed propulsion systems.
- Methods for significantly extending the life of electric aircraft propulsion energy sources (e.g., batteries).
- Innovative acoustic noise reduction technology for structural and propulsion systems.
- Techniques for manufacturing lighter, thinner, and tougher engine fan blades than current state-of-the-art.
- Measurement technologies for steady & unsteady aerodynamic, aero-thermal dynamics, structural dynamics, stability & control, and propulsion system performance.
- Verification & Validation (V&V) of complex highly integrated flight systems including hardware-in-the-loop testing.
- Innovative techniques that enable safer operations of aircraft (e.g., non-destructive examination of composites through ultrasonic techniques).

9.1.2 HUMAN EXPLORATION AND OPERATIONS

The Human Exploration and Operations Mission Directorate (HEOMD) is chartered with the development of the core transportation elements, key systems, and enabling technologies required for beyond-Low Earth Orbit (LEO) human exploration that will provide the foundation for the next half-century of American leadership in space exploration. This new deep space exploration era starts with increasingly challenging test missions in cis-lunar space, including flights to the Lagrange points, followed by human missions to near-Earth asteroids (NEAs), moon, the moons of Mars, and Mars as part of a sustained journey of exploration in the inner solar system. HEOMD is a relatively new organization, formed in 2011 by combining the Space Operations Mission Directorate (SOMD) and the Exploration Systems Mission Directorate (ESMD) so as to optimize the elements, systems, and technologies of the precursor Directorates to the maximum extent possible. For the current year, due to budget constraints, HEOMD was asked to adjust the number of Topics and Subtopics included in the call for proposals: after considerable effort, the number of topics included has been reduced from 21 to 12 and the number of subtopics from 57 to 36. HEOMD accomplishes its mission through the following goals:

- Development and use of launch systems and in-space transport capabilities permitting exploration of various regions of space.
- Development of space habitats which permit the processing and operation of physical and life science experiments in the space environment.
- Development of means to return data and explorers from these in-space operations to Earth. Key technology areas including Space Transportation, Space Communications and Navigation, Human Research and Health Maintenance, Radiation Protection, Life Support and Habitation, High Efficiency Space Power Systems, and Ground Processing/ISS Utilization, along with enabling technologies and capabilities, will continue to evolve synergistically as the directorate guides their development and enhancement to meet future needs.

In addition, as other NASA programs develop new mission capabilities and requirements, operational capability will be evolved to include these new enhancements. To create the new capabilities and contribute to the knowledge that is required for humans to explore these destinations, HEOMD is responsible for:

- Conducting technology development and demonstrations to reduce cost and prove required capabilities for future human exploration.
- Developing exploration precursor robotic missions to multiple destinations to cost-effectively scout human exploration targets.
- Increasing investments in human research to prepare for long-duration missions in deep space.
- Enabling U.S. commercial human spaceflight capabilities.
- Developing communication and navigation technologies.
- Reducing operational costs.
- Expanding Human Operations in space.
- Maximizing ISS utilization.

In summary, HEOMD looks forward to incorporating SBIR-developed technologies into current and future systems to contribute to the expansion of humanity across the solar system while providing continued cost effective space access and operations for its customers, with a high standard of safety, reliability, and affordability.

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TOPIC: H1 In-Situ Resource Utilization

The purpose of In-Situ Resource Utilization (ISRU) is to harness and utilize resources (both natural and discarded material) at the site of exploration to create products and services which can enable and significantly reduce the mass, cost, and risk of near-term and long-term space exploration. The ability to make propellants, life support consumables, fuel cell reagents, and radiation shielding from in-situ resources can significantly reduce the cost, mass, and risk of sustained human activities beyond Earth. Since ISRU may be performed wherever resources exist, ISRU systems need to operate in a variety of environments and gravities. Also, because ISRU systems and operations have never been demonstrated before in missions, it is important that ISRU concepts and technologies be evaluated under relevant conditions (gravity, environment, and vacuum) as well as anchored through modeling to regolith/soil, atmosphere, and environmental conditions. While the discipline of ISRU can encompass a large variety of different concept areas, resources, and products, the ISRU Topic will focus on technologies and capabilities associated with atmospheric and trash/waste resource collection, transfer, and processing.

H1.01 In-Situ Resource Utilization

Lead Center: JSC

Participating Center(s): ARC, GRC, KSC

OCT Technology Area: [TA07](#)

Converting in-situ resources into propellants, energy storage reactants, or other useful products at the site of exploration, known as in-situ resource utilization (ISRU), versus transporting from Earth can significantly reduce the cost and risk of human exploration while at the same time enabling new mission concepts and long term exploration sustainability. Potential in-situ resources of interest include extraterrestrial atmospheres, soils/regolith, and discarded mission materials such as trash (food, wipes, paper, etc.), packaging materials, and crew waste. Technologies and innovative approaches are sought related to the collection, transfer, and processing of these in-situ resources into intermediate (carbon monoxide/carbon dioxide, water, hydrogen, and hydrocarbons) and final products (methane and oxygen) for propulsion and energy generation applications. The subtopic seeks proposals for the design and subsequent building of synergistic hardware that can support Mars atmosphere capture and processing and mission trash/waste conversion. Technologies of interest include:

- Trash feed into high temperature reactors with tight cabin leakage specs.
- Trash gasification reactors (steam and/or partial oxidation) with minimum tar and ash generation and subsequent tar/liquid hydrocarbon reduction.
- Highly efficient reactors for carbon monoxide/carbon dioxide (CO/CO₂) conversion into methane (CH₄).
- Highly efficient gas/gas and gas/liquid-vapor separation devices.
- Fine particle/gas separation (regenerative or continuous) technologies for Mars dust and gasification ash particles.

The proposed technology should address benefits in system mass, conversion and power efficiency, and intermediate/final product generation compared to current approaches. Proposed technologies need be able to operate in microgravity. Mars ISRU technologies need to involve separation and processing of 0.5 to 2 kg/hr of carbon dioxide. Trash processing technologies need to be capable of feeding and processing 12 kg of waste material per day.

Technology Readiness Levels (TRL) of 2 to 5 or higher are sought.

Potential NASA Customers include:

- Office of Chief Technologist/ISRU Program.
- Advanced Exploration Systems Logistics.
- Advanced Exploration Systems Mars Program.
- Advanced Exploration Systems & Office of Chief Technologist Life Support Programs.

TOPIC: H2 Space Transportation

Achieving space flight remains a challenging enterprise. It is an undertaking of great complexity, requiring numerous technological and engineering disciplines and a high level of organizational skill. Human Exploration requires advances in operations, testing, and propulsion for transport to the earth orbit, the moon, Mars, and beyond. NASA is interested in making space transportation systems more capable and less expensive. NASA is interested in technologies for advanced in-space propulsion systems to support exploration, reduce travel time, reduce acquisition costs, and reduce operational costs. The goal is a breakthrough in cost and reliability for a wide range of payload sizes and types (including passenger transportation) supporting future orbital flight vehicles. Lower cost and reliable space access will provide significant benefits to civil space (human and robotic exploration beyond Earth as well as Earth science), to commercial industry, to educational institutions, for support to the International Space Station National Laboratory, and to national security. While other strategies can support frequent, low-cost and reliable space access, this topic focuses on the technologies that dramatically alter acquisition, reusability, reliability, and operability of space transportation systems.

H2.01 Cryogenic Fluid Management Technologies

Lead Center: GRC

Participating Center(s): ARC, GSFC, JSC, KSC

OCT Technology Area: [TA02](#)

This subtopic solicits technologies related to cryogenic propellant storage, transfer, and instrumentation to support NASA's exploration goals. Proposed technologies should feature enhanced safety, reliability, long-term space use, economic efficiency over current state-of-the-art, or enabling technologies to allow NASA to meet future space exploration goals. This includes a wide range of applications, scales, and environments consistent with future NASA missions. Specifically:

- Innovative concepts for cryogenic fluid instrumentation are solicited to enable accurate measurement of propellant mass in low-gravity storage tanks, sensors to detect in-space and on-pad leaks from the storage system, and minimally invasive cryogenic liquid mass flow measurement sensors, including cryogenic two-phase flow.
- Passive thermal control for Zero Boil-Off (ZBO) storage of cryogenics for both long term (>200 days) and short term (~14 days) in all mission environments. Insulation systems that can also serve as Micrometeoroid/orbital debris (MMOD) protection and are self-healing are also desired.
- Cryogenic storage technologies for alternate propellants such as xenon.
- Active thermal control for long term ZBO storage for space applications. Technologies include 20K cryocoolers and integration techniques, heat exchangers, distributed cooling, and circulators.
- Zero gravity cryogenic control devices including thermodynamic vent systems, spray bars, mixers, and liquid acquisition devices.
- Advanced spacecraft valve actuators using piezoelectric ceramics. Actuator should reduce the size and power while minimizing heat leak and increasing reliability.
- Propellant conditioning and densification technologies for propellant storage and transfer. Specific component technologies include compact, efficient and economical cryogenic compressors, pumps, Joule-Thompson orifices and heat exchangers. Also, subcooling of propellants for ground processing and long-term in-space cryogen storage and transfer.
- Liquefaction of oxygen for in space applications. This includes passive cooling with radiators, cryocooler liquefaction, or open cycle systems that work with high-pressure electrolysis.
- Efficient small to medium scale hydrogen liquefaction technologies (1-10k gal/day) including domestically produced wet cryogenic turboexpanders.

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I and show a path toward Phase II demonstration, and delivering a demonstration package for NASA testing at the completion of the Phase II contract.

Phase I Deliverables -Research to identify and evaluate candidate technology applications to demonstrate the technical feasibility and show a path towards a demonstration. Bench or lab-level demonstrations are desirable. The technology concept at the end of Phase I should be at a TRL range of 3-4.

Phase II Deliverables - Emphasis should be placed on developing and demonstrating the technology under simulated mission conditions. The proposal shall outline a path showing how the technology could be developed into mission-worthy systems. The contract should deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract. The technology concept at the end of Phase II should be at a TRL range of 4-5.

Potential NASA Customers include:

- Cryogenic Propulsion Storage and Transfer Technology Demonstration Mission.
- Office of Chief Technologist - Game Changing Development Cryogenic Propulsion Stage Program.

H2.02 In-Space Propulsion Systems

Lead Center: GRC

Participating Center(s): JSC, MSFC

OCT Technology Area: [TA02](#)

This solicitation intends to examine a range of key technology options associated with cryogenic, non-toxic storable, and solid core nuclear thermal propulsion (NTP) systems for use in future exploration missions.

Non-toxic engine technology, including new mono and bipropellants, is desired for use in lieu of the currently operational NTO/MMH engine technology. Handling and safety concerns with toxic chemical propellants can lead to more costly propulsion systems. NTP systems using nuclear fission reactors may enable future short round trip missions to Mars, by helping to reduce launch mass to reasonable values and thereby increasing the payload delivered for Mars exploration missions.

Non-toxic and cryogenic engine technologies could range from pump fed or pressure fed reaction control engines of 25-1000 lbf up to 60,000 lbf primary propulsion engines. Pump fed NTP engines in the 15,000-25,000 lbf class, used individually or in clusters, would be used for primary propulsion.

Specific technologies of interest to meet proposed engine requirements include:

- Non-toxic bipropellant or monopropellants that meet performance targets (as indicated by high specific impulse and high specific impulse density) while improving safety and reducing handling operations as compared to current state-of-the-art storable propellants.
- Manufacturing techniques that lower the cost of manufacturing complex components such as injectors and coolant channels. Examples include, but are not limited to, development and demonstration of rapid prototype techniques for metallic parts, powder metallurgy techniques, and application of nano-technology for near net shape manufacturing.
- High temperature materials, coatings and/or ablatives or injectors, combustion chambers, nozzles, and nozzle extensions.
- Long life, lightweight, reliable turbo-pump designs and technologies include seals, bearing and fluid system components. Hydrogen technologies are of particular interest.
- Highly-reliable, long-life, fast-acting propellant valves that tolerate long duration space mission environments with reduced volume, mass, and power requirements is also desirable.
- High temperature, low burn-up carbide- and ceramic-metallic (cermet) based nuclear fuels with improved coatings and/or claddings to maximize hydrogen propellant heating and to reduce fission product gas release into the engine's hydrogen exhaust stream.
- High temperature and cryogenic radiation tolerant instrumentation and avionics for engine health monitoring. Non-invasive designs for measuring neutron flux (outside of reactor), chamber temperature, operating pressure, and liquid hydrogen propellant flow rates over wide range of temperatures are desired. Sensors need to operate for months/years instead of hours.

Note to Proposer: Subtopic S3.03 under the Science Mission Directorate also addresses in-space propulsion. Proposals more aligned with science mission requirements should be proposed in S3.03.

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I and show a path toward Phase II demonstration, and delivering a demonstration package for NASA testing at the completion of the Phase II contract.

Phase I Deliverables - Research to identify and evaluate candidate technology applications to demonstrate the technical feasibility and show a path towards a demonstration. Bench or lab-level demonstrations are desirable. The technology concept at the end of Phase I should be at a TRL range of 3-4.

Phase II Deliverables - Emphasis should be placed on developing and demonstrating the technology under simulated mission conditions. The proposal shall outline a path showing how the technology could be developed into mission-worthy systems. The contract should deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract. The technology concept at the end of Phase II should be at a TRL range of 4-6.

Potential NASA Customers include:

- Office of Chief Technologist/Game Changing Development Program - In-Space Propulsion Project.
- Office of Chief Technologist/Game Changing Development Program - Manufacturing Innovation (MIP).
- Cryogenic Propulsion Stage/Advanced Upper Stage Engine Program.
- Human Exploration and Operations Directorate/Advanced Exploration Systems - Nuclear Cryogenic Propulsion Stage.

H2.03 Advanced Technologies for Propulsion Testing

Lead Center: SSC

OCT Technology Area: [TA13](#)

Nuclear Thermal Propulsion (NTP), Rocket Based Combined Cycle (RBCC) and Turbine Based Combined Cycle (TBCC) propulsion systems have been identified as high priority NASA technology areas by the United States National Research Council. The goal of this subtopic is to foster development of advanced technologies with commercialization potential that will be needed for component and system level ground testing of these systems during the development and certification phases of their life-cycle.

NTP could be an enabling technology to reduce transit time and mission risk to Near-Earth Objects, Mars, and other deep space destinations. Nuclear power and propulsion technologies are key enabling technologies for future NASA exploration missions. Technology development to facilitate ground testing of NTP is required in the following areas:

- Advanced high-temperature and hydrogen resistant materials for use in a hot hydrogen environment (3000 °F).
- Efficient non-nuclear generation of high flow rate (100 lb/sec), high temperature hydrogen.
- High temperature fluid and thermal management systems.
- High temperature flow control and relief systems.
- High temperature power conversion systems.
- High temperature process piping systems and associated components.
- High temperature instrumentation.

RBCC and TBCC could be enabling technologies to reduce cost for and increase frequency of access to space and allow for rapid transit within the Earth's atmosphere, far exceeding our nation's current capabilities. Technology development to facilitate ground testing of RBCC and TBCC is required in the following areas:

- Thrust take-out and thrust measurement systems that address the unique challenges of a RBCC / TBCC test facility design.

- Non-intrusive velocity / temperature / pressure profile measurement of inlet and exhaust flows.

For the above technology subject areas, research should be conducted to demonstrate technical feasibility during Phase I and show a path toward hardware and/or material development as appropriate which occurs during Phase II and culminates in a proof-of-concept system.

Phase I Deliverables - Phase I deliverables shall include a final report describing design studies and analyses, system, sensor, or instrumentation concepts, prospective material formulations, testing, etc. Prototype systems, components, sensors, instruments or materials can be developed in Phase I as well. The designs or concepts should have commercialization potential. For Phase II consideration, the final report should include a detailed path towards Phase II hardware proof-of-concept system or component or material manufacturing and testing as applicable. The technology concept at the end of Phase I should be at a TRL of 3-4.

Phase II Deliverables - Phase II deliverables shall consist of working proof-of-concept systems, tested material formulations with samples, tested component, sensor, or instrumentation hardware, etc. which have been successfully demonstrated in a relevant environment and delivered to NASA for testing and verification. The technology at the end of Phase II should be at a TRL of 6-7.

Potential NASA Customers include:

- Rocket Propulsion Test Program.
- Nuclear Thermal Propulsion Program.

TOPIC: H3 Life Support and Habitation Systems

Life support and habitation encompasses the process technologies and equipment necessary to provide and maintain a livable environment within the pressurized cabin of crewed spacecraft. Functional areas of interest to this solicitation include atmosphere revitalization and particulate control, environmental monitoring and fire protection systems, crew accommodations, water recovery systems, solid waste management and thermal control. Technologies must be directed at long duration missions in microgravity, including Earth orbit and planetary transit. Requirements include operation in microgravity and compatibility with cabin atmospheres of up to 34% oxygen by volume and pressures ranging from 1 atmosphere to as low as 7.6 psi (52.4 kPa). Special emphasis is placed on developing technologies that will fill existing gaps, reduce requirements for consumables and other resources including mass, power, volume and crew time, and which will increase safety and reliability with respect to the state-of-the-art. Non-venting processes may be of interest for technologies that have future applicability to planetary protection. Results of a Phase I contract should demonstrate proof of concept and feasibility of the technical approach. A resulting Phase II contract should lead to development, evaluation and delivery of prototype hardware. Specific technologies of interest to this solicitation are addressed in each subtopic.

H3.01 Advanced Technologies for Atmosphere Revitalization

Lead Center: MSFC

Participating Center(s): ARC, GRC, JSC, KSC

OCT Technology Area: [TA06](#)

Advancing process technologies for key atmosphere revitalization (AR) functions will be essential for enabling future efforts to extend crewed space exploration beyond low Earth orbit. Specific process technology advancements are sought in the technical areas of regenerative CO₂ removal, process gas drying, regenerable particulate matter filtration and separation techniques, and photocatalytic processes for removing trace volatile organic compounds (VOCs) from cabin atmospheric gases. Specifics pertaining to each technical area are the following:

- *Advanced Sorbents for CO₂ Removal* - Development of robust, high capacity, regenerable CO₂ adsorbents that substantially reduce the energy required for regeneration, are resistant to material degradation (i.e., dusting, spalling) and are highly selective to CO₂ over moisture. Candidate sorbents must be capable of operating in either CO₂ venting (open loop) or CO₂ processing (closed loop) modes.

- *Passive Moisture Removal* - Development of advanced water vapor removal techniques from air streams that operate at near-ambient pressure and temperatures and with little to no energy costs. This may include the development of water-selective materials (e.g., membranes, adsorbents) that exhibit significantly higher efficiencies than current commercial products. Very dry air (-65 °C dew point) can be assumed to be available to aid in drying process stream (1:1 ratio). Candidate process technologies must be capable of either venting moisture to space or returning moisture to the cabin for subsequent recovery for crew use.
- *Particulate Management* - Long-life and self-cleaning particulate pre-filters are required to reduce crew maintenance time and eliminate the need for consumable filter elements. These units should be able to handle large surges of particles and operate over very long periods. They should also be self-cleaning in-place or off-line (in-place is preferable, and provide viable methods for disposing of collected particulate matter while minimizing or eliminating direct contact by the crew. Complete (100%) capture of particles 20 microns and larger is required. Targeted technologies should be compact and lightweight, and easily integrated with the spacecraft Environmental Control and Life Support Systems (ECLSS).
- *Photocatalytic Oxidation (PCO) for Trace Contaminant Control* - Technologies are of interest for photocatalytic oxidation of Volatile Organic Carbon (VOCs) completely to CO₂ and H₂O (i.e., complete “mineralization”) without producing partial oxidation products such as aldehydes and/or organic acids. Catalysts that are activated not only by UV, but also the visible region of the solar spectrum to capitalize on the highly efficient blue LEDs or solar energy are desired. Concepts should minimize PCO reactor volume via improved catalysts and catalyst activity, improved UV illumination scheme and/or improved illuminated catalyst surface area-to-volume ratio.

Technology Readiness Levels (TRL) of 2 to 3 or higher are sought.

Potential NASA Customers include:

- Mission elements and vehicles: Orion Multi-Purpose Crew Vehicle, Multi-Mission Space Exploration Vehicle, Deep Space Habitat, Pressurized Rovers and Planetary Surface Systems, International Space Station.
- Human exploration missions include: Low-Earth orbit, Earth’s neighborhood (Earth-moon libration points, lunar orbit and surface, geosynchronous orbits, etc), Near-Earth Asteroids, Mars Missions (transit, orbit, moons and surface).

(<http://www.nasa.gov/exploration/home/index.html>)

H3.02 Environmental Monitoring and Fire Protection for Spacecraft Autonomy

Lead Center: JPL

Participating Center(s): ARC, GRC, JSC, KSC, MSFC

OCT Technology Area: [TA06](#)

Environmental Monitoring

Technologies are desired to ensure that the chemical content of the air and water environment of the crew habitat falls within acceptable limits and the life support system is functioning properly and efficiently. Required technology characteristics include: 2 year shelf-life; functionality in microgravity and low pressure environments (~8 psi). The technologies require significant improvements in miniaturization, reliability, life-time, self-calibration, and reduction of expendables. Examples of desired analytes are:

- Trace silver (0.05-15 mg/L) and trace organics in water (acetone: 0.05-5 mg/L; aldehydes: 0.4-60 mg/L; alcohols: 1-100 mg/L).

Technologies for quantification and identification of microbial species are requested within an alternative subtopic, ISS Utilization.

Spacecraft Fire Protection

A first response crew mask capable of protecting the crew from ammonia, hydrazine, and combustion products is desired. A suitable first response mask should be quick to don, protect the wearer from environmental contaminants and elevated temperature hazards, and provide breathable air during prolonged emergency response activities. This mask would be one-size fits all and be effective for a minimum of 1 hour. While wearing the mask, the crew should have excellent freedom of motion and positive indication of effectiveness.

A portable, self-contained fire and toxic atmosphere cleanup system is desired that can rapidly remove contaminants from a spacecraft volume.

Technology Readiness Levels (TRL) of 3 to 4 or higher are sought.

H3.03 Crew Accommodations and Water Recovery for Long Duration Missions

Lead Center: JSC

Participating Center(s): ARC, KSC, MSFC

OCT Technology Area: [TA06](#)

Spacecraft crew accommodations requires volumetrically reconfigurable and hygienic crew interiors that maintain crew productivity. Advancements are required to reduce logistical packaging mass residual, repurpose logistical items for outfitting, provide extended wear clothing, clothes laundering, and metabolic waste collection/processing. Advancements in technology for water recovery are required to exceed existing 85% recovery from urine and humidity condensate. It is expected that both the variety of wastewater sources and the total volume of wastewater will increase with increasing mission duration. Technologies that increase closure of the water system and reduce expendables will enable future missions. Specific focus areas include:

Human Fecal & Waste Management:

- Technology is needed to collect, dry, process, and recover useful materials, and to safely store human feces, trash, and processed residuals. Technologies for micro-gravity collection of urine and feces should have modes that allow for operation even if active components fail, by relying on or being aided by passive processes for function, such as capillary forces. Minimal crew interaction, low energy, contamination tolerant waste processing systems that recover water, methane, or other useful materials are desired.

Logistical Repurposing:

- Novel alternatives to existing launch foam packaging materials that are light weight, have low frangibility, and can be compressed or heated to achieve low residual volume after launch.
- Launch packaging systems (bags, nets, hard structures) that can be repurposed or reconfigured on orbit to provide interior crew accommodations (sleep areas, exercise, hygiene, thermal/sound control) with minimal mass penalty.
- Logistical materials that can be readily processed or reformulated on orbit to provide atmospheric gases, water, or material for in-space fabrication processes with minimal power requirements.

Mixed Brine Water Recovery:

- Recovery of water from mixed waste stream brines with 12% or higher dissolved solids are desired. Low energy, microgravity, low expendable systems should be tolerant of urine stabilization chemicals such as oxone, sulfuric acid and hexavalent chromium.

Biocide Delivery Systems:

- Technologies to replace the use of iodine for potable water disinfection. This may include techniques to replenish silver ions to a concentration of 0.4 mg/l in potable water or techniques to minimize the loss of silver ions in a potable water system. In addition, alternative disinfection technologies to inhibit biofilm

formation on surfaces and provide residual disinfectant to maintain potable water quality would be considered.

Technology Readiness Levels (TRL) of 3 or higher are sought.

Potential NASA Customers include:

- Mission elements and vehicles:
 - Orion Multi-Purpose Crew Vehicle.
 - Multi-Mission Space Exploration Vehicle.
 - Deep Space Habitat.
 - Pressurized Rovers and Planetary Surface Systems.
 - International Space Station.

Human exploration missions include:

- Low-Earth orbit, Earth's neighborhood (Earth-moon libration points, lunar orbit and surface, geosynchronous orbits, etc).
- Near-Earth Asteroids.
- Mars Missions (transit, orbit, moons and surface).

(<http://www.nasa.gov/exploration/home/index.html>)

H3.04 Thermal Control Systems

Lead Center: JSC

Participating Center(s): GRC, GSFC, JPL, KSC, LaRC, MSFC

OCT Technology Area: [TA14](#)

Future human spacecraft will venture far beyond the relatively benign environment of low Earth orbit. They will transit through the deep space, but they may encounter warm transient environments such as low lunar orbit. Some spacecraft elements may be launched untended and would operate at relatively low power levels as they transit to their final destination. The combination of extreme environments and high turndown capability will be a major challenge for spacecraft Active Thermal Control Systems (ATCSs). Sophisticated thermal control systems will be required that can dissipate a wide range of heat loads in widely varying environments while using fewer of the limited spacecraft mass, volume and power resources. Advances are sought for microgravity room temperature thermal control in the areas of:

- Innovative thermal components and system architectures that are capable of operating over a wide range of heat loads in varying environments (for example, a 5:1 heat load range in environments ranging from 0 to 275 K).
- Two-phase heat transfer components and system architectures will allow the efficient acquisition, transport, and rejection of waste heat.
- Heat rejection strategies and hardware for transient, cyclical applications – e. g., phase change material heat exchangers, heat pumps, or efficient evaporative heat sinks.
- Smaller, lighter, high performance heat exchangers and coldplates.
- Low temperature external working fluids (a temperature limit approaching 150K) with favorable thermophysical properties – e. g., high specific heat, high thermal conductivity, and viscosity that does not dramatically increase at lower temperatures.
- Internal working fluids that are non-toxic, have favorable thermophysical properties, and are compatible with aluminum tubing (i.e., no corrosion for up to 10 years). Low temperature limits (~150 K) and favorable thermophysical properties would allow their use externally in a single loop ATCS.
- Low mass, high conductance ratio thermal switches.
- Long-life, light-weight, efficient single-phase pumps capable of producing relatively high pressure heads (~4 atm).
- Variable area radiators (e.g., variable conductance heat pipe radiators or drainable radiators).

- New thermal design tools to reduce the time and costs required for analysis, design, integration, and testing of the spacecraft. In particular, an innovative thermal design tool capable of fast and accurate spacecraft thermal modeling with significantly reduced effort and cost is needed.

Technology Readiness Levels (TRL) of 2 to 4 or higher are sought.

Potential NASA Customers include:

- Orion Multipurpose Crew Vehicle (http://www.nasa.gov/mission_pages/constellation/orion/index.html)

Future Human Space Missions - (<http://www.nasa.gov/exploration/home/index.html>)

TOPIC: H4 Extra-Vehicular Activity Technology

Advanced Extra -Vehicular Activity (EVA) systems are necessary for the successful support of the International Space Station (ISS) beyond 2020 and future human space exploration missions for in-space microgravity EVA and for planetary surface exploration. Advanced EVA systems include the space suit pressure garment, airlocks, the Portable Life Support System (PLSS), Avionics and Displays, and EVA Integrated Systems. Future human space exploration missions will require innovative approaches for maximizing human productivity. Advanced EVA system must also provide the capability to perform useful tasks safely, such as assembling and servicing large in-space systems and exploring surfaces of the Moon, Mars, and small bodies. Top-level requirements for advanced EVA systems include reduction of system weight and volume, minimization of consumables usage, increased hardware reliability, durability, operating life, increased human comfort, and less restrictive work performance in the space environment. All proposed Phase I research must lead to specific Phase II experimental development that could be integrated into a functional EVA system.

H4.01 Space Suit Pressure Garment and Airlock Technologies

Lead Center: JSC

Participating Center(s): GRC

OCT Technology Area: [TA06](#)

Advanced space suit pressure garment and airlock technologies are necessary for the successful support of the International space Station (ISS) and future human space exploration missions for in-space microgravity EVA and planetary surface operations. The space suit pressure garment requires innovative technologies focused on performance, environmental protection, and mass reduction. Two of the critical performance characteristics of a suit are mobility and durability. Improved mobility typically competes against durability and suit component life. Materials that enable both highly mobile and durable designs would negate the need for compromise in one of these areas. Other key suit performance enhancements include materials that enable improved fit and sizing, such as shape change materials that increase the ease of suit don/doff or facilitate adaptable fit for specific functional tasks. Space suit environmental protection includes protection from thermal extremes, vacuum, cuts, abrasion and micrometeoroid and orbital debris (MMOD). Additional environmental protection is desired for plasma, radiation, electrical shock, antimicrobials and dust. It is desirable to provide protection in as few material layers as possible; therefore, multi-functional materials are desired. Self-healing materials and materials that alert the inspector to wear/maintenance needs are also of interest. Mass reduction of the space suit system is highly desirable for many reasons, with arguably the biggest drivers being launch mass and on-back mass during EVA. New materials that can lead to reductions in suit component mass, for example, lightweight materials for bearings and hard structures, are therefore desirable.

Due to the expected large number of space walks that will be performed on the ISS beyond 2020 and during future human space exploration missions, innovative technologies and designs for both microgravity and surface airlocks will be needed. Technology development is needed to decrease the time associated with egressing and ingressing the vehicle or habitat, reducing the gas loss during depressurization, and decreasing the potential of contaminating the cabin due to bringing in dust or CO₂. These enhancements could be achieved with a suitport, suitlock or some type of advanced airlock.

Technology Readiness Levels (TRL) of 4 to 6 or higher are sought.

Potential NASA Customers include:

- EVA Project Office.
- International Space Station.
- Human Exploration Operations Mission Directorate.
- Office of Chief Technologist.

H4.02 Space Suit Life Support and Avionics Systems

Lead Center: JSC

Participating Center(s): GRC

OCT Technology Area: [TA06](#)

Space Suit Life Support Systems

Advanced space suit life support systems are necessary for the successful support of the International Space Station (ISS) and future human space exploration missions for in-space microgravity EVA and planetary surface operations. Exploration missions will require a robust, lightweight, and maintainable Primary Life Support System (PLSS). The PLSS attaches to the space suit pressure garment and provides approximately an 8 hour supply of oxygen for breathing, suit pressurization, ventilation and CO₂ removal, and a thermal control system for crew member metabolic heat rejection. Innovative technologies are needed for high-pressure O₂ delivery, crewmember cooling, heat rejection, and removal of expired CO₂ and water vapor.

Space Suit Avionics Systems

Future generations of advanced space suit avionics will be far superior to those on the current generation of space suits. They will be more capable, configurable, lightweight, and low power with a footprint that will rival current consumer electronic devices, but survive the harsh space environment. They must be self-contained, so that maintenance on the devices can be performed on-orbit or they can be easily swapped for functioning or upgraded devices. Those considered will be radio, displays, and cameras.

Future advanced radios will be configurable and, potentially, software-defined and/or re-configurable to support future communications network-based architectures in addition to the point-to-point communications links that are prevalent today. The next-generation EVA radios will need to support voice, telemetry, and standard/high definition video data flows (up to 20 Mbps) and the radio architecture will need to be lightweight and power efficient while managing data in a seamless and lossless manner between multiple interfaces. Radios should support space-based or terrestrial-based protocols to enable communications between multiple entities across a communications link and have an open and modular architecture.

The current generation of Head-Mounted Displays (HMDs) and Near-to-Eye (NTE) Displays are not viable, since it is desirable for the display to be decoupled from the user's head for improved safety, comfort, and alignment. The decoupling makes the specifications for the eyebox (tolerance to misalignment before image goes out of focus), field of view (angle of the image created by the optics), and eye relief (working distance from the eye to the last optical element) difficult. Key performance targets include:

- Graphical Data Presentation: SXGA @ 40 °FOV (possibly biocular).
- Decoupled from User's Head - Large Eyebox: 100 mm x 100mm x 50mm (D).
- Sunlight Readability: 500 fL inside visor, 1800 fL outside visor (>10 to 1 contrast).

Display technologies must ensure that suit displays can operate outside the suit environment in thermal, radiation, and vacuum as well as internally without imposing ignition hazards due to 100% oxygen environment.

Cameras will not only provide the crewmember the ability for still and motion image, but also situational awareness, which enhances safety for the crewmember. The cameras should be capable of recording high definition motion and high-resolution imagery with the ability to compress the data for transmission over a variety of RF transmissions and/or IP networks with varying bandwidths. Hemispherical and dynamic cameras are desired. Dynamic cameras can take still images and motion video in variable bandwidths, capture images based on link quality, and change frame rates. Hemispherical cameras record 360 ° video views of a crewmember, distort views through optics and then undistort the views via software on the ground to pan/zoom for total situational awareness. Cameras should be low-power and lightweight with a number of mounting options for optimal placement on the suit.

Technology Readiness Levels (TRL) of 4 to 6 or higher are sought.

Potential NASA Customers include:

- EVA Project Office.
- International Space Station.
- Human Exploration Operations Mission Directorate.
- Office of Chief Technologist.

TOPIC: H5 Lightweight Spacecraft Materials and Structures

The SBIR topic area of Lightweight Spacecraft Materials and Structures centers on developing lightweight inflatable structures, solar array structures, and advanced manufacturing technologies for metallic materials. Applications are expected to include space exploration vehicles including launch vehicles, crewed vehicles, and surface and habitat systems, and solar electric propulsion tugs. The subtopic Expandable/Deployable Structures solicits innovative concepts to support the development of lightweight-structure technologies that would be viable solutions to high packaging efficiency, and of deployment mechanisms. Technologies are needed to minimize launch mass, volume and costs, while maintaining the required structural performance for the loads and environments. Of particular interest for expandable/inflatable systems are high-tenacity fibrous materials for the restraint layer of inflatable structures, and bladder materials with limited air permeation and good flexure properties at low temperatures. Analysis and test methods that verify the performance of highly loaded inflated structures are highly desired. For large solar arrays systems, mass-efficient solar array designs with a scalable path from 20-30 kW up to 300 kW and beyond are needed. Advanced analysis and test techniques to ensure reliable deployment of large solar array structures are of special interest. Novel design and packaging concepts, analysis techniques, and both ground and in-space test methods are sought for large deployable solar arrays as well as for individual components such as lightweight booms, ribs, or frames; flexible substrate materials; and mechanisms. The overall objective of the subtopic on Advanced Manufacturing and Material Development for Lightweight Metallic Structures is to advance technology readiness levels of lightweight metals and manufacturing techniques for launch vehicles and in-space applications resulting in structures having affordable, reliable, predictable performance with reduced costs. Proposals are sought that offer innovative manufacturing processes and/or materials to locally increase the stiffness and strength of structural elements added to NNS components. Manufacturing methods of interest include additive manufacturing methods that employ wire feedstock, fusion and friction stir welding. Of specific interest in materials are advances in aluminum wire and tape feedstock materials, including customized alloy chemistry and metal matrix composites (MMCs) incorporating either discontinuous or continuous reinforcements. Of specific interest in manufacturing and processing are proposals that address issues such as residual stress and distortion control, post-deposition processing to develop service mechanical properties, and energy source/reinforcement interactions. Research under this topic should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II hardware demonstration, and when possible, deliver a full-scale demonstration unit for functional and environmental testing at the completion of the Phase II contract.

H5.01 Expandable/Deployable Structures

Lead Center: LaRC

Participating Center(s): JSC

OCT Technology Area: [TA12](#)

The SBIR subtopic area of Lightweight Expandable/Deployable Structures solicits innovative concepts to support the development of primary pressurized inflatable modules or large solar array structures for space exploration environments. Concepts should illustrate simple designs, low launch-to-deployed dimension ratios, efficient packaging and deployment techniques. Robustness, damage tolerance, and minor repair capabilities should also be considered in concept submittals. Development of advanced analysis and test methods that verify the performance of highly loaded inflated structures or large solar array systems are highly desired.

Of particular interest for expandable/inflatable systems are high-tenacity fibrous materials for the restraint layer of inflatable structures. Proposed materials should have well-characterized long-term creep behavior or a characterization plan for determination thereof. Also of significant interest are bladder materials with an air permeation rate no greater than 1.5 cc/100 in²/day/atm that remain sufficiently flexible at -50 °F to be deployed on orbit without external heating. Permeation rate should show no increase upon fold/flex testing at -50 °F.

For large solar arrays systems, mass-efficient solar array designs with a scalable path from 20-30 kW up to 300 kW and beyond are needed. Advanced analysis and test techniques to ensure reliable deployment of large solar array structures are of special interest. Novel design and packaging concepts, analysis techniques, and both ground and in-space test methods are sought for large deployable solar arrays as well as for individual components such as lightweight booms, ribs, or frames; flexible substrate materials; and mechanisms.

Technology Readiness Levels (TRL) of 3 to 4 or higher are sought.

Potential NASA Customers include:

- International Space Station.
- Advanced Exploration Systems - Deep Space Habitat.
- Office of Chief Technology - Game Changing Technology Division, and Technology Demonstration Missions.

H5.02 Advanced Manufacturing and Material Development for Lightweight Metallic Structures

Lead Center: LaRC

Participating Center(s): GRC, MSFC

OCT Technology Area: [TA12](#)

The overall objective of this subtopic is to advance technology readiness levels of lightweight metals and manufacturing techniques for launch vehicles and in-space applications resulting in structures having affordable, reliable, predictable performance with reduced costs.

The current state-of-the-art for fabrication of launch vehicle structure is multi-piece welded and riveted construction to assemble parts that are heavily machined from thick wrought products. Fabrication of single-piece launch vehicle structure using near-net shape (NNS) manufacturing methods can reduce mass and cost while increasing safety and reliability, primarily through elimination of welds and parasitic weld land weight and reduction in the number of manufacturing steps. However, to fully realize the benefits of these NNS manufactured components, methods to add structural elements and/or locally enhance material properties of these structural elements are needed. Structural elements added by welding or deposited by additive manufacturing methods typically have dissimilar microstructures and reduced mechanical properties compared with the NNS fabricated component. Materials of construction are typically aluminum and aluminum lithium (Al-Li) alloys. Some examples where this technology would be applied include adding stiffeners to thin-walled single-piece monocoque shells such as cylinders, bulkheads, domes, and frustums, and for reinforcing cut outs and windows.

Proposals are sought that offer innovative manufacturing processes and/or materials to locally increase the stiffness and strength of structural elements added to NNS components. Manufacturing methods of interest include additive

manufacturing methods that employ wire feedstock, fusion and friction stir welding. Of specific interest in materials are advances in aluminum wire and tape feedstock materials, including customized alloy chemistry and metal matrix composites (MMCs) incorporating either discontinuous or continuous reinforcements. Of specific interest in manufacturing and processing are proposals that address issues such as residual stress and distortion control, post-deposition processing to develop service mechanical properties, and energy source / reinforcement interactions.

Research should be conducted to demonstrate technical feasibility in Phase I and show a path toward demonstration in Phase II of material fabrication and / or manufacturing process improvement. When possible proposals should include delivery of sample material for test and evaluation by NASA and / or a component demonstration article.

Technology Readiness Levels (TRL) of 4 to 6 or higher are sought.

Potential NASA Customers include:

- Office of Chief Technology – Integrated Manufacturing Modeling with Experiment.
- Space Launch System.
- Multi Purpose Crew Vehicle.
- Fundamental Aeronautics – Fixed Wing, High Speed, Aerosciences Projects.

TOPIC: H6 Autonomous and Robotic Systems

NASA invests in the development of autonomous systems, advanced avionics, and robotics technology capabilities for the purpose of enabling complex missions and technology demonstrations supporting the Human Exploration and Operations Mission Directorate (HEOMD). The software, avionics, and robotics elements requested within this topic are critical to enhancing human spaceflight system functionality. These elements increase autonomy and system reliability; reduce system vulnerability to extreme radiation and thermal environments; and support human exploration missions with robotic assistants, precursors and caretaker robots. As key and enabling technology areas, autonomous systems, avionics and robotics are applicable to broad areas of technology use, including heavy lift launch vehicle technologies, robotic precursor platforms, utilization of the International Space Station, and spacecraft technology demonstrations performed to enable long duration space missions. All of these flight applications will require unique advances in software, robotic technologies and avionics. The exploration of space requires the best of the nation's technical community to provide the technologies, engineering, and systems to enable human exploration beyond LEO, to visit asteroids and the Moon, and to extend our reach to Mars.

H6.01 Spacecraft Autonomy and Space Mission Automation

Lead Center: ARC

Participating Center(s): JPL

OCT Technology Area: [TA04](#)

Future human spaceflight missions will place crews at large distances and light-time delays from Earth, requiring novel capabilities for crews and ground to manage spacecraft consumables such as power, water, propellant and life support systems to prevent Loss of Mission (LOM) or Loss of Crew (LOC). This capability is necessary to handle events such as leaks or failures leading to unexpected expenditure of consumables coupled with lack of communications. If crews in the spacecraft must manage, plan and operate much of the mission themselves, NASA must migrate operations functionality from the flight control room to the vehicle for use by the crew. Migrating flight controller tools and procedures to the crew on-board the spacecraft would, even if technically possible, overburden the crew. Enabling these same monitoring, tracking, and management capabilities on-board the spacecraft for a small crew to use will require significant automation and decision support software. Required capabilities to enable future human spaceflight to distant destinations include:

- Enable on-board crew management of vehicle consumables that are currently flight controller responsibilities.
- Increase the onboard capability to detect and respond to unexpected consumables-management related events and faults without dependence on ground.

Human Exploration and Operations

- Reduce up-front and recurring software costs to produce flight-critical software.
- Provide more efficient and cost effective ground based operations through automation of consumables management processes, and up-front and recurring mission operations software costs.

The same capabilities for enabling human spaceflight missions are directly applicable to efforts to automate the operation of unmanned aircraft flying in the National Airspace (NAS) and robotic planetary explorers.

Mission Operations Automation:

- Peer-to-peer mission operations planning.
- Mixed initiative planning systems.
- Elicitation of mission planning constraints and preferences.
- Planning system software integration.

Space Vehicle Automation:

- Autonomous rendezvous and docking software.
- Integrated discrete and continuous control software.
- Long-duration high-reliability autonomous system.
- Power aware computing.

Spacecraft Systems Automation:

- Multi-agent autonomous systems for mapping.
- Safe proximity operations (including astronauts).
- Uncertainty management for proximity ops, movement, etc.

Emphasis of proposed efforts:

- Software proposals only, but emphasize hardware and operating systems the proposed software will run on (e.g., processors, sensors).
- In-space or Terrestrial applications (e.g., UAV mission management) are acceptable.
- Proposals must demonstrate mission operations cost reduction by use of standards, open source software, staff reduction, and/or decrease of software integration costs.
- Proposals must demonstrate autonomy software cost reduction by use of standards, demonstration of capability especially on long-duration missions, system integration, and/or use of open source software.

Technology Readiness Levels (TRL) of 4 to 6 or higher are sought.

Potential NASA Customers include:

- Autonomous Mission Operations Project (<http://www.nasa.gov/directorates/heo/aes/index.html>)
- Habitation Systems Project.
 - (http://www.nasa.gov/exploration/analog/hdu_project.html)
- Mission Operations Directorate
- Human Exploration Telerobotics Project
 - (http://www.nasa.gov/mission_pages/tel/telerobotics/telerobotics_overview.html)

H6.02 Radiation Hardened/Tolerant and Low Temperature Electronics and Processors

Lead Center: MSFC

Participating Center(s): GSFC, JPL

OCT Technology Area: [TA11](#)

Exploration flight projects, robotic precursors, and technology demonstrators that are designed to operate beyond low-Earth orbit require avionic systems, components, and controllers that are capable of enduring the extreme

temperature and radiation environments of deep space, the lunar surface, and eventually the Martian surface. Spacecraft vehicle electronics will be required to operate across a wide temperature range and must be capable of enduring frequent (and often rapid) thermal-cycling. Packaging for these electronics must be able to accommodate the mechanical stress and fatigue associated with the thermal cycling.

Spacecraft vehicle electronics must be radiation hardened for the target environment. They must be capable of operating through a minimum total ionizing dose (TID) of 300 krad (Si), provide fewer Single Event Upsets (SEUs) than 10⁻¹⁰ to 10⁻¹¹ errors/bit-day, and provide single event latchup (SEL) immunity at linear energy transfer (LET) levels of 100 MeV cm²/mg (Si) or more. All three characteristics for radiation hardened electronics of TID, SEU and SEL are needed.

Electronics hardened for thermal cycling and extreme temperature ranges should perform beyond the standard military specification range of -55 °C to 125 °C, running as low as -230 °C or as high as 350 °C.

Using the target environment performance parameters for thermal and radiation extremes, proposals are sought in the following specific areas:

- Low power, high efficiency, radiation-hardened processor technologies.
- Technologies and techniques for environmentally hardened Field Programmable Gate Array (FPGA).
- Innovative radiation-hardened volatile and nonvolatile memory technologies.
- Tightly-integrated electronic sensor and actuator modules that include power, command and control, and processing.
- Radiation-hardened analog application specific integrated circuits (ASICs) for spacecraft power management and other applications.
- Radiation-hardened DC-to-DC converters and point-of-load power distribution circuits.
- Computer Aided Design (CAD) tools for predicting the electrical performance, reliability, and life cycle for low-temperature and wide-temperature electronic systems and components.
- Physics-based device models valid at temperature ranging from -230 °C to +130 °C to enable design, verification and fabrication of custom mixed-signal and analog circuits.
- Circuit design and layout methodologies/techniques that facilitate radiation hardness and low-temperature (-230 °C) analog and mixed-signal circuit performance.
- Packaging capable of surviving numerous thermal cycles, tolerant of the extreme temperatures, and the ionizing radiation environment on the Moon and Mars. This includes the use of appropriate materials including substrates, die-attach, encapsulants, thermal compounds, etc.

Technology Readiness Levels (TRL) of 3 to 5 or higher are sought.

Potential NASA Customers include:

- Autonomous Landing Systems.
- Mars Science Lab Instrumentation.
- Tele-robotics.
- Surface Mobility.
- Nuclear Systems.
- Robotic Satellite Servicing.
- In-Space propulsion.
- Deep Space X-Ray Navigation and Communication.
- Deep Space Optical Communications.
- Mars Sample Return.
- Europa Orbiter.
- Near Earth Objects and Primitive Body Missions.
- Space Launch System.
- Extra-Vehicular Activity Suits

H6.03 Human-Robotic Systems - Manipulation Subsystem

Lead Center: JSC

Participating Center(s): ARC, JPL

OCT Technology Area: [TA04](#)

This call for technology development is in direct support of the Human Exploration and Operations Mission Directorate (HEOMD). The purpose of this research is to develop component and subsystem level technologies to support robotic precursor exploration missions. To that end, it is the intent of this Subtopic to capitalize on advanced technologies that allow humans and robots to interact seamlessly and significantly increase their efficiency and productivity in space. The objective is to produce new technologies that will reduce the total mass-volume-power of equipment and materials required to support both short and long duration planetary missions. The proposals must focus on component and subsystem level technologies in order to maximize the return from current SBIR funding levels and timelines. Doing so increases the likelihood of successfully producing a technology that can be readily infused into existing robotic system designs. This research focuses on technology development for the critical functions that will ultimately enable surface exploration for the advancement of scientific research. Surface exploration begins with short duration missions to establish a foundation, which leads to extensible functional capabilities. Successive buildup missions establish a continuous operational platform from which to conduct scientific research while on the planetary surface. Reducing risk and ensuring mission success depends on the coordinated interaction of many functional surface systems including power, communications infrastructure, mobility, and ground operations. This Subtopic addresses robotic manipulation and related technology needs associated with planetary surface systems infrastructure, interaction of humans and machines, mobility systems, payload and resource handling, and mitigation of environmental contaminations.

The objective of this Subtopic is to create human-robotic technologies (hardware and software) to improve the exploration of space.

Robots can perform tasks to assist and off-load work from astronauts. Robots may perform this work before, in support of, or after humans.

Ground controllers and astronauts will remotely operate robots using a range of control modes (teleoperation to supervised autonomy), over multiple spatial ranges (shared-space, line-of-sight, in orbit, and interplanetary), and with a range of time-delay and communications bandwidth.

Proposals are sought that address the following technology needs:

- Subsystems that improve handling and maintenance of payloads and assets.
- Enable crew and ground controllers to better operate, monitor, and supervise robots.
- Improve the transport of crew, instruments, and payloads on planetary surfaces, asteroids, as well as in space.

This includes:

- Robot user interfaces.
- Automated performance monitoring.
- Tactical planning software.
- Ground data system tools.
- Command planning and sequencing.
- Real-time visualization/notification.
- Software for situational awareness, as well as, subsystems to improve handling and maintenance of payloads and assets.
- Tactile sensors.
- Human-safe actuation.
- Active structure.
- Dexterous grasping.
- Modular “plug and play” mechanisms for deployment and setup.

- Standardized interfaces for structural loads & commodity transfer.
- Novel robotic manipulation methods.
- Small/lightweight devices to provide subsurface access and sampling.
- Small/lightweight regolith excavation, handling & delivery devices.
- Regolith anchoring methods for near Earth objects (neo).
- Subsystems to improve the transport of crew, instruments, and payloads on planetary surfaces, asteroids, and in-space.
- Hazard detection sensors/perception.
- Active suspension.
- Grappling/anchoring.
- Legged locomotion.
- Sub-surface locomotion.
- Robot navigation.
- Infrastructure-free localization.

Technology Readiness Levels (TRL) of 2 to 6 are sought.

Potential NASA Customers include:

- Software Robotics and Simulation Division (JSC-ER).
- International Space Station.
- Habitat Development Unit (AES Project).
- Multi-Mission Space Exploration Vehicle (MMSEV-AES Project).
- MPCV Orion Project.
- R2 (Robonaut Project).

TOPIC: H7 Entry, Descent and Landing Technology

The Thermal Protection System (TPS) protects a spacecraft from the severe heating encountered during hypersonic flight through a planetary atmosphere. In general, there are two classes of TPS - reusable and ablative. Typically, reusable TPS applications are limited to relatively mild entry environments like that of Space Shuttle. No change in the mass or properties of the TPS material results from entry with a significant amount of energy being re-radiated from the heated surface and the remainder conducted into the TPS material. Typically, a surface coating with high emissivity (to maximize the amount of energy re-radiated) and with low surface catalycity (to minimize convective heating by suppressing surface recombination of dissociated boundary layer species) is employed. The primary insulation has low thermal conductivity to minimize the mass of material required to insulate the primary structure. Ablative TPS materials, in contrast, accommodate high heating rates and heat loads through phase change and mass loss. All NASA planetary entry probes to date have used ablative TPS. Most ablative TPS materials are reinforced composites employing organic resins as binders. When heated, the resin pyrolyzes producing gaseous products that are heated as they percolate toward the surface thus transferring some energy from the solid to the gas. Additionally, the injection of the pyrolysis gases into the boundary layer alters the boundary layer properties resulting in reduced convective heating. However, the gases may undergo chemical reactions with the boundary layer gases that could return heat to the surface. Furthermore, chemical reactions between the surface material and boundary layer species can result in consumption of the surface material leading to surface recession. Those reactions can be endothermic (vaporization, sublimation) or exothermic (oxidation) and will have an important impact on net energy to the surface. Clearly, in comparison to reusable TPS materials, the interaction of ablative TPS materials with the surrounding gas environment is much more complex as there are many more mechanisms to accommodate the entry heating. NASA has successfully tackled the complexity of thermal protection systems for numerous missions to inner and outer planets in our solar system in the past; the knowledge gained has been invaluable but incomplete. Future missions will be more demanding. Better performing ablative TPS than currently available is needed to satisfy requirements of the most severe missions, e.g., Near Earth Object Earth Return with velocities exceeding 11.5 km/s and Heavy Mass Mars Landing with 8 km/s entry. In addition, new low ballistic coefficient deployable systems may require flexible ablative TPS materials that can protect systems experiencing heat fluxes ranging from

30 W/cm² to 300 W/cm², depending on their missions. Beyond the improvement needed in ablative TPS materials, more demanding future missions such as large payload missions to Mars will require novel entry system designs that consider different vehicle shapes, deployable or inflatable configurations and integrated approaches of TPS materials with the entry system sub-structure.

H7.01 Ablative Thermal Protection Systems

Lead Center: ARC

Participating Center(s): GRC, JPL, JSC, LaRC

OCT Technology Area: [TA14](#)

The technologies described below support the goal of developing higher performance ablative TPS materials for higher performance future Exploration missions. Developments are sought for ablative TPS materials and heat shield systems that exhibit maximum robustness, reliability and survivability while maintaining minimum mass requirements, and capable of enduring severe combined convective and radiative heating. In addition, in order to adequately test and design with these materials, advancements in instrumentation, inspection, and modeling of ablative TPS materials is also sought.

Areas of interest include improvements in the reinforcement materials as follows:

- Advancements in carbon felts including thickness (>1.0-in), density (>0.12 g/cm³), uniformity to use as reinforcement for high strain-to-failure ablative TPS materials.
- Advancements in thin (~0.1-in) three dimensional woven carbon materials to act as stress bearing structure for deployable aeroshells.
- Advancements in thick (>1.0-in) three dimensional woven carbon materials to use as reinforcement for high heat flux mid-to-high density ablative TPS materials.

TPS Materials advancements sought in felts or woven materials impregnated with polymers to improve ablation performance. Areas of interest include:

- One class of materials, for planetary aerocapture and entry for a rigid mid L/D (lift to drag ratio) shaped vehicle, will need to survive a dual heating exposure, with the first at heat fluxes of 400-500 W/cm² (primarily convective) and integrated heat loads of up to 55 kJ/cm², and the second at heat fluxes of 100-200 W/cm² and integrated heat loads of up to 25 kJ/cm². These materials or material systems must improve on the current state-of-the-art recession rates of 0.25 mm/s at heating rates of 200 W/cm² and pressures of 0.3 atm and improve on the state-of-the-art areal mass of 1.0 g/cm² required to maintain a bondline temperature below 250 °C
- The second class of materials, for planetary aerocapture and entry for a deployable aerodynamic decelerator, will need to survive a single or dual heating exposure, with the first (or single pulse) at heat fluxes of 50-150 W/cm² (primarily convective) and integrated heat loads of 10 kJ/cm² and the second at heat fluxes of 30-50 W/cm² and heat loads of 5 kJ/cm². These materials may be either flexible or deployable.
- The third class of materials, for higher velocity (>11.5km/s) Earth return, will need to survive heat fluxes of 1500-2500 W/cm², with radiation contributing up to 75% of that flux, and integrated heat loads from 75-150 kJ/cm². These materials, or material systems must improve on the current state-of-the-art recession rates of 1.00 mm/s at heating rates of 2000 W/cm² and pressures of 0.3 atm and improve on the state-of-the-art areal mass of 4.0 g/cm², required to maintain a bondline temperature below 250 °C.

Development of in-situ heat flux sensors, surface recession diagnostics, and in-depth or interface thermal response measurement devices for use on rigid and/or flexible ablative materials. In-situ heat flux sensors and surface recession diagnostics tools are needed for flight systems to provide better traceability from the modeling and design tools to actual performance. The resultant data will lead to higher fidelity design tools, risk reduction, decreased heat shield mass and increases in direct payload. The heat flux sensors should be accurate within 20%, surface recession diagnostic sensors should be accurate within 10%, and any temperature sensors should be accurate within 5% of actual values.

Non Destructive Evaluation (NDE) tools for evaluation of bondline and in-depth integrity for light weight rigid and/or flexible ablative materials. Non Destructive Evaluation (NDE) tools are sought to verify design requirements are met during manufacturing and assembly of the heat shield, e.g., verifying that anisotropic materials have been installed in their proper orientation, that the bondline as well as the TPS materials have the proper integrity and are free of voids or defects. Void and/or defect detection requirements will depend upon the materials being inspected. Typical internal void detection requirements are on the order of 6mm, and bondline defect detection requirements are on the order of 25.4mm by 25.4mm by the thickness of the adhesive.

Advances are sought in ablation modeling, including radiation, convection, gas surface interactions, pyrolysis, coking, and charring for low and mid-density fiber based (woven or felt) ablative materials. There is a specific need for improved models for low and mid density as well as multi-layered charring ablators (with different chemical composition in each layer). Consideration of the non-equilibrium states of the pyrolysis gases and the surface thermochemistry, as well as the potential to couple the resulting models to a computational fluid dynamics solver, should be included in the modeling efforts

Technology Readiness Levels (TRL) of 2-3 or higher are sought.

Potential NASA Customers include:

- Human Exploration and Operations Mission Directorate .
 - Multi Purpose Crewed Vehicle (MPCV) heatshield and backshell projects.
 - Asteroid Sample Return projects.
 - Future design of low Ballistic Coefficient entry vehicles using Hypersonic Inflatable Aerodynamic Decelerator (HIAD) or Adaptive Deployable Entry and Placement Technology (ADEPT) systems.
- Science Mission Directorate – Planetary Exploration Entry, Decent and Landing heatshield and backshell projects and Planetary Sample Return projects.
- NASA Commercial Orbital Transportation Services (COTS) projects.

TOPIC: H8 High Efficiency Space Power Systems

This topic solicits technology development for high-efficiency power systems to be used for the human exploration of space. Power system needs include:

- Batteries for extravehicular activity suits.
- Electrical power for in-space propulsion systems.
- Electric power generation and energy storage for planetary and lunar surface applications.

H8.01 Fuel Cells and Electrolyzers:

- Ion-exchange membranes for PEM electrolyzers, emphasizing low acid generation to meet a critical ISS need and low permeability to increase the efficiency of high pressure systems for surface systems.
- Solid oxide fuel cell technology to spark the next-generation of fuel cell technology that will enable operation with multiple fuels including methane for landers and hydrocarbons generated from ISRU processes.

H8.02 Ultra High Specific Energy Batteries:

- Cathodes compatible with silicon-composite anodes to address the key obstacle to current lithium ion battery development for extravehicular activities.
- High-risk battery chemistries offering performance well beyond Li-ion.

H8.03 Space Nuclear Power Systems:

- 10 kWe-class power conversion devices and 450K radiators to support the Technology Demonstration Unit for surface power and 100kW-class electric vehicles.
- 100 kWe-class power conversion devices, > 500K radiators, and high temperature fuels, materials, and heat transport to support fission power systems for MW-class electric vehicles.
- 1 kW-class fission power systems concepts to support science missions and small-scale surface power systems.

H8.04 Advanced Photovoltaic Systems:

- Solar cell, blanket, and interconnect technologies consistent with the needs of solar electric propulsion systems:
 - Flexible blankets.
 - High voltage and high power operation.
 - Low cost, high volume fabrication techniques.
- Modular panel concepts that emphasize low mass and cost reduction.

H8.01 Fuel Cells and Electrolyzers

Lead Center: GRC

Participating Center(s): JPL, JSC, KSC

OCT Technology Area: [TA03](#)

Ion-Exchange Membranes for PEM Electrolyzers

During high-pressure electrolysis operation, hydrogen permeation through the ion-exchange membrane acts to reduce the current efficiency within the cell. This permeation increases with increasing pressure. Technological approaches are sought that significantly reduce this permeation. Areas of interest include:

- Demonstrated hydrogen permeability reduction >50% for Nafion membranes.
- Concurrent conductivity reductions <10%.
- Additionally, such membranes should have low acid generation rates to avoid degrading other elements within the cell stack, and must maintain good water transfer capability, bubble point, and tensile strength for use with cathode liquid-feed systems.

Solid Oxide Fuel Cell Systems

Technologies are sought that improve the durability, efficiency, and reliability of SOFC systems fed by oxygen and fuels such as propellant-grade methane and those generated by ISRU systems (e.g., CO, syngas). Primary SOFC components and systems of interest:

- Power outputs in the 1 to 3 kW range.
- Offer thermodynamic efficiencies of 70% (fuel source-to-DC output) when operating at the current draw corresponding to optimized specific power.
- Operate as specified after at least 50 start-up cycles (from cold to operating temperature within 20 minutes) and 50 shut-down cycles.
- Operate as specified after at least 2500 hours of steady state operation on propellant-grade methane and oxygen. System should startup dry but after reaching operating conditions an amount of water/H₂ consistent with what can be obtained from anode recycle can be used. Amounts must be justified.
- Minimal cooling required as obtained by way of conduction through the stack to a radiator exposed to space and/or by anode exhaust flow.

Technology Readiness Levels (TRL) of 3 to 4 or higher are sought.

Potential NASA Customers include:

- International Space Station.
- Human Exploration and Operations Mission Directorate.

H8.02 Ultra High Specific Energy Batteries

Lead Center: GRC

Participating Center(s): JPL, JSC

OCT Technology Area: [TA03](#)

Advanced rechargeable batteries are sought for future NASA missions.

For near-term missions, advanced lithium-ion (Li-ion) systems are being developed with the goal to achieve 265 Wh/kg and 675 Wh/L on a cell level. Advanced cathodes are sought, which when integrated into a full cell with a silicon-carbon composite anode, can enable a Li-ion cell to achieve the stated goals at practical voltage levels at a C/10 discharge rate when operating at 10 °C. The cathode should retain 80% of its initial capacity after 250 cycles. In addition, because the cathodes must be manufactured practically, cathodes must achieve a tap density of >1.5 g/cc, should possess qualities that can enable loading of at least 15 mg/square cm per side, and should utilize synthesis approaches that are readily scalable and are amenable to large scale electrode processing utilizing standard battery component equipment. The anode will achieve a reversible capacity of 1000 mAh/g and operate between 50 millivolts and 1 volt versus lithium. The cathode should have no detrimental impact on anode electrochemical performance, cycle-ability or cycle life, should possess a high degree of thermal stability, should have low toxicity, and should be stable against typical carbonate-based electrolytes at voltage levels and material loadings that are practical for the proposed system.

For far-term missions, proposals are sought for advanced next generation rechargeable chemistries that go beyond Li-ion and have the potential to offer >500 Wh/kg and >700 Wh/L on the cell level. Advanced next generation chemistries will be required for human missions, therefore specific energy and energy density goals must be met while simultaneously delivering a high level of safety. Applications may include Extravehicular Activities (spacesuit) and robotic landers and rovers for missions to outer planets, moons and asteroids.

Phase I proposals must include analysis and numerical/quantitative evidence to justify the choice of cathode or advanced chemistry that clearly shows how the proposed component/system has the potential to meet the projected specific energy and energy density goals at the end of a Phase II effort. Additionally, Phase I proposals should describe the technical path that will be followed to achieve the desired specific energy and energy density.

Technology Readiness Levels (TRL) of 4 or higher are sought.

Potential NASA Customers include:

- *Technology is cross-cutting* – applicable to any mission or application that requires low mass, low volume, safe batteries. Some examples:
 - Office of Chief Technologist.
 - Human Exploration and Operations Directorate (EVA suits, landers, rovers, habitats, vehicle power).
 - Aeronautics Research Directorate (electric aircraft).
 - Science Directorate (power for payloads).

H8.03 Space Nuclear Power Systems

Lead Center: GRC

Participating Center(s): JPL, JSC, MSFC

OCT Technology Area: [TA03](#)

NASA is developing fission power system technology for future space transportation and surface power applications using a stepwise approach. Early systems are envisioned in the 10 to 100 kWe range that utilize a 900 K liquid metal cooled reactor, dynamic power conversion, and water-based heat rejection. The anticipated design life is 8 to 15

years with no maintenance. Candidate mission applications include initial power sources for human outposts on the Moon or Mars, and nuclear electric propulsion systems (NEP) for Mars cargo transport. A non-nuclear system ground test in thermal-vacuum is planned by NASA to validate technologies required to transfer reactor heat, convert the heat into electricity, reject waste heat, process the electrical output, and demonstrate overall system performance. 1-10 kWe systems are also envisioned for power for robotic science missions to fill the gap between radioisotope power systems and higher power systems.

The primary goals for the early systems are low cost, high reliability, and long life. Proposals are solicited that could help supplement or augment the planned NASA system test. Specific areas for development include:

- 10 kWe-class Stirling and Brayton power conversion devices.
- 450 K radiator panels with embedded heat pipes.
- Kilowatt-class fission power systems concepts and technologies

The NASA non-nuclear system ground test is expected to provide the foundation for later systems in the multi-hundred kilowatt or megawatt range that utilize higher operating temperatures, alternative materials, and advanced components to improve system performance. For the later systems, specific power will be a key performance metric with goals of 30 kg/kWe at 100 kWe and 10 kg/kWe at 1 MWe. Possible mission applications include large NEP cargo vehicles, NEP piloted vehicles, and surface-based resource production plants. In addition to low cost, high reliability, and long life, the later systems should address the low system specific mass goal. Proposals are solicited that identify novel system concepts and methods to reduce mass and increase power output. Specific areas for development include:

- 100 kWe-class Brayton and Rankine power conversion devices.
- Waste heat rejection technologies for 500 K and above.
- High temperature reactor fuels, structural materials and heat transport technologies.

Technology Readiness Levels (TRL) of 3 to 5 or higher are sought.

Potential NASA Customers include:

- The primary customer is the Office of Chief Technologist (OCT).
- Game Changing Development Program.
- Nuclear Systems Project.

Secondary customers include:

- Advanced Exploration Systems (AES) under the Human Exploration and Operations Mission Directorate.
- Planetary Science Division under the Science Mission Directorate.

H8.04 Advanced Photovoltaic Systems

Lead Center: GRC

Participating Center(s): JPL, JSC

OCT Technology Area: [TA03](#)

Advanced photovoltaic (PV) power generation and enabling power system technologies are sought for improvements in capability and reliability of PV power generation for space exploration missions. Power levels for PV applications may reach 100s of kWe. System and component technologies are sought that can deliver efficiency, cost, reliability, mass and volume improvements under various operating conditions. Compatibility with solar cells having at least 29% efficiency and flexible blankets is required.

PV technologies must enable or enhance the ability to provide low-cost, low mass and higher efficiency for power systems with particular emphasis on high power arrays to support solar electric propulsion spacecraft operating at high voltage in the deep space environment. Technologies can address recurring and non-recurring costs for flight

units or development units. Examples include technologies that reduce the solar cell cost, modular panel designs, automated blanket/cell/integration and interconnects, low cost/low mass coverglass/coatings, etc.

Areas of particular emphasis for 2012 include:

- Advanced PV blanket and component technology/ designs that support very high power and high voltage (> 200 V) applications.
- PV module/ component technologies that emphasize low mass and cost reduction (in materials, fabrication and testing).
- Improvements to solar cell efficiency that are consistent with low cost, high volume fabrication techniques.
- Automated/ modular fabrication methods for PV panels/ modules on flexible blankets (includes cell laydown, interconnects, shielding and high voltage operation mitigation techniques).

Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract.

Technology Readiness Levels (TRL) of 2 to 6 or higher are sought.

Potential NASA Customers include:

- Solar Electric Propulsion Technology Demonstration Project in the Office of the Chief Technologist.
- Human Exploration and Operations Mission Directorate; Science Mission Directorate.

TOPIC: H9 Space Communications and Navigation

The Space Communication and Navigation Technology Area supports all NASA space missions with the development of new capabilities and services that make our missions possible. Communication links are the lifelines to our spacecraft that provide the command, telemetry, and science data transfers as well as navigation support. Advancement in communication and navigation technology will allow future missions to implement new and more capable science instruments, greatly enhance human missions beyond Earth orbit, and enable entirely new mission concepts. NASA's communication and navigation capability is based on the premise that communications shall enable and not constrain missions. Today our communication and navigation capabilities, using Radio Frequency technology, can support our spacecraft to the fringes of the solar system and beyond. As we move into the future, we are challenged to increase current data rates- 300 Mbps in LEO to about 6 Mbps at Mars- to support the anticipated numerous missions for space science, Earth science and exploration of the universe. Technologies such as optical communications, RF including antennas and ground based Earth stations, surface networks, cognitive networks, access links, reprogrammable communications systems, advanced antenna technology, transmit array concepts, and communications in support of launch services are very important to the future of exploration and science activities of the Agency. Additionally, innovative, relevant research in the areas of positioning, navigation, and timing (PNT) are desirable. NASA's Space Communication and Navigation (SCaN) Office considers the three elements of PNT to represent distinct, constituent capabilities:

- Positioning, by which we mean accurate and precise determination of an asset's location and orientation referenced to a coordinate system.
- Navigation, by which we mean determining an asset's current and/or desired absolute or relative position and velocity state, and applying corrections to course, orientation, and velocity to attain achieve the desired state.
- Timing, by which we mean an assets acquiring from a standard, maintaining within user-defined parameters, and transferring where required, an accurate and precise representation of time, minimize the impact of latency on overall system performance.

This year, the following technology areas are being solicited to meet increasing data throughput and accuracy needs: Optical communications, RF communications, experiments involving reprogrammable communications systems,

flight dynamics and breakthrough or high impact communication technologies. Emphasis is placed on size, weight and power improvements. Innovative solutions centered on operational issues are needed in all of the aforementioned areas. All technologies developed under this topic area to be aligned with the Architecture Definition Document and technical direction as established by the NASA SCaN Office. For more details, see (<http://ti.arc.nasa.gov/tech/asr/intelligent-robotics/haughton-field/>).

H9.01 Long Range Optical Communications

Lead Center: JPL

Participating Center(s): GRC, GSFC

OCT Technology Area: [TA05](#)

This subtopic seeks innovative technologies for long range Optical Telecommunications supporting the needs of space missions. Proposals are sought in the following areas:

Systems and technologies relating to acquisition, tracking and sub-micro-radian pointing of the optical communications beam under typical deep-space ranges (to 40 AU) and spacecraft micro-vibration environments.

- *Isolation platforms* - Compact, lightweight, space-qualifiable vibration isolation platforms for payloads massing between 3 and 50 kg that require less than 15 W of power and mass less than 3 kg that will attenuate an integrated angular disturbance of 150 micro-radians to less than 0.5 micro-radians (1-sigma), from <0.1 Hz to ~500 Hz.
- *Laser Transmitters* - Space-qualifiable, >20% DC-to-optical (wall-plug) efficiency, 0.2 to 16 nanosecond pulse-width 1550-nm laser transmitter for pulse-position modulated data with from 16 to 320 slots per symbol, less than 35 picosecond pulse rise and fall times, near transform limited spectral width, single polarization output with at least 20 dB polarization extinction ratio, amplitude extinction ratio greater than 38 dB, average power of 5 to 20 Watt, massing less than 500 grams per Watt. Also of interest for the laser transmitter are: robust and compact packaging with radiation tolerant electronics inherent in the design, and high speed electrical interface to support output of pulse position modulation encoding of sub nanosecond pulses and inputs such as Spacewire, Firewire or Gigabit Ethernet. Detailed description of approaches to achieve the stated efficiency is a must.
- *Photon counting near-infrared detectors arrays for ground receivers* - Hexagonal close packed kilo-pixel arrays sensitive to 1000 to 1650 nm wavelength range with single photon detection efficiencies greater than 60% and single photon detection jitters less than 40 picoseconds 1-sigma, active diameter greater than 15 microns/pixel, and 1 dB saturation rates of at least 10 mega-photons (detected) per pixel and dark count rates of less than 1 MHz/square-mm.
- *Photon counting near-infrared detectors arrays for flight receivers* - For the 1000 to 1600 nm wavelength range with single photon detection efficiencies greater than 40% and 1dB saturation rates of at least 1 mega-photons/pixel and operational temperatures above 220K and dark count rates of <10 MHz/mm. Radiation doses of at least 20 Krad (unshielded) shall result in less than 10% drop in single photon detection efficiency and less than 2X increase in dark count rate.
- *Ground-based telescope assembly* - Telescope/photon-buckets with primary mirror diameter ~2.5 meter, f-number of ~1.1 and Cassegrain focus to be used as optical communication receiver/transmitter optics at 1000-1600nm. Produce a maximum image spot size of ~20 micro-radian, and field-of-view will be ~50 micro-radian. Telescope shall be positioned with a two-axis gimbal capable of 0.25 milli-radian pointing. Desired manufacturing cost for combined telescope, gimbal and dome in quantity (tens) is ~\$3 M each.

Research should be conducted to convincingly prove technical feasibility during Phase I – ideally through hardware development, with clear pathways to demonstrating and delivering functional hardware, meeting all objectives and specifications, in Phase II.

Phase I Deliverables - Phase I deliverables shall include a final report describing design studies and analyses, system, sensor, or instrumentation concepts, prospective material formulations, testing, etc. Prototype systems, components, sensors, instruments or materials can be developed in Phase I as well. The designs or concepts should have commercialization potential. For Phase II consideration, the final report should include a detailed path towards Phase II hardware proof-of-concept system or component or material manufacturing and testing as applicable. The technology concept at the end of Phase I should be at a TRL of 4.

Phase II Deliverables - Phase II deliverables shall consist of working proof-of-concept systems, tested material formulations with samples, tested component, sensor, or instrumentation hardware, etc. which have been successfully demonstrated in a relevant environment and delivered to NASA for testing and verification. The technology at the end of Phase II should be at a TRL of 5-6.

Potential NASA Customers include:

- Deep Space Planetary Missions.
- Deep Space Optical Terminal (DOT) Project.
- Space Communications and Navigation (SCaN) Program.

H9.02 Long Range Space RF Communications

Lead Center: JPL

Participating Center(s): ARC, GRC, GSFC

OCT Technology Area: [TA05](#)

This subtopic seeks to develop innovative long-range RF telecommunications technologies supporting the needs of space missions.

In the future, spacecraft with increasingly capable instruments producing large quantities of data will be visiting the Moon and the planets. These spacecraft will also support long term missions, such as to the outer planets, or extended missions with new objectives. They will possess reconfigurable avionics and communication subsystems and will be designed to require less intervention from earth during periods of low activity. The communication needs of these missions motivate higher data rate capabilities on the uplink and downlink as well as more reliable RF and timing subsystems. Innovative long-range telecommunications technologies that maximize power efficiency, reliability, receiver capability, transmitted power and data rate, while minimizing size, mass and DC power consumption are required. The current state-of-the-art in long-range RF space telecommunications is 6 Mbps from Mars using microwave communications systems (X-Band and Ka-Band) with output power levels in the low tens of Watts and DC-to-RF efficiencies in the range of 10-25%.

Technologies of interest:

This subtopic seeks innovative technologies in the following areas:

- Ultra-small, light-weight, low-cost, low-power, modular deep-space transceivers, transponders and components, incorporating MMICs, MEMs and Bi-CMOS circuits.
- MMIC modulators with drivers to provide a wide range of linear phase modulation (greater than 2.5 rad), high-data rate (10 - 200 Mbps) BPSK/QPSK modulation at X-band (8.4 GHz), and Ka-band (26 GHz, 32 GHz and 38 GHz).
- High DC-to-RF-efficiency (> 60%), low mass Solid-State Power Amplifiers (SSPAs), of both medium output power (10 W-50 W) and high-output power (150 W-1 KW), using power combining and/or wide band-gap semiconductors at X-band (8.4 GHz) and Ka-band (26 GHz, 32 GHz and 38 GHz).
- Utilization of nano-materials and/or other novel materials and techniques for improving the power efficiency or reducing the mass and cost of reliable vacuum electronics amplifier components (e.g., TWTAs and Klystrons).
- Ultra low-noise amplifiers (MMICs or hybrid, uncooled) for RF front-ends (< 50 K noise temperature).
- High dynamic range (> 65 dB), data rate receivers (> 20 Mbps) supporting BPSK/QPSK modulations.
- MEMS-based integrated RF subsystems that reduce the size and mass of space transceivers and transponders. Frequencies of interest include UHF, X- and Ka-Band. Of particular interest is Ka-band from 25.5 - 27 GHz and 31.5 - 34 GHz.
- Novel approaches to mitigate RF component susceptibility to radiation and EMI effects.

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I and show a path towards Phase II hardware/software demonstration with delivery of a demonstration unit or software package for NASA testing at the completion of the Phase II contract.

Phase I Deliverables - Feasibility study, including simulations and measurements, proving the proposed approach to develop a given product (TRL 3-4). Verification matrix of measurements to be performed at the end of Phase II, along with specific quantitative pass-fail ranges for each quantity listed.

Phase II Deliverables - Working engineering model of proposed product, along with full report of development and measurements, including populated verification matrix from Phase I (TRL 5-6). Opportunities and plans should also be identified and summarized for potential commercialization.

Potential NASA Customers include:

- Deep Space Planetary Missions such as Mars 2018, Mars Sample Return, Jupiter Outer Planet Missions.
- Human Space Exploration Missions such as missions to Asteroids, Mars or various Earth-Moon Libration Waypoints.

H9.03 CoNNeCT Experiments

Lead Center: GRC

Participating Center(s): JPL

OCT Technology Area: [TA05](#)

NASA has developed an on-orbit, reprogrammable, software defined radio-based (SDR) testbed facility aboard the International Space Station (ISS), to conduct a suite of experiments to advance technologies, reduce risk, and enable future mission capabilities. The Communications, Navigation, and Networking reConfigurable Testbed (CoNNeCT) Project provides SBIR recipients and through other mechanisms NASA, large business, other Government agencies, and academic partners the opportunity to develop and field communications, navigation, and networking technologies in the laboratory and space environment based on reconfigurable, software defined radio platforms. Each SDR is compliant with the Space Telecommunications Radio System (STRS) Architecture, NASA's common architecture for SDRs. The Testbed is installed on the truss of ISS and communicates with both NASA's Space Network via Tracking Data Relay Satellite System (TDRSS) at S-band and Ka-band and direct to/from ground systems at S-band. One SDR is capable of receiving L-band at the GPS frequencies of L1, L2, and L5.

NASA seeks innovative software applications and experiments to run aboard the Testbed to demonstrate and enable future mission capability using the reconfigurable features of the software defined radios. Experiment software/firmware can run in the flight SDRs, the flight avionics computer, and on a corresponding ground SDR at the Space Network, White Sands Complex. Unique experimenter ground hardware equipment may also be used.

Experimenters will be provided with appropriate documentation (e.g., flight SDR, avionics, ground SDR) to aid their experiment application development, and may be provided access to the ground-based and flight SDRs to prepare and conduct their experiment. Access to the ground and flight system will be provided on a best effort basis and will be based on their relative priority with other approved experiments. Please note that selection for award does not guarantee flight opportunities on the ISS.

Desired capabilities include, but are not limited to, the examples below:

- Demonstration of mission applicability of SDR.
- Aspects of reconfiguration:
 - Unique/efficient use of processor, FPGA, DSP resources.
 - Inter-process communications.
- Spectrum efficient technologies.
- Space internetworking:
 - Disruption Tolerant Networking.
- Position, navigation and timing (PNT) technology.

- Technologies/waveforms for formation flying.
- High data rate communications.
- Uplink antenna arraying technologies.
- Multi-access communication.
- RF sensing applications (science emulation).
- Cognitive applications.

Experimenters using ground or flight systems will be required to meet certain pre-conditions for flight including:

- Provide software/firmware deliverables (software/firmware source, executables, and models) suitable for flight.
- Document development and build environment and tools for waveform/applications.
- Provide appropriate documentation (e.g., experimenter requirements, waveform/software user's guide, ICD's) throughout the development and code delivery process.
- Software/firmware deliverables compliant to the Space Telecommunications Radio System (STRS) Architecture, Release 1.02.1 and submitted to waveform repository for reuse by other users.
- Verification of performance on ground based system prior to operation on the flight system.

Methods and tools for the development of software/firmware components that is portable across multiple platforms and standards-based approaches are preferred.

Documentation for both the CoNNeCT system and STRS Architecture may be found at the following link:

(<http://spaceflight systems.grc.nasa.gov/SpaceOps/CoNNeCT/>)

These documents will provide an overview of the CoNNeCT flight and ground systems, ground development and test facilities, and experiment flow. Documentation providing additional detail on the flight SDRs, hardware suite, development tools, and interfaces will be made available to successful SBIR award recipients. Note that certain documentation available to SBIR award recipients is restricted by export controls and available to U.S. citizens only.

For all above technologies, Phase I will provide experimenters time to develop and advance waveform/application architectures and designs along with detailed experiment plans. The subtopic will seek to leverage more mature waveform developments to reduce development risk in subsequent phases, due to the timeframe of the on-orbit Testbed. The experiment plan will show a path toward Phase II software/firmware completion, ground verification process, and delivering a software/firmware and documentation package for NASA space demonstration aboard the flight SDR. Phase II will allow experimenters to complete the waveform development and demonstrate technical feasibility and basic operation of key algorithms on CoNNeCT ground-based SDR platforms and conduct their flight system experiment. Opportunities and plans should also be identified and summarized for potential commercialization.

Phase I Deliverables:

- Waveform/application architecture and detailed design document, including plan/approach for STRS compliance.
- Experiment Reference Design Mission Concept of Operations.
- Experiment Plan (according to provided template).
- Demonstrate simulation or model of key waveform/application functions.
- Plan and approach for Commercialization of the technology (part of final report).
- Feasibility study, including simulations and measurements, proving the proposed approach to develop a given product. Early software/firmware application source and binary code and documentation. Source/binary code will be run on engineering models and/or SDR breadboards (at TRL-3-4).

Phase II Deliverables:

- Applicable Experiment Documents (e.g., requirements, design, management plans).

- Simulation or model of waveform application.
- Demonstration of waveform/application in the laboratory on CoNNeCT breadboards and engineering models.
- Results of implementing the Commercialization Plan outlined in Phase I.
- Software/firmware application source and binary code and documentation (waveform contribution to STRS Repository for reuse by others). Source/binary code will be run on engineering models and/or demonstrated on-orbit in flight system (at TRL-5-7) SDRs.

Potential NASA Customers include:

- Deep Space Planetary Missions.
- Extra Vehicular Activity Office.
- Space Communications and Navigation (SCaN) Program.

H9.04 Flight Dynamics Technologies and Software

Lead Center: GRC

Participating Center(s): GSFC, JPL

OCT Technology Area: [TA05](#)

NASA's current Position, Navigation, and Timing (PNT) state-of-the-art relies on both ground-based and space-based radiometric tracking, laser ranging, and optical navigation techniques. Post-processed GPS position determination performance accuracy is at the cm-level at Near-Earth distances and at meter-level at High-Earth Orbit distances; while autonomous real-time GPS performance, such as provided by GPS-Enhanced Onboard Navigation System (GEONS) can achieve accuracy performance of 20 meters. For missions at Mars, Deep Space Network navigation services provide performance accuracy of 1km, while optical navigation methodologies obtain performance accuracy of 10s of km at this distance.

Future NASA missions will require precision landing, rendezvous, formation flying, cooperative robotics, proximity operations, and coordinated platform operations. As such, the need for increased precision in absolute and relative navigation solutions increases. As operations occur further from Earth and more complex navigational maneuvers are performed, it will be necessary to reduce the reliance on Earth-based systems for real-time decisions. Investments in technologies to implement autonomous on-board navigation and maneuvering will permit a reduction in dependence on ground-based tracking, ranging, trajectory/orbit/attitude determination, and maneuver planning and support functions. Therefore, the early focus for NASA will be to improve PNT through increasing real-time PNT accuracy and precision, as well as achieving this performance in autonomously on-board the spacecraft.

Technologies and software should support a broad range of spaceflight customers. Technologies and software specifically focused on a particular mission's or mission set's needs are the subject of other solicitations by the relevant sponsoring organizations and should not be submitted in response to this solicitation. In the context of this solicitation, flight dynamics technologies and software are algorithms and software that may be used in ground support facilities, or onboard a spacecraft, so as to provide PNT services that reduce the need for ground tracking and ground navigation support. Flight dynamics technologies and software also provide critical support to pre-flight mission design, planning, and analysis activities.

This solicitation is primarily focused on NASA's flight dynamics software and technology needs in the following focused areas:

- Next generation of multi-purpose ground-based and on-board autonomous navigation filtering techniques, such as adaptive filtering where measurements are selectively weighted, or filters that monitor state noise and measurement noise processes.
- Algorithms for real-time multi-platform relative navigation (relative position, velocity, attitude/pose).
- Algorithms which process clock measurements and estimate and/or propagate the timekeeping model (which generates the time and frequency signal output) and timekeeping system architectures in which outputs of an ensemble of clocks are weighed and software filtered to synthesize an optimized time estimate.

- Sensor measurement models and processing algorithms for next generation sensors, including (but not limited to): optical navigation sensors (high resolution flash LIDAR, visible cameras, infrared cameras), radar sensors, radiometrics, fine guidance sensors, laser rangefinders, high volume/high speed FPGA-based electronics for LIDAR.
- Algorithms for real-time vision processing, path planning and optimization, constraint handling, integrated system health management, fault management (FDIR), event sequencing, optimal resource allocations, collaborative sensor fusion, sensor image motion compensation and processing, pattern recognition/matching, hazard search and detection, feature location and mapping, high performance inertial and celestial sensor models, accurate and fast converging vehicle state estimation filters and adaptive flight control systems.
- Applications of advanced dynamical theories to space mission design and analysis for ground-based and on-board autonomous algorithms, especially in the context of unstable orbital trajectories in the vicinity of small bodies, libration points, and Near-Earth objects.
- Autonomous navigational planning, detection, and filter optimization, as well as attitude control systems for autonomous platform orientation, using sensor measurement fault detection & management and/or fault-tolerant filtering algorithms.
- Addition of novel estimation techniques and/or orbit determination capabilities to existing NASA mission design software that is either freely available via NASA Open Source Agreements, or that is licensed by the proposer.

Proposals that leverage state-of-the-art capabilities already developed by NASA are especially encouraged, such as:

- GPS-Enhanced Onboard Navigation Software:
 - (http://techtransfer.gsfc.nasa.gov/ft_tech_gps_navigator.shtm)
- AutoNav (NTR 43546 Deep Impact Autonomous Navigation (AutoNav) Flight Software 23-FEB-2006)
- General Mission Analysis Tool (<http://sourceforge.net/projects/gmat/>)
- GPS-Inferred Positioning System and Orbit Analysis Simulation Software:
 - (<http://gipsy.jpl.nasa.gov/orms/goa/>)
- Optimal Trajectories by Implicit Simulation (<http://otis.grc.nasa.gov/>)

Proposers who contemplate licensing NASA technologies are highly encouraged to coordinate with the appropriate NASA technology transfer offices prior to submission of their proposals.

Phase I Deliverables - Phase I research should be conducted to demonstrate technical feasibility (to reach TRL 3), with preliminary software being delivered for NASA testing at the end of the Phase I contract, as well as show a plan towards Phase II integration. Phase I Deliverables include:

- Midterm Technical Report.
- Preliminary Software at end of Phase I contract.
- Final Phase I Technical Feasibility Report with a Phase II Integration Path.

Phase II Deliverables - Phase II efforts should build on Phase I research towards a Phase II software demonstration and delivering a software package for NASA testing at the completion of the Phase II contract (to reach TRL 5). Also, prototype software should be delivered to NASA at the end of the first year of the contract, to be reviewed and iterated upon towards the development of the final software demonstration and delivery. Phase II efforts should also include development of proper documentation, which includes a thorough Algorithm Specification document. Phase II Deliverables include:

- Prototype Software at end of first year of Phase II contract.
- Final Phase II Technical Report.
- Algorithm Specification at end of Phase II contract.
- Delivery of software package at end of Phase II contract.
- Demonstration of software package at end of Phase II contract.

Potential NASA Customers include:

- Space Communications and Navigation (SCaN) Program

H9.05 Game Changing Technologies

Lead Center: GRC

Participating Center(s): ARC, GSFC, JPL

OCT Technology Area: [TA05](#)

NASA seeks revolutionary, highly innovative, game changing communications technologies that have the potential to enable order of magnitude performance improvements for space operations, exploration systems, and/or science mission applications. As NASA moves towards an integrated network architecture, infusion of critical, enabling technologies will be key to meeting user needs and offering standardized services. Emphasis for this subtopic is on the mid - (3-8 yrs.), and far-term (>8 yrs.) with focused research in the following areas:

Develop novel techniques for size, weight, and power (SWAP) of communications systems by addressing digital processing and logic implementation tradeoffs, dynamic power management, hardware and software partitioning. Address reliability, robustness, and radiation tolerance for missions beyond low Earth orbit. Investigate and demonstrate unique, innovative electronic or optical technologies to alleviate demanding mission requirements (at least 10X improvement over state-of-the-art) in areas such as chip speed, compression, encoding/decoding, etc. Communication systems optimized for energy efficiency (information bits per unit energy) will be increasingly important for low energy communication systems.

Small spacecraft, due to their limited surface area, are typically power constrained, limiting small spacecraft communications systems to low bandwidth architectures. Technologies and architectures that can exploit commercial or other terrestrial communication infrastructures to enable novel small satellite (e.g., CubeSat) missions are desired. Identify advanced solutions for higher density integration techniques and packaging. Address how existing communications architectures can be adapted and utilized to provide higher bandwidth communications capabilities with better performance and at lower cost for spacecraft to ground, and spacecraft to spacecraft applications.

Novel approaches to addressing extremely high bandwidth, high data rate signaling using RF, mm-wave (Ka- to W-band), and/or optical (1550 nm) links.) Purely optical links are subject to atmospheric interference (clouds, rain, snow, fog, etc.) and can restrict operations for Earth-based optical terminals, so hybrid RF/optical systems are intriguing. Technologies that address flexible, scalable digital/optical core processing topologies to support both RF and optical communications in a single dual-feed terminal, such as: programmable modulation/coding, multi-rate clocking and data recovery, system-on-a-chip integration, memory management, multi-processor architectures, etc. are sought to mitigate risk of such a system.

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I and show a path towards Phase II demonstration with delivery of a demonstration unit or package for NASA testing at the completion of the Phase II contract.

Opportunities and plans should also be identified and summarized for potential commercialization.

Phase I Deliverables - Phase I deliverables shall include a final report describing design studies and analyses, system, sensor, or instrumentation concepts, prospective formulations, testing, etc. Prototype systems, components, sensors, instruments or materials can be developed in Phase I as well. The designs or concepts should have commercialization potential. For Phase II consideration, the final report should include a detailed path towards Phase II proof-of-concept system or component or testing as applicable. The technology concept at the end of Phase I should be at a TRL range of 2-3.

Phase II Deliverables - Phase II deliverables shall consist of working proof-of-concept systems, samples, component, sensor, or instrumentation hardware, etc. which have been successfully demonstrated in a relevant environment and delivered to NASA for testing and verification. The technology at the end of Phase II should be at a TRL range of 3-4.

Potential NASA Customers include:

- Deep Space Planetary Missions.
- Extra Vehicular Activity Office.
- Space Suit Communications.
- Space Communications and Navigation (SCaN) Program.

TOPIC: H10 Ground Processing and ISS Utilization

The Human Exploration and Operations Mission Directorate (HEOMD) provides mission critical space exploration services to both NASA customers and to other partners within the U.S. and throughout the world: assembling and operating the International Space Station; ensuring safe and reliable access to space; maintaining secure and dependable communications between platforms across the solar system; and ensuring the health and safety of our Nation's astronauts. Activities include ground-based and in-flight processing and operations tasks, along with support that ensures these tasks are accomplished efficiently and accurately, enables successful missions and healthy crews. This topic area, while largely focused on operational space flight activities, is broad in scope. NASA is seeking technologies that address how to improve and lower costs related to ground and flight assets, and maximize the utilization of the International Space Station. A typical flight focused approach would include:

- Phase I - Research to identify and evaluate candidate technology applications to demonstrate the technical feasibility and show a path towards a hardware/software demonstration. Bench or lab-level demonstrations are desirable.
- Phase II - Emphasis should be placed on developing and demonstrating the technology under simulated flight conditions.

The proposal shall outline a path showing how the technology could be developed into space-worthy systems. For ground processing and operations tasks, the proposal shall outline a path showing how the technology could be developed into ground or flight systems. The contract shall deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract and, if possible, demonstrate earth based uses or benefits.

H10.01 Ground Processing Optimization and Technology Infusion

Lead Center: KSC

Participating Center(s): ARC, SSC

OCT Technology Area: [TA13](#)

This subtopic seeks innovative concepts and solutions for both addressing long-term ground processing and test complex operational challenges and driving down the cost of government and commercial access to space. Technology infusion and optimization of existing and future operational programs, while concurrently maintaining continued operations, are paramount for cost effectiveness, safety assurance, and supportability.

Strategies to optimize and support changes in operations concepts should consider:

- The needs of geographically distributed and mobile teams.
- Efficient configuration changes to support operations of different customers.
- Protection of information for the different customers.
- Infrastructure availability.
- Increased situational awareness for operators.

Technology areas of Interest include:

- Strategies, technology innovations, and technology maturation of control room services to provide cost effective data handling and storage and standardized interfaces for data generated by dissimilar systems.

Methods for rapid prototype of control and data systems software from engineering data, ensuring scalability of data presentation and streamlined communication, and methods to address and inform consumers of time delays in data transmission:

- Cost effective solutions to connect control and data system software to facility models that provide for ease of use and maximize the return on investment for concurrent test and launch complex environments.
 - Approaches, such as a single console to perform command and control for a set of test resources or provisions for model-based diagnostic methods to provide rapid feedback on the test and launch complex environment state, can be explored.
- Methodologies for benchmarking, migrating, upgrading, and/or enhancing tools and control and data system architectures to lower the cost of technology infusion concurrently with the operational environment while reducing sustaining costs:
 - Focus should also be on system maintenance concepts for a highly COTS intensive environment to ensure configuration management and control, verification and validation approaches, technology refresh and security updates.
 - Innovative capabilities in information technology are required to provide robust and highly efficient information security for maintaining customer-specific intellectual property while providing a collaborative environment for launch and testing services.
- Optimization of ground controller and test conductor staffing and roles requirements through robust, innovative, and operator-infused simulation/training capabilities to efficiently train ground and test controllers in a collaborative environment. Objectives should focus on skills proficiency and maintenance for troubleshooting, decision making, and time management in critical situations.
- Migration of models used in the design and development of infrastructure to the operations/training phase (e.g., Model-Based System Engineering (MBSE) process).
- Cost effective solutions for operations automation including peer-to-peer planning, mixed initiatives, elicitation of constraints and preferences, and system software integration. Focus should be on the use of standards and open source software enabling staff reduction, fault isolation and recovery methods, and decrease of software integration costs. Additionally, on understanding the interfaces of planning/mixed initiative systems with diagnostic systems, as diagnostic systems will inform the planning system of the available resources.
- Prognostic technologies to optimize component maintenance, support, mission and test planning, evaluation of system component redundancy, monitoring of performance and safety margins, and critical decision making.

Proposed concepts would benefit from clean, well-defined, unambiguous interfaces that account for configuration changes over the ground processing and test complex timeline; such proposals will receive higher consideration. All concepts must place an emphasis on how the interfaces in the system behave. Approaches to model, verify, and validate interfaces will be of interest.

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I and show a path toward Phase II demonstration, and delivering a demonstration package for NASA testing at the completion of the Phase II contract.

Phase I Deliverables - Research to identify and evaluate candidate technology applications to demonstrate the technical feasibility and show a path towards a demonstration. Concept methodology, infusion strategies (including risk trades), and business model. Identify improvements over the current state of the art and the feasibility of the approach in a multi-customer environment. Bench or lab-level demonstrations are desirable. The technology concept at the end of Phase I should be at a TRL of 4.

Phase II Deliverables - Emphasis should be placed on developing and demonstrating the technology under simulated mission conditions, including the mission of engine testing. The proposal shall outline a path showing how the technology could be developed into mission-worthy systems. The contract should deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract. The technology concept at the end of Phase II should be at a TRL of 7

H10.02 ISS Demonstration & Development of Improved Exploration Technologies**Lead Center: JSC****Participating Center(s): ARC****OCT Technology Area: [TA07](#)**

The focus of this subtopic is on technologies and techniques which may advance the state of the art of spacecraft systems by utilizing the International Space Station as a technology test bed.

Successful proposals will address using the long duration environment of the ISS to demonstrate component or system characteristics that extend beyond the current state of the art by:

- Increasing capability/operating time including overall operational availability.
- Reducing logistics and maintenance efforts.
- Reducing operational efforts, minimizing crew interaction with both systems and the ground.
- Reducing known spacecraft/spaceflight technical risks and needs.
- Providing information on the long term space environment needed in the development of future spacecraft technologies through model development, simulations or ground testing verified by on orbit operational data.

These demonstrations should focus on increasing the TRL in the following fields:

- Power generation and energy storage (e.g., regenerative fuel cells and battery).
- Robotics Tele-robotics and Autonomous (RTA) Systems.
- Communication and Navigation (e.g., autonomous rendezvous and docking advancements).
- Human health, Life Support and Habitation Systems (e.g. closed loop aspects of environmental control and life support systems).
- Science Instruments, Observatories and Sensor Systems.
- Nanotechnology.
- Materials, Structures, Mechanical Systems and Manufacturing.
- Thermal Management Systems (e.g., cryogenic propellant storage and transfer).
- Environmental control systems, including improved carbon dioxide removal.
- On-orbit trash processing/recycling.
- Radiation.
- Providing Engineering Motion Imagery “smart” imaging systems that reduce bandwidth but maintain high quality imaging in areas of interest; maintenance of window clarity on optical systems without creating a debris source; data storage and retrieval for instances when bandwidth is constrained or the rocket or spacecraft will not be retrieved; compression and/or modulation techniques to maximize efficiency of constrained telemetry downlinks; and imaging system components that are radiation and electromagnetic interference tolerant.

For the above technology subject areas, research should be conducted to demonstrate technical feasibility during Phase I and show a path toward hardware and/or material development as appropriate which occurs during Phase II and culminates in a proof-of-concept system.

Phase I Deliverables - Phase I Deliverables: Research to identify and evaluate candidate technologies applications to demonstrate the technical feasibility and show a path towards a hardware/software demonstration. Bench or lab-level demonstrations are desirable. The technology concept at the end of Phase I should be at a TRL of 3-6.

Phase II Deliverables - Phase II Deliverables: Emphasis should be placed on developing and demonstrating the technology under simulated flight conditions. The proposal shall outline a path showing how the technology could be developed into space-worthy systems. The contract should deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract. The technology at the end of Phase II should be at a TRL of 6-7.

TOPIC: H11 Radiation Protection

The SBIR topic area of Radiation Protection focuses on the development and testing of mitigation concepts to protect astronaut crews and exploration vehicles from the harmful effects of space radiation, both in Low Earth Orbit (LEO) and while conducting long-duration missions beyond LEO. Advances are needed in mitigation schema for the next generation of exploration vehicles inclusive of radiation shielding materials and structures technologies to protect humans from the hazards of space radiation during NASA missions. As NASA continues to form plans for long duration exploration, it has also become increasingly clear that the ability to mitigate the risks posed to both crews and vehicle systems by the space weather environment are also of central importance. This Radiation Protection Topic will concentrate on the Alert and Warning Systems. This area of interest is ways in which SBIR-developed technologies can contribute to NASA's overall mission requirements are advances in the understanding and predictability of space weather science. Current operational space weather support utilizes both inter- and extra-agency assets to maintain situational awareness and mitigate radiation risks associated with agency missions. Operational space weather support consists in the most basic terms of maintaining situational awareness of both the state of the Sun as a physical system and the radiation environment and its dynamics within the Heliosphere, and altering in real-time, a mission in order to minimize their effects. Therefore, advances are needed in the development of scientific research products for real-time operational forecasting tools to mitigate mission risk. Research under this topic should be conducted to demonstrate technical feasibility during Phase I and show a path forward to Phase II hardware demonstration, and when possible, deliver a full-scale demonstration unit for functional and environmental testing at the completion of the Phase II contract.

H11.01 Radiation Prediction (Integrated Advanced Alert/Warning Systems for Solar Proton Events)

Lead Center: JSC

Participating Center(s): LaRC

OCT Technology Area: [TA06](#)

Advances are needed in alerts/warnings and risk assessment models that give mission planners, flight control teams and crews sufficient advanced warning of impending Solar Proton Event (SPE) impact. Research and development should be targeted which leverages modeling techniques used throughout terrestrial weather for extreme event assessment. There is particular interest in development of models capable of delivering the probability of no SPE occurrence in a 24-hour time period, i.e., an “All-Clear” forecast.

Forecast techniques should utilize the historical record of archived SPEs to characterize model forecast validity in terms accepted metrics, i.e., skill score, false alarm rates, etc. Specific areas in which SBIR-developed technologies can contribute to NASA’s overall mission requirements include the following:

- Innovative forecasting solutions that leverage model development in other areas such as ensemble forecasting of hurricane tracks, flooding, financial market behavior, and earthquake prediction.
- Innovative methods that integrate historical trending, real-time data, and fundamental physics-based models into advance warning and detection systems.

Technology Readiness Levels (TRL) of 2 to 4 or higher are sought.

Potential NASA Customers include:

- Human Exploration and Operations Mission Directorate.
- International Space Station Program.
- Science Mission Directorate.

TOPIC: H12 Human Research and Health Maintenance

NASA’s Human Research Program (HRP) investigates and mitigates the highest risks to astronaut health and performance in exploration missions. The goal of the HRP is to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space

exploration, and to ensure safe and productive human spaceflight. The scope of these goals includes both the successful completion of exploration missions and the preservation of astronaut health over the life of the astronaut. HRP developed an Integrated Research Plan (IRP) to describe the requirements and notional approach to understanding and reducing the human health and performance risks. The IRP describes the Program's research activities that are intended to address the needs of human space exploration and serve HRP customers. The IRP illustrates the program's research plan through the timescale of early lunar missions of extended duration. The Human Research Roadmap (<http://humanresearchroadmap.nasa.gov>) is a web-based version of the IRP that allows users to search HRP risks, gaps, and tasks. The HRP is organized into Program Elements:

- Human Health Countermeasures.
- Behavioral Health & Performance.
- Exploration Medical Capability.
- Space Human Factors and Habitability.
- Space Radiation and ISS Medical Projects.

Each of the HRP Elements address a subset of the risks, with ISS Medical Projects responsible for the implementation of the research on various space and ground analog platforms. The overview and responsibilities of each of the Elements is described within the Human Research Roadmap (referenced above). With the exception of Space Radiation, the SBIR subtopics in this solicitation align with the HRP Program Elements:

- H12.01 Exploration Countermeasure Capability - Portable Activity Monitoring System helps address Human Health Countermeasures musculoskeletal risks.
- H12.02 Exploration Medical Capability - Medical Suction Capability addresses a specific Exploration Medical Capability technology gap.
- H12.03 Behavioral Health and Performance - Innovative Technologies for A Virtual Social Support System for Autonomous Exploration Missions helps address Behavioral Health and Space Human Factors and Habitability risks.
- H12.04 Advanced Food Systems Technology helps address the Space Human Factors and Habitability food system risks.
- H12.05 In-Flight Biological Sample Analysis helps address an ISS Medical Project technology need to allow on-orbit biological sample analysis, limiting the need for biological sample return.

H12.01 Exploration Countermeasure Capability - Portable Activity Monitoring System

Lead Center: JSC

Participating Center(s): GRC

OCT Technology Area: [TA06](#)

Human space flight is associated with losses in muscle strength, bone mineral density and aerobic capacity. Crewmembers returning from the International Space Station (ISS) can lose as much as 10-20% of their strength in weight bearing and postural muscles. Likewise, bone mineral density is decreased at a rate of ~1% per month. During future exploration missions such physiologic decrements represent the potential for a significant loss of human performance which could lead to mission failure and/or a threat to crewmember health and safety. NASA is conducting research to enhance and optimize exercise countermeasure hardware and protocols for these missions. In this solicitation, we are seeking portable technologies to collect foot ground reaction force data from current exercise hardware deployed on the International Space Station to be analyzed by research teams on the ground.

NASA seeks a portable, force/load measurement system capable of being integrated into existing ISS exercise systems and suitable for use in future transfer and exploration vehicles. During long duration spaceflight, exercise is prescribed to mitigate bone and muscle loss. Advancement of these exercise prescriptions may require biomechanical analysis of exercise on orbit. Output parameters from the proposed device must be valid in the bandwidth from 0-100Hz and be able to be synchronized with existing analog data systems. 3-D force, torque, acceleration, and turn rates are required. Must include a portable data logging system or wireless interface compatible with the Windows platform or Apple iPad. On-board data processing, activity recognition and display is desirable. The portable system should be low-maintenance, durable, easy to set-up and calibrate, non-disruptive to

exercise form or gait, accurate (<1% error for static and dynamic loads), low mass, and require minimal power. Regenerative power feature is desirable.

NASA Deliverables - Fully developed concept complete with feasibility and top-level drawings as well as computational methodology as applicable. A breadboard or prototype system is highly desired.

HRP IRP Risks - Risk of Impaired Performance Due to Reduced Muscle Mass, Strength, and Endurance; Risk Of Early Onset Osteoporosis Due To Spaceflight

Technology Readiness Levels (TRL) of 6 or higher are sought.

Potential NASA Customers include:

- Human Health Countermeasures Element in Human Research Program:
 - (http://www.nasa.gov/exploration/humanresearch/elements/research_info_element-hhc.html)

H12.02 Exploration Medical Capability - Medical Suction Capability

Lead Center: JSC

Participating Center(s): GRC

OCT Technology Area: [TA06](#)

The existing in-space medical suction system (used on ISS) provides insufficient medical suction capability. Medical suction clears the airway, empties the stomach, decompresses the chest, and keeps the operative field clear. The existing design provides limited operational flexibility in providing airway management support, oropharyngeal suction, and chest tube drainage during an exploration mission due to limitations in suction performance, usability, patient interfaces, and reusability. It is restricted for use by a trained medical doctor and has several design limitations including:

- It can only be used to clear the airway. It would be insufficient/incapable to perform other types of medical suction.
- Device consists of several pieces that are only held together by a friction fit/seal and may come apart unless handled carefully.
- Device does not meet flow rate requirement since it is limited by operator speed.
- Device can only collect about 1 liter total volume. This volume includes volume of air since there is no gas separator.

The Phase I technology developed under this SBIR should demonstrate proof of concept medical suction capability in a space operational environment and should focus on the following aspects:

- Phase separation.
- Range of flow rates.
- Range of applied vacuum pressure.
- Continuous and intermittent operation.
- Variety of operational conditions including micro, partial and normal gravity; and in-space and post-landing usage.
- Minimize mass, volume, and power usage.

Minimum specifications that should be in the design:

- Airway Management and Oropharyngeal Suction:
 - Suction pressure - at least 500 mmHg
 - Flow rate - at least 25 liters per minute
 - Duration - at least 30 minutes
- Chest tube drainage:
 - Suction pressure - between 150-180 mmHg

- Duration - at least 24 hours
- Biological waste cleanup:
 - Suction pressure - at least 500 mmHg
 - Flow rate - at least 35 liters per minute
 - Duration - at least 30 minutes

NASA Deliverable - Prototype functional system in a proof of concept demonstration

HRP IRP Risk - Inability to Adequately Recognize or Treat an Ill or Injured Crew Member

Technology Readiness Levels (TRL) of 3 or higher are sought.

Potential NASA Customers include:

- Exploration Medical Capability Element in Human Research Program:
 - (http://www.nasa.gov/exploration/humanresearch/elements/research_info_element-exmc.html)

H12.03 Behavioral Health and Performance - Innovative Technologies for A Virtual Social Support System for Autonomous Exploration Missions

Lead Center: JSC

OCT Technology Area: [TA06](#)

NASA wants to identify how virtual worlds (i.e., interactive games, avatars, social networks) could be used for long-duration space exploration missions. This subtopic is aimed at developing a virtual social support system for crews of such missions.

During these missions, the crews, by virtue of their distance from Earth, are separated from their significant others and will no longer have access to social support currently provided to the ISS crews. They are living in a confined and isolated environment devoid of normal Earth settings as they venture to distant destinations. Long communication delays between Earth and vehicle are also anticipated. Expanding the crew's social connectivity to friends, family, and colleagues back home through a variety of virtual platforms will help mitigate the stressors inherent to living and working in such an isolated, confined, and extreme environment.

During the actual mission, the tool could provide a more homelike “virtual world” to augment the constrained physical habitat the crew lives and works. It could also help the crews maintain connections and provide the needed social support. As a design tool, the insight gained into the crew members’ interaction with the outside world would be valuable for developing new mission training regimens and design concepts for future long-duration missions.

The proposal shall describe:

- The virtual environment to be developed.
- Plans to provide adaptive systems to deal with communication latencies.
- How the tool could enhance and measure behavioral health and performance, including perceived closeness to home.
- Ways to assess habitability issues.

NASA Deliverables - Phase I deliverable shall yield a proof of concept that includes both an evidence review that encompasses an assessment of current knowledge of virtual reality technologies and their use in supporting this topic.

In addition, the following deliverables shall be required:

- A requirements document for such a support system that fits the needs of a NASA exploration mission.
- A plan for evaluating the effectiveness of the tool as a behavioral health countermeasure, training, and habitability assessment.

The subsequent Phase II deliverable shall provide a prototype of specific modules that can demonstrate improved communication and perceived social support by utilizing these technologies.

HRP IRP Risks - Risk of Adverse Behavioral Conditions and Psychiatric Disorders; Risk of Performance Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team; Risk of an Incompatible Vehicle/Habitat Design

Technology Readiness Levels (TRL) of 4 or higher are sought.

Potential NASA Customers include:

- Behavior and Performance Element in Human Research Program:
 - (http://www.nasa.gov/exploration/humanresearch/elements/research_info_element-bhp.html)

H12.04 Advanced Food Systems Technology

Lead Center: JSC

OCT Technology Area: [TA06](#)

The purpose of the NASA Advanced Food Technology Project is to develop, evaluate and deliver food technologies for human centered spacecraft that will support crews on long duration missions beyond low-Earth orbit. Safe, nutritious, acceptable, and varied shelf-stable foods with a shelf life of 5 years will be required to support the crew during these exploration missions. Concurrently, the food system must efficiently balance appropriate vehicle resources such as mass, volume, water, air, waste, power, and crew time.

Refrigeration and freezing require significant vehicle resource utilization, so NASA provisions consist solely of shelf stable foods. Stability is achieved by thermal or irradiative processing to kill the microorganisms in the food, or drying to prevent viability of the microorganisms. These methods do impact the micronutrients within the food substrate. Environmental factors (such as moisture ingress and oxidation) are also capable of compromising the nutrient content over the shelf life of the food. Since the food system is the sole source of nutrition to the crew, a significant loss in nutrient availability could significantly jeopardize the health and performance of the crew. Optimal nutritional content of the food for five years will ensure that the food can support crew performance and help protect their bodies from deficiencies that cause disease.

Vitamin content in NASA foods, such as vitamin C, vitamin A, thiamin, and folic acid, is degraded during processing and as the product ages in storage. The goal is to develop a system that either increases the bioavailability of the nutrients or protects the vitamins from this biological or chemical degradation at ambient temperatures over a five year duration. Possible technologies that could be investigated include novel food ingredients, protective or stabilizing technologies (e.g., encapsulation), biosensors, and controlled-release systems.

Phase I Requirements - Phase I should concentrate on the scientific, technical, and commercial merit and feasibility of the proposed innovation resulting in a feasibility report and concept, complete with analyses.

NASA Deliverables - A system which will result in higher nutrient content in shelf stable foods.

HRP IRP risk - Risk of Inadequate Food System

Technology Readiness Levels (TRL) of 4 to 5 or higher are sought.

Potential NASA Customers include:

- Space Human Factors and Habitability Element in Human Research Program:
 - (http://www.nasa.gov/exploration/humanresearch/elements/research_info_element-shfh.html)

H12.05 In-Flight Biological Sample Analysis**Lead Center: JSC****Participating Center(s): ARC****OCT Technology Area: [TA06](#)**

Although crewmembers undergo intensive medical screening, the possibility of crew injury or illness can never be completely eliminated. A mission could be jeopardized or compromised by reduction of able crewmembers, both directly and indirectly if an incapacitated crewmember requires nursing or care. Mission architecture limits the amount of equipment, consumables, and procedures that will be available to treat medical problems. Mission allocation and technology development must be performed to ensure that the limited mass, volume, power, and crew training time are used efficiently to provide the broadest possible treatment capability. There is also a gap in knowledge in how the spaceflight environment affects the effectiveness of drug therapies. This subtopic aims to mitigate those space mission constraints by means of innovative approaches for addressing the knowledge gap in the area of drug stability during long duration spaceflight.

This subtopic seeks proposals for novel approaches to develop an in-flight tool capable of monitoring stability of pharmaceuticals (ideally, solids, liquids and creams) under low gravity conditions. Such a device must be able to determine percentage of active ingredients with a preference to also characterize degradation of products while minimizing the amount of pharmaceutical sample consumed in the test. The technology will need to address approaches and methodologies for handling the different forms of pharmaceuticals (pills, liquids, creams) through the use of a flexible sample preparation front-end amenable to the space environment. The proposed technology should be low-resource, low-footprint, and should involve a low volume of supplies/consumables, which do not require refrigeration or freezing for storage. Also, the technological innovation should be user-friendly, requiring minimal training and operating via uncomplicated protocols.

The Phase I technology developed under this SBIR should investigate one or more one or more of the following drugs:

- Acetaminophen.
- Azithromycin.
- Injectable epinephrine.
- Lidocaine topical gel.

In the Phase I effort, the proof of concept analysis should be demonstrated by the innovative technology and provide comparable results to drug stability laboratory USP standards (i.e., high performance liquid chromatography, differential scanning calorimetry, UV/FTIR spectroscopy). Phase II will seek to optimize these results for additional drugs as well as sensitivity, compound identification, drug degradation products, analysis time and facilitated end-user protocols.

NASA Deliverables: Prototype functional system in a proof of concept analysis demonstrated by the innovative technology producing drug stability characterization including integrity and percentage of active ingredients and characterization/degradation of products (in Phase I). Drugs to be demonstrated in Phase I include: Acetaminophen, Azithromycin, Injectable epinephrine and Lidocaine topical gel.

HRP IRP Risks - Inability to Adequately Recognize or Treat an Ill or Injured Crew Member; Risk of Therapeutic Failure Due to Ineffectiveness of Medication

Technology Readiness Levels (TRL) of 5 or higher are sought.

Potential NASA Customers include:

- ISS Medical Project Element in Human Research Program:
 - (http://www.nasa.gov/exploration/humanresearch/elements/research_info_element-issmp.html)

9.1.3 SCIENCE

NASA leads the nation on a great journey of discovery, seeking new knowledge and understanding of our planet Earth, our Sun and solar system, and the universe out to its farthest reaches and back to its earliest moments of existence. NASA's Science Mission Directorate (SMD) and the nation's science community use space observatories to conduct scientific studies of the Earth from space, to visit and return samples from other bodies in the solar system, and to peer out into our Galaxy and beyond.

NASA's science program seeks answers to profound questions that touch us all:

- How are Earth's climate and the environment changing?
- How and why does the Sun vary and affect Earth and the rest of the solar system?
- How do planets and life originate?
- How does the universe work, and what are the origin and destiny of the universe?
- Are we alone?

For more information on SMD, visit: (<http://science.nasa.gov/>).

The following topics and subtopics seek to develop technology to enable science missions in support of these strategic objectives.

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TOPIC: S1 Sensors, Detectors and Instruments

NASA's Science Mission Directorate (SMD) (<http://nasascience.nasa.gov/>) encompasses research in the areas of Astrophysics, Earth Science, Heliophysics and Planetary Science. The National Academy of Science has provided NASA with recently updated Decadal surveys that are useful to identify technologies that are of interest to the above science divisions. Those documents are available at the following locations:

- Astrophysics – (http://sites.nationalacademies.org/bpa/BPA_049810).
- Planetary – (<http://solarsystem.nasa.gov/2013decadal/index.cfm>).
- Earth Science – (<http://science.nasa.gov/earth-science/decadal-surveys/>).
- Heliophysics – The 2009 technology roadmap can be downloaded here (<http://science.nasa.gov/heliophysics/>).

A major objective of SMD instrument development programs is to implement science measurement capabilities with smaller or more affordable spacecraft so development programs can meet multiple mission needs and therefore make the best use of limited resources. The rapid development of small, low-cost remote sensing and in situ instruments is essential to achieving this objective. For Earth Science needs, in particular, the subtopics reflect a focus on instrument development for airborne and Unmanned Aerial Vehicle (UAV) platforms. Astrophysics has a critical need for sensitive detector arrays with imaging, spectroscopy, and polarimetric capabilities, which can be demonstrated on ground, airborne, balloon, or suborbital rocket instruments. Heliophysics, which focuses on measurements of the sun and its interaction with the Earth and the other planets in the solar system, needs a significant reduction in the size, mass, power, and cost for instruments to fly on smaller spacecraft. Planetary Science has a critical need for miniaturized instruments with in situ sensors that can be deployed on surface landers, rovers, and airborne platforms. For the 2012 program year, we are restructuring the Sensors, Detectors and Instruments Topic, rotating out, combining and retiring some of the subtopics. Please read each subtopic of interest carefully. One new subtopic, S1.09 Surface and Sub-surface Measurement Systems was added this year. This new subtopic solicits proposals that are for ground-based surface vehicles, and submerged systems. Systems that will provide near-term benefit in a ground-based application but that are ultimately intended for flight or mobile platforms are in scope. A key objective of this SBIR topic is to develop and demonstrate instrument component and subsystem technologies that reduce the risk, cost, size, and development time of SMD observing instruments and to enable new measurements. Proposals are sought for development of components, subsystems and systems that can be used in planned missions or a current technology program. Research should be conducted to demonstrate feasibility during Phase I and show a path towards a Phase II prototype demonstration. The following subtopics are concomitant with these objectives and are organized by technology.

S1.01 Lidar Remote Sensing Technologies

Lead Center: LaRC

Participating Center(s): GSFC, JPL

OCT Technology Area: [TA08](#)

NASA recognizes the potential of lidar technology in meeting many of its science objectives by providing new capabilities or offering enhancements over current measurements of atmospheric and topographic parameters from ground, airborne, and space-based platforms. To meet NASA's requirements, advances are needed in state-of-the-art lidar technology with emphasis on compactness, efficiency, reliability, lifetime, and high performance. Innovative lidar subsystem and component technologies systems that directly address the measurements of the atmosphere and surface topography of the Earth, Mars, the Moon, and other planetary bodies will be considered under this subtopic.

Proposals relevant to the development of lidar instruments that can be used in planned missions or current technology programs are highly encouraged. Examples of planned missions and technology programs are: Laser Interferometer Space Antenna (LISA), Doppler Wind Lidar (3D-WINDS), Ozone Lidar, Lidar for Surface Topography (LIST), Mars atmospheric sensing, Mars and earth re-entry atmospheric entry and descent, Active Sensing of CO₂ Emissions over Nights, Days, and Seasons (ASCENDS), and Aerosols-Clouds-Ecosystems (ACE). In addition, innovative technologies relevant to the NASA sub-orbital programs, such as Unmanned Aircraft Systems (UAS) and Venture-class focusing on the studies of the Earth climate, carbon cycle, weather, and atmospheric composition, are being sought.

The proposals should target components and subsystems development for eventual space utilization. Phase I research should demonstrate the technical feasibility and show a path toward a Phase II prototype unit. Phase II prototypes should be capable of laboratory demonstration and preferably suitable for operation in the field from a ground-based station or an aircraft platform. For the PY12 SBIR Program, we are soliciting the component and subsystem technologies described below.

Solid state, single frequency, pulsed, laser transmitter operating in the 1.0 μm - 1.7 μm range with wall-plug efficiency of greater than 25% suitable for CO_2 measurement, interferometry, and free-space laser communication applications. The laser transmitter must be capable of generating frequency transform-limited pulses with a quality beam M^2 of less than 1.5. We are interested in two different regimes of repetition rate and output energy: in one case, repetition rate from 5 KHz to 20 KHz with pulse energy from 1 - 4 mJ, and in the second case, repetition rate 20 Hz to 2 KHz with pulse energy from 30 - 300 mJ. In addition, development of non-traditional optical amplifier architectures that yield optical efficiency of >70% are of interest. Attention to the compact and rugged designs for possible aircraft flight tests is highly desirable.

Single-frequency solid-state crystal, planar waveguide or fiber amplifiers/lasers operating at 1.5 and 2.0 micron wavelength regimes suitable for direct detection differential absorption lidar (DIAL) and coherent lidar applications. These lasers must meet one of the two general requirements:

- Pulse energy 0.5 mJ to 2 mJ, repetition rate 2 KHz to 10 KHz, and pulse duration of 10 nsec for direct detection lidars.
- 5 mJ to 50 mJ, 20 Hz to 2 KHz, 200 nsec for coherent detection lidars.

2-micron single frequency laser system generating at least 30 mW of power with a precision frequency locking mechanism suitable for measurements of atmospheric CO_2 . The laser must be locked to a CO_2 absorption line peak via a fiber gas cell with accuracy better than 200 KHz. The frequency locked laser shall be modulated to generate two preset offset frequencies from the center frequency alternatively, one at 3-4 GHz, and the other at 15-20GHz range. The frequency stability at these off-center frequencies shall be better than 500 KHz.

Pulsed, single frequency, solid state laser operating in the 450-500 nm range serving as a transmitter for an oceanography lidar. The laser must be able to produce bandwidth-limited pulses with 10 nsec or shorter duration. The proposed design must be scalable to at least 10 W of average power, preferably generating 100 mJ at 100-200 Hz, but will consider lower pulse energies with higher repetition rates. Pulse energies can be less than the above stated goals by a factor of 10 for the Phase II delivered unit.

S1.02 Microwave Technologies for Remote Sensing

Lead Center: JPL

Participating Center(s): GSFC, LaRC

OCT Technology Area: [TA08](#)

NASA employs active (radar) and passive (radiometer) microwave sensors for a wide range of remote sensing applications (for example, see: <http://www.nas.nasa.gov/public/11820.html>). These sensors include low frequency (less than 10 MHz) sounders to G-band (160 GHz) radars for measuring precipitation and clouds, for planetary landing, upper atmospheric monitoring, and global snow coverage (SCLP). We are seeking proposals for the development of innovative technologies to support these future radar and radiometer missions and applications. The areas of interest for this call are listed below:

- Space qualifiable, High power and efficiency P-band power amplifiers: Center Frequency: 420-450 MHz, Gain: > 40 dB, Efficiency: >80%, Duty Cycle: 10%, Mass < 500g, Size: 16 cm x 9cm x 3.1 cm
- Space-qualifiable Single-Board Digital Radar Transceiver in PC-104e form factor. Frequency bands: 400-500, 1200-1300 MHz, with arbitrary waveform generator (100 us pulselength, 30 MHz BW), 2-channel ADC, FPGA, PCIe bus, Size: Approx 9cm x 9.6cm x 3.1cm
- Cryogenic LNAs for 180 to 270 GHz with noise temperatures of less than 100K. Earth Science Decadal Survey missions that apply: PATH, GACM and future Earth Venture Class low cost millimeter wave instruments.

- Receiver technologies for the PATH mission including: low noise (<4 dB noise figure) I&Q receivers for the band from 118 to 126 GHz and efficient active multiplier chains delivering 16 dBm at 59-63 and 82-92 GHz from a low power 27-32 GHz reference
- Local Oscillator technologies for 2nd generation instruments for SOFIA, next generation HIFI, and suborbital instruments (GUSSTO). This can include: GaN based frequency multipliers that can work in the 200-400 GHz range (output frequency) with input powers up to 1 W. Graphene-based (or other suitable technology) devices that can work as frequency multipliers in the frequency range of 1-3 THz.
- Compact, light-weight array antennas with 50 – 60% bandwidth using electronic frequency hopping and tuning capabilities, dual-polarization, high cross -polarization isolation (> 25 dB) for airborne and spaceborne radar applications
- P-, L-, C-, X band MMIC pulsed radar transceivers with dynamic load matching, wideband (> 50 MHz) high power efficiency (> 30%), high T/R isolation (> 90 dB)
- Large (~5m) deployable parabolic cylindrical antennas, F=35, 94 GHz
- G-Band Microwave Components: For measurement of microphysical properties of clouds and upper atmospheric constituents (particles of less than mm sizes):
 - G-band Noise Source (ENR> 10dB).
 - W-band LO (6 dBm, Freq. Stability 5-10 MHz (-20 C- 40 C) DC Power < 4W).
 - G-band isolator (Isolation > 15 dB, Insertion Loss < 1dB).
 - G-band switching circulator (Isolation > 15 dB Insertion Loss < 1.2 dB).
 - Integration and packaging G-band receiver for cubesat and microsat platforms.
- Multi-Frequency and/or multi-Beam Focal Plane Arrays (FPA) as a primary feed for reflector antennas. In NASA's SCLP mission, it is required to collect Earth science data at high spatial and as well as temporal resolutions simultaneously. In addition to high spatial and temporal resolutions, the proposed antenna system must offer ways to suppress RFI and control antenna illumination. NASA is looking for a small (3 x 3) focal plane array system to be used as a feed for its main reflector. Wideband array element covering 19, and 37 GHz must be used as a basic element of the proposed FPA.

S1.03 Sensor and Detector Technology for Visible, IR, Far IR and Submillimeter

Lead Center: JPL

Participating Center(s): ARC, GSFC, KSC, LaRC

OCT Technology Area: [TA08](#)

NASA is seeking new technologies or improvements to existing technologies to meet the detector needs of future missions, as described in the most recent decadal surveys for Earth science (<http://www.nap.edu/catalog/11820.html>), planetary science (<http://www.nap.edu/catalog/10432.html>), and astronomy and astrophysics (<http://www.nap.edu/books/0309070317/html/>).

The following technologies are of interest for the Scanning Microwave Limb Sounder (<http://mls.jpl.nasa.gov/index-cameo.php>) on the Global Atmospheric Composition Mission and the SOFIA (Stratospheric Observatory for Infrared Astronomy) airborne observatory:

- Radiation tolerant digital polyphase filterbank back ends for sideband separating microwave spectrometers. Requirements are >5GHz instantaneous bandwidth per sideband, 2 MHz resolution, low power (<5 W/GHz), and 4 bits or higher digitization.
- Improved submillimeter mixers for frequencies >2 THz are needed for heterodyne receivers to fly on SOFIA. Minimum noise temperatures for cryogenic operation and instantaneous bandwidths >5 GHz are key parameters.
- Efficient, flight qualifiable, spur free, local oscillators for SIS mixers operating in low earth orbit. Two bands:
 - Tunable from 200 to 250 GHz.
 - Tunable from 610 to 650 GHz, phase-locked to or derived from an ultra-stable 5 MHz reference.
- Quantum cascade laser-based local oscillators >2THz for astrophysics applications

Thermal imaging, LANDSAT Thermal InfraRed Sensor (TIRS), Climate Absolute Radiance and Refractivity Observatory (CLARREO), BOREal Ecosystem Atmosphere Study (BOREAS), other infrared earth observing

missions, Trojan Tour, Europa Jupiter System Mission (EJSM) such as a descoped Jupiter Europa Orbiter (JEO), Io Observer, or Jupiter Io Callisto Europa (JuICE) missions (see the Jupiter Europa Orbiter Mission Study 2008: Final Report, <http://opfm.jpl.nasa.gov/library/>) and future planetary missions:

- Development of un-cooled or cooled Infrared detectors (hybridized or designed to be hybridized to an appropriate read-out integrated circuit) with $NE\Delta T < 20\text{mK}$, $QE > 30\%$ and dark currents $< 1.5 \times 10^{-6} \text{ A/cm}^2$ in the 5-14 μm infrared wavelength region. Array formats may be variable, 640 x 512 typical, with a goal to meet or exceed 2k X 2k pixel arrays. Evolve new technologies such as InAs/GaSb type-II strain layer super-lattices to meet these specifications.
- 2-D arrays of thermopile detectors (wavelength range 20-100 μm ; Detectivity $\geq 4 \times 10^9$; operating temp 100-200 K).

1kx1k MCT detector arrays with cutoff wavelength extended to $\geq 12 \mu\text{m}$ for use in missions to NEOs, comets and the outer planets.

New or improved technologies leading to measurement of trace atmospheric species (e.g., CO, CH₄, N₂O) from geostationary and low-Earth orbital platforms; see Methane Trace Gas Sounder. Of particular interest are new techniques in gas filter correlation spectroscopy, Fabry-Perot spectroscopy, or improved component technologies. Technologies are needed for active and passive wave front and amplitude control, and relevant missions include Extra solar Planetary Imaging Coronagraph (EPIC), and other coronagraphic missions such as Terrestrial Planet Finder (http://exep.jpl.nasa.gov/TPF-C/tpf-C_index.cfm) and Stellar Imager (<http://hires.gsfc.nasa.gov/si/>):

- MEMS based segmented deformable mirrors consisting of arrays of up to 1200 hexagonal packed segments with strokes over the range of 0 to 1.0 microns, quantized with 16-bit electronics with segment level stabilities of 0.015 nm rms (1-bit) over 1 hour intervals. Segments should be flat to 2 nm rms or better and the substrate flat to 125 nm or better and high uniformity of coatings (1% rms).
- Technologies for high contrast integral field spectroscopy, in particular for microlens arrays with or without accompanying mask arrays, working in the visible and NIR (0.4 - 1.8 microns), with lenslet separations in the 0.2 -0.5 mm range, with contrast between neighboring spectra of $\sim 10^{-4}$, and uniform focal lengths to $< 0.05 \text{ mm}$ with output f/ numbers < 10 .
- Spatial Filter Array (SFA) consisting of a monolithic array of up to 1200 coherent, polarization preserving, single mode fibers, or custom waveguides, that operate with minimal coupling losses over a large fraction of the spectral range from 0.4 - 1.0 microns. The SFA should have input and output lenslet with each pair mapped to a single fiber or waveguide and such that the lenslets maintain path length uniformity to $< 100 \text{ nm}$. Uniformity of both output intensity and wave front phase, and high throughput is desired and fiber-to-fiber placement accuracies of $< 1.0 \text{ microns}$ are required with $< 0.5 \text{ microns}$ desired.

Blazed, holographic optical gratings on convex surfaces: The Offner spectrometer design uses a symmetric optical layout to balance aberrations, producing good imaging performance and spectral images with little or no distortion. Both of these attributes improve the measurement capability of the spectrometer by eliminating the spatial-spectral information mixing that other spectrometer forms typically produce. The key element in an Offner spectrometer is the convex spherical grating that is used to disperse the light spectrally. While such gratings can be made holographically, these gratings suffer from low efficiency due to their lack of signal-enhancing blazed groove structure. Development is needed for production of holographically-generated convex gratings that have a continuously-varying blaze angle to provide high efficiency diffraction into a chosen wavelength range and diffraction order (415 nm to 695 nm in first order and 290 nm to 390 nm in the second order). Such gratings also should have less scattered light than similar mechanically-ruled gratings, improving spectrometer performance.

SI.04 Detector Technologies for UV, X-Ray, Gamma-Ray and Cosmic-Ray Instruments

Lead Center: GSFC

Participating Center(s): JPL, MSFC

OCT Technology Area: [TA08](#)

This subtopic covers detector requirements for a broad range of wavelengths from UV through to gamma ray for applications in Astrophysics, Earth science, Heliophysics, and Planetary science. Requirements across the board are

for greater numbers of readout pixels, lower power, faster readout rates, greater quantum efficiency, and enhanced energy resolution.

The proposed efforts must be directly linked to a requirement for a NASA mission. These include Explorers, Discovery, Cosmic Origins, Physics of the Cosmos, Vision Missions, and Earth Science Decadal Survey missions. Details of these can be found at the following URLs:

- General Information on Future NASA Missions: (<http://www.nasa.gov/missions>).
- Specific mission pages: IXO: (<http://htxs.gsfc.nasa.gov/index.html>), future planetary programs: (http://nasascience.nasa.gov/planetary-science/mission_list), Earth Science Decadal missions: (<http://www.nap.edu/catalog/11820.html>).
- Helio Probes: (http://nasascience.nasa.gov/heliophysics/mission_list).

Specific technology areas are listed below:

- Significant improvement in wide band gap semiconductor materials, such as AlGaIn, ZnMgO and SiC, individual detectors, and detector arrays for operation at room temperature or higher for missions such as Geo-CAPE, NWO, ATALAST and planetary science composition measurements.
- Highly integrated, low noise (< 300 electrons rms with interconnects), low power (< 100 uW/channel) mixed signal ASIC readout electronics as well as charge amplifier ASIC readouts with tunable capacitive inputs to match detector pixel capacitance. See needs of National Research Council's Earth Science Decadal Survey (NRC, 2007): Future Missions include GEOCAPE, HypsIRI, GACM, future GOES and SOHO programs and planetary science composition measurements.
- Large format UV and X-ray focal plane detector arrays: micro-channel plates, CCDs, and active pixel sensors (>50% QE, 100 Megapixels, <0.1 W/Megapixel, 30 Hz). Improved micro-channel plate detectors, including improvements to the plates themselves (smaller pores, greater lifetimes, lower ion feedback alternative fabrication technologies, e.g., silicon), as well as improvements to the associated electronic readout systems (spatial resolution, signal-to-noise capability, and dynamic range), and in sealed tube fabrication yield. Possible future mission applications are the International X-ray Observatory and Advanced Technology Large Aperture Space Telescope (ATLAST).
- Advanced Charged Couple Device (CCD) detectors, including improvements in UV quantum efficiency and read noise, to increase the limiting sensitivity in long exposures and improved radiation tolerance. Electron-bombarded CCD and CMOS detectors, including improvements in efficiency, resolution, and global and local count rate capability. In the X-ray, we seek to extend the response to lower energies in some CCDs, and to higher, perhaps up to 50 keV, in others. Possible missions are future GOES missions and International X-ray Observatory.
- Wide band gap semiconductor, radiation hard, visible and solar blind large format imagers for next generation hyperspectral Earth remote sensing experiments. Need larger formats (>1Kx1K), much higher resolution (<18µm pixel size), high fill factor and low read noise (<60 electrons). See needs of National Research Council's Earth Science Decadal Survey (NRC, 2007): Future missions include GEOCAPE, HypsIRI, GACM.
- Solar blind, compact, low-noise, radiation hard, EUV and soft X-ray detectors are required. Both single pixels (up to 1cm x 1cm) and large format 1D and 2D arrays are required to span the 0.05nm to 150nm spectral wavelength range. Future missions include GOES post R and T.
- Visible-blind SiC Avalanche Photodiodes (APDs) for EUV photon counting are required. The APDs must show a linear mode gain >1E6 at a breakdown reverse voltage between 80 and 100V. The APD's must demonstrate detection capability of better than 6 photons/pixel/s down to 135nm wavelength. See needs of National Research Council's Earth Science Decadal Survey (NRC, 2007): Tropospheric ozone.
- Large format 1D (1 x 2k) and 2D (2k x 2k) SiC arrays (operating temp 170-300K; $D^* \geq 3 \times 10^{15}$) including Schottky diodes, PINs and ADPs for instruments on future outer planets missions.
- Imaging from low-Earth orbit of air fluorescence, UV light generated by giant air showers by ultra-high energy ($E > 10^{19}$ eV) cosmic rays require the development of high sensitivity and efficiency detection of 300-400 nm UV photons to measure signals at the few photon (single photo-electron) level. A secondary goal minimizes the sensitivity to photons with a wavelength greater than 400 nm. High electronic gain (~106), low noise, fast time response (<10 ns), minimal dead time (<5% dead time at 10 ns response time),

high segmentation with low dead area (<20% nominal, <5% goal), and the ability to tailor pixel size to match that dictated by the imaging optics. Optical designs under consideration dictate a pixel size ranging from approximately $2 \times 2 \text{ mm}^2$ to $10 \times 10 \text{ mm}^2$. Focal plane mass must be minimized (2g/cm^2 goal). Individual pixel readout is required. The entire focal plane detector can be formed from smaller, individual sub-arrays.

- Large area (3 m^2) photon counting near-UV detectors with 3 mm pixels and able to count at 10 MHz. Array with high active area fraction (>85%), 0.5 Megapixels and readout less than 1 mW/channel. Future instruments are JEM-EUSO and OWL.
- Large area (m^2) X-ray detectors with <1mm pixels and high active area fraction (>85%). Future instrument is a Phased-Fresnel X-ray Imager.
- Improve beyond CdZnTe detectors using micro-calorimeter arrays at hard X-ray, low gamma-ray bands (above 10 keV and Below 80 keV).
- Technologies to improve spatial resolution for the hard X-ray band to 10 and ultimately to 5 arc-second resolution.
- High-density, low-temperature electrical interfaces: In microcalorimeter and cryogenic IR detector assemblies, the large number of electrical connections required on the low-temperature stage (below 4 Kelvin) requires high-density, miniaturized cryogenic connectors. NASA needs suitable nano-miniature connectors that can connect to superconducting wires (Nb or Al) deposited on a high density flex cable. The metal traces will likely be layered into a stripline configuration to minimize cross-talk, leading to pads onto which the connector is attached. This type of flex cable has extremely low thermal conductivity. A modular connector, easily integrated into or removed from the superconducting flex cable, is sought.

S1.05 Particles and Field Sensors and Instrument Enabling Technologies

Lead Center: GSFC

Participating Center(s): ARC, JPL, JSC, MSFC

OCT Technology Area: [TA08](#)

Advanced sensors for the detection of elementary particles (atoms, molecules and their ions) and electric and magnetic fields in space and associated instrument technologies are often critical for enabling transformational science from the study of the sun's outer corona, to the solar wind, to the trapped radiation in Earth's and other planetary magnetic fields, and to the atmospheric composition of the planets and their moons. Improvements in particles and fields sensors and associated instrument technologies enable further scientific advancement for upcoming NASA missions such as Solar Orbiter, Solar Probe Plus, ONEP, SEPAT, INCA, CISR, DGC, HMag and planetary exploration missions. Technology developments that result in a reduction in size, mass, power, and cost will enable these missions to proceed. Of interest are advanced magnetometers, electric field booms, ion/atom/molecule detectors, and associated support electronics and materials. Specific areas of interest include:

- Self-calibrating scalar-vector magnetometer for future Earth and space science missions. Performance goals: dynamic range: $\pm 100,000 \text{ nT}$, accuracy with self-calibration: 1 nT, sensitivity: $5 \text{ pT} \cdot \text{Hz}^{-1/2} (\text{max})$, max sensor unit size: $6 \times 6 \times 12 \text{ cm}$, max sensor mass: 0.6 kg, max electronics unit size: $8 \times 13 \times 5 \text{ cm}$, max electronics mass: 1 kg, and max power: 5 W operation, 0.5 W standby, including, but not limited to "sensors on a chip".
- High magnetic-field sensor that measures magnetic field magnitudes to 16 Gauss with an accuracy of 1 part in 105.
- Strong, lightweight, thin, compactly stowed electric field booms possibly using composite materials that deploy sensors to distances of 10-m or more.
- Cooled ($-60 \text{ }^\circ\text{C}$) solid-state ion detector capable of operating at a floating potential of -15 kV relative to ground.
- Low-noise magnetic materials for advanced magnetometer sensors with performance equal to or better than those in the 6-81.3 Mo-Permalloy family.
- Radiation-hardened ASICs including ADCs, DACs, and spectrum analyzer modules that determine mass spectra using fast algorithm deconvolution to produce ion counts for specific ion species.
- Low-cost, low-power, fast-stepping ($\leq 50\text{-}\mu\text{s}$), high-voltage power supplies 5-15 kV.
- Low-cost, efficient low-power power supplies (5-10 V).
- Low-power, charge-sensitive preamplifiers on a chip.

- High efficiency (5% or greater) conversion surfaces for low-energy neutral atom conversion to ions possibly based on nanotechnology.
- Miniature low-power, high-efficiency, thermionic cathodes, capable of 1-mA electron emission per 100-mW heater power with emission surface area of 1-mm² and expected lifetime of 20,000 hours.
- Long wire boom (\geq 50 m) deployment systems for the deployment of very lightweight tethers or antennae on spinning spacecraft.
- Systems to determine the orthogonality of a deployed electric/magnetic field boom system in flight (for use with three-axis rigid 10-m booms) accurate to 0.10° dynamic.
- Die-level optical interferometer, micro-sized, for measuring Fabry-Perot plate spacing with 0.1-nm accuracy.
- Diffractive optics (photon sieves) of 0.1-m aperture or larger with micron-sized outer Fresnel zones for high-resolution EUV imaging.
- Avalanche Photodiode Detectors (APDs), in single pixel and multi-pixel form, to make a breakthrough in particle detection by taking advantage of their inherent gain compared to the unity gain SSDs. The APDs, typically used for photons, should be optimized for particles including thin dead layer, increased energy range, gain stability and radiation hardness, but with much higher energy resolution ($<0.5\text{KeV}$) compared to SSDs.
- Developing near real-time data-assimilative models and tools, for both solar quiet and active times, which allow for precise specification and forecasts of the space environment, beginning with solar eruptions and propagation, and including ionospheric electron density specification.

S1.06 Cryogenic Systems for Sensors and Detectors

Lead Center: GSFC

Participating Center(s): ARC, JPL, KSC, MSFC

OCT Technology Area: [TA08](#)

Cryogenic cooling systems often serve as enabling technologies for detectors and sensors flown on scientific instruments as well as advanced telescopes and observatories. As such, technological improvements to cryogenic systems (as well as components) further advance the mission goals of NASA through enabling performance (and ultimately science gathering) capabilities of flight detectors and sensors. Presently, there are six potential investment areas that NASA is seeking to expand state of the art capabilities in for possible use on future programs such as GEOID, SPICA, WFIRST (<http://wfirst.gsfc.nasa.gov/>), Spirit, Specs (<http://nmdb.gsfc.nasa.gov/geons>) and the Europa Science missions (<http://www.nasa.gov/multimedia/podcasting/jpl-europa20090218.html>). The topic areas are as follows:

- *Extremely Low Vibration Cooling Systems* - Examples of such systems include pulse tube coolers and turbo brayton cycles. Desired cooling capabilities sought are on the order of 20 mW at 4K or 1W at 50K. Present state of the art capabilities display $< 100\text{ mN}$ vibration at operational frequencies of 30-70 Hz. Proposed systems should either satisfy or improve upon this benchmark.
- *Advanced Magnetic Cooler Components* - An example of an advanced magnetic cooler might be Adiabatic Demagnetization Refrigeration systems. Specific components sought include:
 - Low current superconducting magnets.
 - Active/Passive magnetic shielding (3-4 Tesla magnets).
 - Superconducting leads (10K - 90K) capable of 10 amp operation with 1 mW conduction.
 - 10 mK scale thermometry.
- *Continuous Flow Distributed Cooling Systems* - Distributed cooling provides increased lifetime of cryogen fluids for applications on both the ground and spaceborne platforms. This has impacts on payload mass and volume for flight systems which translate into costs (either on the ground, during launch or in flight). Cooling systems that provide continuous distributed flow are a cost effective alternative to present techniques/methodologies. Cooling systems that can be used with large loads and/or deployable structures are presently being sought after.
- *Heat Switches* - Current heat switches require detailed procedures for operational repeatability. More robust (performance wise) heat switches are currently needed for ease of operation when used with space flight applications.

- *Highly Efficient Magnetic and Dilution Cooling Technologies* - The desired temperature range for proposed systems is < 1K. Presently, systems with performance capabilities on this scale are limited to continuous ADRs. Alternative systems and/or technologies are desired.
- *Low Temperature/Input Power Cooling Systems* - Cooling systems providing cooling capacities approximately 0.3W at 35K with heat rejection capability to temperature sinks upwards of 150K are of interest. Presently there are no cooling systems operating at this heat rejection temperature. Input powers should be limited to no greater than 20W. Study of passive cooler in tandem with low power, low mass cryocooler satisfying the above mentioned requirements is also of interest.

S1.07 In Situ Sensors and Sensor Systems for Lunar and Planetary Science

Lead Center: JPL

Participating Center(s): ARC, GRC, GSFC, JSC, KSC, LaRC, MSFC

OCT Technology Area: [TA08](#)

This subtopic solicits development of advanced instrument technologies and components suitable for deployment on planetary and lunar missions. These technologies must be capable of withstanding operation in space and planetary environments, including the expected pressures, radiation levels, launch and impact stresses, and range of survival and operational temperatures. Technologies that reduce mass, power, volume, and data rates for instruments and instrument components without loss of scientific capability are of particular importance. In addition, technologies that can increase instrument resolution and sensitivity or achieve new & innovative scientific measurements are solicited. For example missions, see (<http://science.hq.nasa.gov/missions>). For details of the specific requirements see the National Research Council's, Vision and Voyages for Planetary Science in the Decade 2013-2022 (<http://solarsystem.nasa.gov/2013decadal/>). Technologies that support NASA's New Frontiers and Discovery missions to various planetary bodies are of top priority.

In situ technologies are being sought to achieve much higher resolution and sensitivity with significant improvements over existing technologies. Orbital sensors and technologies that can provide significant improvements over previous orbital missions are also sought. Specifically, this subtopic solicits instrument development that provides significant advances in the following areas, broken out by planetary body:

- *Mars* - Sub-systems relevant to current in situ instrument needs (e.g., lasers and other light sources from UV to microwave, X-ray and ion sources, detectors, mixers, mass analyzers, etc.) or electronics technologies (e.g., FPGA and ASIC implementations, advanced array readouts, miniature high voltage power supplies). Technologies that support high precision in situ measurements of elemental, mineralogical, and organic composition of planetary materials are sought. Conceptually simple, low risk technologies for in situ sample extraction and/or manipulation including fluid and gas storage, pumping, and chemical labeling to support analytical instrumentation. Seismometers, mass analyzers, technologies for heat flow probes, and atmospheric trace gas detectors. Improved robustness and g-force survivability for instrument components, especially for geophysical network sensors, seismometers, and advanced detectors (iCCDs, PMT arrays, etc.). Instruments geared towards rock/sample interrogation prior to sample return are desired.
- *Europa & Io* - Technologies for high radiation environments, e.g., radiation mitigation strategies, radiation tolerant detectors, and readout electronic components, which enable orbiting instruments to be both radiation-hard and undergo the planetary protection requirements of sterilization (or equivalent) for candidate instruments on the Europa-Jupiter System Mission (JEO) and Io Observer are sought.
- *Titan* - Low mass and power sensors, mechanisms and concepts for converting terrestrial instruments such as turbidimeters and echo sounders for lake measurements, weather stations, surface (lake and solid) properties packages, etc. to cryogenic environments (95K). Mechanical and electrical components and subsystems that work in cryogenic (95K) environments; sample extraction from liquid methane/ethane, sampling from organic 'dunes' at 95K and robust sample preparation and handling mechanisms that feed into mass analyzers are sought. Balloon instruments, such as IR spectrometers, imagers, meteorological instruments, radar sounders, air sampling mechanisms for mass analyzers, and aerosol detectors are also solicited.
- *Venus* - Sensors, mechanisms, and environmental chamber technologies for operation in Venus's high temperature, high-pressure environment with its unique atmospheric composition. Approaches that can

enable precision measurements of surface mineralogy and elemental composition and precision measurements of trace species, noble gases and isotopes in the atmosphere are particularly desired.

- *Small Bodies* - Technologies that can enable sampling from asteroids and from depth in a comet nucleus, improved in situ analysis of comets. Also, imagers and spectrometers that provide high performance in low light environments.
- *Saturn, Uranus and Neptune* - Technologies are sought for components, sample acquisition and instrument systems that can enhance mission science return and withstand the low-temperatures/high-pressures of the atmospheric probes during entry.
- *The Moon* - This solicitation seeks advancements in the areas of compact, light-weight, low power instruments geared towards in situ lunar surface measurements, geophysical measurements, lunar atmosphere and dust environment measurements & regolith particle analysis, lunar resource identification, and/or quantification of potential lunar resources (e.g., oxygen, nitrogen, and other volatiles, fuels, metals, etc.). Specifically, advancements geared towards instruments that enable elemental or mineralogy analysis (such as high-sensitivity X-ray and UV-fluorescence spectrometers, UV/fluorescence flash lamp/camera systems, scanning electron microscopy with chemical analysis capability, time-of-flight mass spectrometry, gas chromatography and tunable diode laser sensors, calorimetry, laser-Raman spectroscopy, imaging spectroscopy, and LIBS) are sought. These developments should be geared towards sample interrogation, prior to possible sample return. Systems and subsystems for seismometers and heat flow sensors capable of long-term continuous operation over multiple lunar day/night cycles with improved sensitivity at lower mass and reduced power consumption are sought. Also of interest are portable surface ground penetrating radars to characterize the thickness of the lunar regolith, as well as, low mass, thermally stable hollow cubes and retro-reflector array assemblies for lunar surface laser ranging. Of secondary importance are instruments that measure the micrometeoroid and lunar secondary ejecta environment, plasma environment, surface electric field, secondary radiation at the lunar surface, and dust concentrations and its diurnal dynamics are sought. Further, lunar regolith particle analysis techniques are desired (e.g., optical interrogation or software development that would automate integration of suites of multiple back scatter electron images acquired at different operating conditions, as well as permit integration of other data such as cathodoluminescence and energy-dispersive X-ray analysis.)

Proposers are strongly encouraged to relate their proposed development to:

- NASA's future planetary exploration goals.
- Existing flight instrument capability, to provide a comparison metric for assessing proposed improvements.

Proposed instrument architectures should be as simple, reliable, and low risk as possible while enabling compelling science. Novel instrument concepts are encouraged particularly if they enable a new class of scientific discovery. Technology developments relevant to multiple environments and platforms are also desired.

Proposers should show an understanding of relevant space science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S1.08 Airborne Measurement Systems

Lead Center: GSFC

Participating Center(s): ARC, JPL, KSC, LaRC, MSFC, SSC

OCT Technology Area: [TA08](#)

A focus is on miniaturization and increased sensitivity/performance needed to support for NASA's airborne science missions. Linkage to other subtopics such as S3.05 Unmanned Aircraft and Sounding Rocket Technologies is encouraged. Complete instrument systems are desired, including features such as remote/unattended operation and data acquisition, low power consumption, and minimum size and weight.

Relevance to future space missions such as Active Sensing of CO₂ Emissions over Nights, Days, and Seasons (ASCENDS), Orbiting Carbon Observatory-2 (OCO-2), Global Precipitation Measurement (GPM), Geostationary Coastal and Air Pollution Events (GEO-CAPE), etc., is important, yet early adoption for alternative uses by NASA, other agencies, or industry is recognized as a viable path towards full maturity. Additionally, sensor system

innovations with significant near-term commercial potential that may be suitable for NASA's research after full development, are of interest:

- Precipitation (multiphase).
- Surface snow thickness (5 cm resolution is desired), and potentially, snow density.
- Aerosols and cloud particles.
- Volcanic ash and gases.
- Gases: Reactive and tracers of source emissions. Examples include (but are not limited to) carbon dioxide, carbon monoxide, methane, water vapor.
- High quality three-dimensional wind instruments suitable for gas flux measurements, as well as advanced temperature and pressure systems.

S1.09 Surface & Sub-surface Measurement Systems

Lead Center: GSFC

Participating Center(s): ARC, JPL, KSC, LaRC, MSFC, SSC

OCT Technology Area: [TA08](#)

For ground-based surface vehicles, and submerged systems. Systems that are ultimately intended for flight or mobile platforms that will provide near-term benefit in a ground-based application are in scope, as this step will aid in maturation of new concepts.

Relevance to future space missions such as Active Sensing of CO₂ Emissions over Nights, Days, and Seasons (ASCENDS), Orbiting Carbon Observatory – 2 (OCO-2), Global Precipitation Measurement (GPM), Geostationary Coastal and Air Pollution Events (GEO-CAPE), etc., is important, yet early adoption for alternative uses by NASA, other agencies, or industry is recognized as a viable path towards full maturity. Additionally, sensor system innovations with significant near-term commercial potential that may be suitable for NASA's research after full development are of interest:

- Precipitation (e.g., stabilized disdrometer).
- Particles: mineral, biogenic, nutrients.
- Gases – carbon dioxide, methane, etc.
- Air and water quality.
- Water and ice flow rates.
- Seismic monitoring.
- Autonomous sample collection and/or analysis systems.
- Air-dropped sensors for surface and subsurface measurements such as conductivity, temperature, and depth. Miniature systems suitable for penetration of thin ice are highly desirable.
- Multi-wavelength lidar-based atmospheric ozone and aerosol profilers for continuous, simultaneous observations from multiple sites. Examples include three-band ozone measurement systems operating in the UV spectrum (e.g., 280-316 nm, possibly tunable), combined with visible or infrared systems for aerosols. Remote/untended operation, minimum eye-hazards, and portability are desired.
- Oceanic, coastal, and fresh water measurements including inherent and apparent optical properties for calibration and validation of satellite ocean color radiometric data, temperature, salinity, currents, in situ biogeochemical and chemical particle composition, sediments, and biological or ecological properties of aquatic environments including but not limited to nutrients, phytoplankton and their functional groups, harmful algal blooms, fish or aquatic plants and animals.
- Novel geophysical and diagnostic instruments suitable for ecosystem monitoring. Fielding for NASA's Applications and Earth Science Research activities is a primary goal. Innovations with future utility for other NASA programs (for example, Planetary Research) that can be matured in a Earth science role are also encouraged.

TOPIC: S2 Advanced Telescope Systems

The NASA Science Missions Directorate seeks technology for cost-effective high-performance advanced space telescopes for astrophysics and Earth science. Astrophysics applications require large aperture light-weight highly reflecting mirrors, deployable large structures and innovative metrology, control of unwanted radiation for high-contrast optics, precision formation flying for synthetic aperture telescopes, and cryogenic optics to enable far infrared telescopes. A few of the new astrophysics telescopes and their subsystems will require operation at cryogenic temperatures as cold as 4-degrees Kelvin. This topic will consider technologies necessary to enable future telescopes and observatories collecting electromagnetic bands, ranging from UV to millimeter waves, and also include gravity waves. The subtopics will consider all technologies associated with the collection and combination of observable signals. Earth science requires modest apertures in the 2 to 4 meter size category that are cost effective. New technologies in innovative mirror materials, such as silicon, silicon carbide and nanolaminates, innovative structures, including nanotechnology, and wavefront sensing and control are needed to build telescopes for Earth science.

S2.01 Proximity Glare Suppression for Astronomical Coronagraphy

Lead Center: JPL

Participating Center(s): ARC, GSFC

OCT Technology Area: [TA08](#)

This subtopic addresses the unique problem of imaging and spectroscopic characterization of faint astrophysical objects that are located within the obscuring glare of much brighter stellar sources. Examples include planetary systems beyond our own, the detailed inner structure of galaxies with very bright nuclei, binary star formation, and stellar evolution. Contrast ratios of one million to ten billion over an angular spatial scale of 0.05-1.5 arcsec are typical of these objects. Achieving a very low background requires control of both scattered and diffracted light. The failure to control either amplitude or phase fluctuations in the optical train severely reduces the effectiveness of starlight cancellation schemes.

This innovative research focuses on advances in coronagraphic instruments, starlight cancellation instruments, and potential occulting technologies that operate at visible and near infrared wavelengths. The ultimate application of these instruments is to operate in space as part of a future observatory mission. Measurement techniques include imaging, photometry, spectroscopy, and polarimetry. There is interest in component development, and innovative instrument design, as well as in the fabrication of subsystem devices to include, but not limited to, the following areas:

Starlight Suppression Technologies

- Advanced aperture apodization and aperture shaping techniques.
- Advanced apodization mask or occulting spot fabrication technology controlling smooth density gradients to 10^{-4} with spatial resolutions $\sim 1 \mu\text{m}$, low dispersion, and low dependence of phase on optical density, in linear and circular patterns.
- Metrology for detailed evaluation of compact, deep density apodizing masks, Lyot stops, and other types of graded and binary mask elements. Development of a system to measure spatial optical density, phase inhomogeneity, scattering, spectral dispersion, thermal variations, and to otherwise estimate the accuracy of masks and stops is needed.
- Interferometric starlight cancellation instruments and techniques to include aperture synthesis and single input beam combination strategies.
- Pupil remapping technologies to achieve beam apodization.
- Techniques to characterize highly aspheric optics.
- Methods to distinguish the coherent and incoherent scatter in a broad band speckle field.
- Methods of polarization control and polarization apodization.
- Components and methods to insure amplitude uniformity in both coronagraphs and interferometers, specifically materials, processes, and metrology to insure coating uniformity.

- Coherent fiber bundles consisting of up to 10^4 fibers with lenslets on both input and output side, such that both spatial and temporal coherence is maintained across the fiber bundle for possible wavefront/amplitude control through the fiber bundle.

Wavefront Control Technologies

- Development of small stroke, high precision, deformable mirrors and associated driving electronics scalable to 104 or more actuators (both to further the state-of-the-art towards flight-like hardware and to explore novel concepts). Multiple deformable mirror technologies in various phases of development and processes are encouraged to ultimately improve the state-of-the-art in deformable mirror technology. Process improvements are needed to improve repeatability, yield, and performance precision of current devices.
- Development of instruments to perform broad-band sensing of wavefronts and distinguish amplitude and phase in the wavefront.
- Adaptive optics actuators, integrated mirror/actuator programmable deformable mirror.
- Reliability and qualification of actuators and structures in deformable mirrors to eliminate or mitigate single actuator failures.
- Multiplexer development for electrical connection to deformable mirrors that has ultra-low power dissipation.
- High precision wavefront error sensing and control techniques to improve and advance coronagraphic imaging performance.
- Development of techniques to improve the wavefront stability of the telescope beam, and/or to mitigate the residual instability. These include but are not limited to: the development of low order wavefront sensors, improved pointing techniques, as well as model-based software algorithms that predict and subtract the instabilities in post-processing.

Optical Coating and Measurement Technologies

- Instruments capable of measuring polarization cross-talk and birefringence to parts per million.
- Highly reflecting broadband coatings for large (> 1 m diameter) optics.
- Polarization-insensitive coatings for large optics.

Other

- Artificial star and planet, point sources, with $1e10$ dynamic range and uniform illumination of an $f/25$ optical system, working in the visible and near infrared.
- Deformable, calibrated, collimating source to simulate the telescope front end of a coronagraphic system undergoing thermal deformations.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S2.02 Precision Deployable Optical Structures and Metrology

Lead Center: JPL

Participating Center(s): GSFC, LaRC

OCT Technology Area: [TA08](#)

Planned future NASA Missions in astrophysics, such as the Wide-Field Infrared Survey Telescope (WFIRST) and the New Worlds Technology Development Program (coronagraph, external occulter and interferometer technologies) will push the state of the art in current optomechanical technologies. Mission concepts for New Worlds science would require 10 - 30 m class, cost-effective telescope observatories that are diffraction limited at wavelengths from the visible to the far IR, and operate at temperatures from 4 - 300 K. In addition, ground based telescopes such as the Cerro Chajnantor Atacama Telescope (CCAT) requires similar technology development.

The desired areal density is 1 - 10 kg/m² with a packaging efficiency of 3-10 deployed/stowed diameter. Static and dynamic wavefront error tolerances to thermal and dynamic perturbations may be achieved through passive means (e.g., via a high stiffness system, passive thermal control, jitter isolation or damping) or through active opto-mechanical control. Large deployable multi-layer structures in support of sunshades for passive thermal control and 20m to 50m class planet finding external occulters are also relevant technologies. Potential architecture implementations must package into an existing launch volume, deploy and be self-aligning to the micron level. The target space environment is expected to be the Earth-Sun L2.

This subtopic solicits proposals to develop enabling, cost effective component and subsystem technology for deploying large aperture telescopes with low cost. Research areas of interest include:

- Precision deployable structures and metrology for optical telescopes (e.g., innovative active or passive deployable primary or secondary support structures).
- Architectures, packaging and deployment designs for large sunshields and external occulters.

In particular, important subsystem considerations may include:

- Innovative concepts for packaging fully integrated subsystems (e.g., power distribution, sensing, and control components).
- Mechanical, inflatable, or other precision deployable technologies.
- Thermally-stable materials (CTE < 1ppm) for deployable structures.
- Innovative systems, which minimize complexity, mass, power and cost.
- Innovative testing and verification methodologies.

The goal for this effort is to mature technologies that can be used to fabricate 16 m class or greater, lightweight, ambient or cryogenic flight-qualified observatory systems. Proposals to fabricate demonstration components and subsystems with direct scalability to flight systems through validated models will be given preference. The target launch volume and expected disturbances, along with the estimate of system performance, should be included in the discussion. Proposals with system solutions for large sunshields and external occulters will also be accepted. A successful proposal shows a path toward a Phase II delivery of demonstration hardware scalable to 5 meter diameter for ground test characterization.

Before embarking on the design and fabrication of complex space-based deployable telescopes, additional risk reduction in operating an actively controlled telescope in orbit is desired. To be cost effective, deployable apertures that conform to a cubesat (up to 3-U) or ESPA format are desired. Consequently, deployment hinge and latching concepts, buildable for these missions and scaleable to larger systems are desired. Such a system should allow <25 micron deployment repeatability and sub-micron stability for both thermal and mechanical on-orbit disturbances. A successful proposal would deliver a full-scale cubesat or ESPA ring compatible deployable aperture with mock optical elements.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop the relevant subsystem technologies and to transition into future NASA program(s).

S2.03 Advanced Optical Component Systems

Lead Center: MSFC

Participating Center(s): GSFC, JPL

OCT Technology Area: [TA08](#)

This subtopic solicits solutions in the following areas:

- Optical Components, Coatings and Systems for potential X-ray missions.
- Optical Components, Coatings and Systems for potential UV/Optical missions.
- Large aperture diffusers (up to 1 meter) to calibrate GeoStationary Earth viewing sensors.

The 2010 National Academy Astro2010 Decadal Report specifically identifies optical components and coatings as key technologies needed to enable several different future missions, including:

- Light-weight X-ray imaging mirrors for future large advanced X-ray observatories.
- Large aperture, light-weight mirrors for future UV/Optical telescopes.
- Broadband high reflectance coatings for future UV/Optical telescopes.

The 2012 National Academy report “NASA Space Technology Roadmaps and Priorities” states that one of the top technical challenges in which NASA should invest over the next five years is developing a new generation of larger effective aperture, lower-cost astronomical telescopes that enable discovery of habitable planets, facilitate advances in solar physics, and enable the study of faint structures around bright objects. To enable this capability requires low-cost, ultra-stable, large-aperture, normal and grazing incidence mirrors with low mass-to-collecting area ratios. To enable these new astronomical telescopes, the report identifies three specific optical systems technologies:

- Active align/control of grazing-incidence imaging systems to achieve < 1 arc-second angular resolution.
- Active align/control of normal-incidence imaging systems to achieve 500 nm diffraction limit (40 nm rms wavefront error, WFE) performance.
- Normal incidence 4-meter (or larger) diameter 5 nm rms WFE (300 nm system diffraction limit) mirrors.

Finally, effecting potential space telescopes, NASA is developing a heavy lift space launch system (SLS). An SLS with an 8 to 10 meter fairing and 80 to 100 mt capacity to LEO would enable extremely large space telescopes. Potential systems include 12 to 30 meter class segmented primary mirrors for UV/optical or infrared wavelengths and 8 to 16 meter class segmented X-ray telescope mirrors. These potential future space telescopes have very specific mirror technology needs. UV/optical telescopes (such as ATLAST-9 or ATLAST-16) require 1 to 3 meter class mirrors with < 5 nm rms surface figures. IR telescopes (such as SAFIR/CALISTO) require 2 to 3 to 8 meter class mirrors with cryo-deformations < 100 nm rms. X-ray telescopes (such as GenX) require 1 to 2 meter long grazing incidence segments with angular resolution < 0.5 arc-sec and surface micro-roughness < 0.5 -nm rms.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

Technical Challenges

In all cases, the most important metric for an advanced optical system is affordability or areal cost (cost per square meter of collecting aperture). Currently both X-ray and normal incidence space mirrors cost \$4 million to \$6 million per square meter of optical surface area. This research effort seeks a cost reduction for precision optical components by 5 to 50 times, to less than \$1M to \$100K/m².

Successful proposals shall provide a scale-up roadmap (including processing and infrastructure issues) for full scale space qualifiable flight optics systems. Material behavior, process control, active and/or passive optical performance, and mounting/deploying issues should be resolved and demonstrated.

Optical Components, Coatings and Systems for potential X-ray missions

Potential X-ray missions require:

- X-ray imaging telescopes with < 1 arc-sec angular resolution and > 1 to 5 m² collecting area.
- Multilayer high-reflectance coatings for hard X-ray mirrors (similar to NuSTAR).
- X-ray transmission and/or reflection gratings.

Multiple technologies are needed to enable < 1 arc-sec X-ray telescopes. These include, but are not limited to: new mirror materials such as silicon carbide, porous silicon, beryllium; improved techniques to manufacture (such as direct precision machining, rapid optical fabrication, slumping or replication technologies) 0.3 to 2 meter mirror shells or segments; improved testing techniques; active alignment of mirrors in a telescope assembly; and active control of mirror shape.

For example, the Wide-Field X-Ray Telescope (WFXT) requires a 6 meter focal length X-ray mirror with 1 arc-sec resolution and 1 m² of collecting area. One implementation of this mirror has 71 concentric full shell hyperbola/parabola pairs whose diameters range from 0.3 to 1.0 meter and whose length is 150 to 240 mm (this length is split between the H/P pair). Total mass for the integrated mirror system (shells and structure) is < 1000 kg. For individual mirror shells, axial slope errors should be ~ 1 arc-sec rms (~100 nm rms figure error for 20 mm spatial frequencies) and surface finish should be < 0.5 nm rms.

Successful proposals will demonstrate an ability to manufacture, test and control a prototype X-ray mirror assembly in the 0.25 to 0.5 meter class; or to coat a 0.25 to 0.5 meter class representative optical component. An ideal Phase I deliverable would deliver a sub-scale component such as a 0.25 meter X-ray precision mirror. An ideal Phase II project would further advance the technology to produce a space-qualifiable 0.5 meter mirror, with a TRL in the 4 to 5 range. Both deliverables would be accompanied by all necessary documentation, including the optical performance assessment and all data on processing and properties of its substrate materials. The Phase II would also include a mechanical and thermal stability analysis.

Optical Components, Coatings and Systems for potential UV/Optical missions

Potential UV/Optical missions require:

- Large aperture, light-weight mirrors.
- Broadband high reflectance coatings.

Future UVOIR missions require 4 to 8 or 16 meter monolithic or segmented primary mirrors with < 10 nm rms surface figures. Mirror areal density depends upon available launch vehicle capacities to Sun-Earth L2 (i.e., 15 kg/m² for a 5 m fairing EELV vs. 60 kg/m² for a 10 m fairing SLS). Additionally, future UVOIR missions require high-reflectance mirror coatings with spectral coverage from 100 to 2500 nm and extremely uniform amplitude and polarization properties.

Successful proposals will demonstrate an ability to manufacture, test and control ultra-low-cost precision 0.25 to 0.5 meter optical systems; or to coat a 0.25 to 0.5 meter representative optical component. Potential solutions include, but are not limited to, new mirror materials such as silicon carbide, nanolaminates or carbon-fiber reinforced polymer; new fabrication processes such as direct precision machining, rapid optical fabrication, roller embossing at optical tolerances, slumping or replication technologies to manufacture 1 to 2 meter (or larger) precision quality mirrors or lens segments. Solutions include reflective, transmissive, diffractive or high order diffractive blazed lens optical components for assembly of large (16 to 32 meter) optical quality primary elements.

Potential solutions to improve UV reflective coatings include, but are not limited to, investigations of new coating materials with promising UV performance; new deposition processes; and examination of handling processes, contamination control, and safety procedures related to depositing coatings, storing coated optics, and integrating coated optics into flight hardware. An ability to demonstrate optical performance on 2 to 3 meter class optical surfaces is important.

An ideal Phase I deliverable would be a precision mirror of at least 0.25 meters; or a coated mirror of at least 0.25 meters. An ideal Phase II project would further advance the technology to produce a space-qualifiable mirror greater than 0.5 meters, with a TRL in the 4 to 5 range. Both deliverables would be accompanied by all necessary documentation, including the optical performance assessment and all data on processing and properties of its substrate materials. The Phase II would also include a mechanical and thermal stability analysis.

Large aperture diffusers (up to 1 meter) to calibrate GeoStationary Earth viewing sensors

The geosynchronous orbit for GEO-CAPE coastal ecosystem imager requires technology for alternative periodic solar calibration strategies including new materials to reduce weight, and new optical analysis to reduce the size of calibration systems. GEO-CAPE will need a light-weight large aperture (greater than 0.5 m) diffuse solar calibrator, employing multiple diffusers to track on-orbit degradation. Typical materials of interest are PTFE (such as Spectralon® surface diffuser) or development of new Mie scattering materials for use as volume diffusers in

transmission or reflection. Material needs to be stable in BTDF/BSDF to 2%/year from 250 to 2500 nm and highly lambertian (no formal specification for deviation from lambertian).

S2.04 Optics Manufacturing and Metrology for Telescope Optical Surfaces

Lead Center: GSFC

Participating Center(s): JPL, MSFC

OCT Technology Area: [TA08](#)

This subtopic focuses primarily on manufacturing and metrology of optical surfaces, especially for very small or very large and/or thin optics. Missions of interest include:

- WFIRST concepts (<http://wfirst.gsfc.nasa.gov/>).
- NGXO (<http://ixo.gsfc.nasa.gov/>).
- SGO (<http://lisa.gsfc.nasa.gov/>).
- ATLAST (<http://www.stsci.edu/institute/atlast/>).

Optical systems currently being researched for these missions are large area aspheres, requiring accurate figuring and polishing across six orders of magnitude in period. Technologies are sought that will enhance the figure quality of optics in any range as long as the process does not introduce artifacts in other ranges. For example, mm-period polishing should not introduce waviness errors at the 20 mm or 0.05 mm periods in the power spectral density. Also, novel metrological solutions that can measure figure errors over a large fraction of the PSD range are sought, especially techniques and instrumentation that can perform measurements while the optic is mounted to the figuring/polishing machine. Large lightweight monolithic metallic aspheres manufactured using innovative mirror substrate materials that can be assembled and welded together from smaller segments are sought. Also, optical system design and tolerancing requires software analysis tools capable of accurately ray tracing a broader range of materials and effects than are currently treated with conventional optical software. Updated software algorithms code is a technology of interest.

By the end of a Phase II program, technologies must be developed to the point where the technique or instrument can dovetail into an existing optics manufacturing facility producing optics at the R&D stage. Metrology instruments should have 10 nm or better surface height resolution and span at least 3 orders of magnitude in lateral spatial frequency.

Examples of technologies and instruments of interest include:

- Innovative metal mirror substrate materials or manufacturing methods such as welding component segments into one monolith that produce thin mirror substrates that are stiffer and/or lighter than existing materials or methods.
- Interferometric nulling optics for very shallow conical optics used in X-ray telescopes.
- Segmented systems commonly span 60 ° in azimuth and 200 mm axial length and cone angles vary from 0.1 to 1 °.
- Low stress metrology mounts that can hold very thin optics without introducing mounting distortion.
- Low normal force figuring/polishing systems operating in the 1 mm to 50 mm period range with minimal impact at significantly smaller and larger period ranges.
- In-situ metrology systems that can measure optics and provide feedback to figuring/polishing instruments without removing the part from the spindle.
- Innovative mirror substrate materials or manufacturing methods that produce thin mirror substrates that are stiffer and/or lighter than existing materials or methods.
- Extreme aspheric and/or anamorphic optics for pupil intensity amplitude apodization.
- Metrology systems useful for measuring large optics with high precision.
- Innovative method of bonding extremely lightweight (less than 1 kg/m² areal density) and thin (less than 1 mm) mirrors to a housing structure, preserving both alignment and figure.
- Innovative method of improving the figure of extremely lightweight and thin mirrors without polishing, such as using the coating stress.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

TOPIC: S3 Spacecraft and Platform Subsystems

The Science Mission Directorate will carry out the scientific exploration of our Earth, the planets, moons, comets, and asteroids of our solar system and the universe beyond. SMD's future direction will be moving away from exploratory missions (orbiters and flybys) into more detailed/specific exploration missions that are at or near the surface (landers, rovers, and sample returns) or at more optimal observation points in space. These future destinations will require new vantage points, or would need to integrate or distribute capabilities across multiple assets. Future destinations will also be more challenging to get to, have more extreme environmental conditions and challenges once the spacecraft gets there, and may be a challenge to get a spacecraft or data back from. A major objective of the NASA science spacecraft and platform subsystems development efforts are to enable science measurement capabilities using smaller and lower cost spacecraft to meet multiple mission requirements thus making the best use of our limited resources. To accomplish this objective, NASA is seeking innovations to significantly improve spacecraft and platform subsystem capabilities while reducing the mass and cost, which would in turn enable increased scientific return for future NASA missions. A spacecraft bus is made up of many subsystems like:

- Propulsion.
- Thermal control.
- Power and power distribution.
- Attitude control.
- Telemetry command and control.
- Transmitters/antenna.
- Computers/on-board processing/software.
- Structural elements.

Science platforms of interest could include unmanned aerial vehicles, sounding rockets, or balloons that carry scientific instruments/payloads, to planetary ascent vehicles or Earth return vehicles that bring samples back to Earth for analysis. This topic area addresses the future needs in many of these sub-system areas, as well as their application to specific spacecraft and platform needs. For planetary missions, planetary protection requirements vary by planetary destination, and additional backward contamination requirements apply to hardware with the potential to return to Earth (e.g., as part of a sample return mission). Technologies intended for use at/around Mars, Europa (Jupiter), and Enceladus (Saturn) must be developed so as to ensure compliance with relevant planetary protection requirements. Constraints could include surface cleaning with alcohol or water, and/or sterilization treatments such as dry heat (approved specification in NPR 8020.12; exposure of hours at 115 °C or higher, non-functioning); penetrating radiation (requirements not yet established); or vapor-phase hydrogen peroxide (specification pending). Innovations for 2012 are sought in the areas of:

- Command and Data Handling, and Instrument Electronics.
- Power Generation and Conversion - Propulsion Systems.
- Power Electronics and Management, and Energy Storage.
- Unmanned Aircraft and Sounding Rocket Technologies.

Significant changes to the S3 Topic for 2011 are that the following areas will not be solicited in 2012, but may be solicited again in the 2013:

- Thermal Control Systems - Guidance, Navigation and Control.
- Terrestrial and Planetary Balloons.

The following references discuss some of NASA's science mission and technology needs:

- The Astrophysics Roadmap: (<http://nasascience.nasa.gov/about-us/science-strategy>).
- Astrophysics Decadal Survey - “New Worlds, New Horizons: in Astronomy and Astrophysics”: (http://www.nap.edu/catalog.php?record_id=12951).
- The Earth Science Decadal Survey: (http://books.nap.edu/catalog.php?record_id=11820).
- The Heliophysics roadmap: “The Solar and Space Physics of a New Era: Recommended Roadmap for Science and Technology 2009-2030”: (http://sec.gsfc.nasa.gov/2009_Roadmap.pdf).
- The 2011 Planetary Science Decadal Survey was released March 2011. This decadal survey is considering technology needs. (http://sites.nationalacademies.org/SSB/currentprojects/SSB_052412).

S3.01 Command, Data Handling, and Electronics

Lead Center: GSFC

Participating Center(s): JPL, LaRC

OCT Technology Area: [TA11](#)

NASA's space-based observatories, fly-by spacecraft, orbiters, landers, and robotic and sample return missions require robust command and control capabilities. Advances in technologies relevant to command and data handling and instrument electronics are sought to support NASA's goals and several missions and projects under development.

The subtopic goals are to:

- Develop high-performance processors, memory architectures, and reliable electronic systems.
- Develop tools and technologies that would enable rapid deployment of high-reliability, high-performance onboard processing applications and would interface to external sensors on flight hardware.

The subtopic objective is to elicit novel architectural concepts and component technologies that are realistic and operate effectively and credibly in environments consistent with the future NASA science missions.

However, it is also expected that some commercial non-radiation hardened, higher performance capabilities should also be leveraged to meet performance, fault tolerance and recovery, power management, or other unique requirements.

Successful proposal concepts should significantly advance the state-of-the-art. Proposals should clearly:

- State what the product is.
- Identify the needs it addresses.
- Identify the improvements over the current state-of-the-art.
- Outline the feasibility of the technical and programmatic approach.
- Present how it could be infused into a NASA program.

Furthermore, proposals should indicate an understanding of the intended operating environment, including temperature and radiation. It should be noted that environmental requirements will vary significantly from mission to mission. For example, some low Earth orbit missions have a total ionizing dose (TID) radiation requirement of less than 10 krad(Si), while some planetary missions can have requirements well in excess of 1 Mrad(Si). For descriptions of radiation effects in electronics, the proposer may visit:

(<http://radhome.gsfc.nasa.gov/radhome/overview.htm>).

If a Phase II proposal is awarded, the combined Phase I and Phase II developments should produce a prototype that can be characterized by NASA.

The technology priorities sought are listed below:

- Novel, ruggedized packaging/Interconnect for high-density packaging (enclosures, printed wiring boards) enabling miniaturization.

- Miniaturization of C&DH subsystem components that enable reduced power computing.
- Innovative approaches for single event effects mitigation technologies leveraging non-RHBD (Radiation Hardened By Design) devices for performance (speed, power, mass) that is capable of exceeding traditional RHBD devices and/or capabilities that are not yet available with RHBD devices. Area of interest for this year is to focus on processors.

Power Conversion and Distribution relevant to Command, Data Handling, and Electronics, will be covered in sub-topic S3.04 Power Electronics and Management, and Energy Storage.

S3.02 Power Generation and Conversion

Lead Center: GRC

Participating Center(s): ARC, GSFC, JPL, JSC, MSFC

OCT Technology Area: [TA03](#)

Future NASA science missions will employ Earth orbiting spacecraft, planetary spacecraft, balloons, aircraft, surface assets, and marine craft as observation platforms. Proposals are solicited to develop advanced power-generation and conversion technologies to enable or enhance the capabilities of future science missions. Requirements for these missions are varied and include long life, high reliability, significantly lower mass and volume, higher mass specific power, and improved efficiency over the state of practice for components and systems. Other desired capabilities are high radiation tolerance and the ability to operate in extreme environments (high and low temperatures and over wide temperature ranges).

While power-generation technology affects a wide range of NASA missions and operational environments, technologies that provide substantial benefits for key mission applications/capabilities are being sought in the following areas:

Radioisotope Power Conversion

Radioisotope technology enables a wide range of mission opportunities, both near and far from the Sun and hostile planetary environments including high energy radiation, both high and low temperature and diverse atmospheric chemistries. Technology innovations capable of advancing lifetimes, improving efficiency, highly tolerant to hostile environments are desired for all thermal to electric conversion technologies considered here. Specific systems of interest for this solicitation are listed below:

Stirling Power Conversion: advances in, but not limited to, the following:

- System specific mass greater than 10 We/kg.
- Highly reliable autonomous control.

Thermoelectric Power Conversion: advances in, but not limited to, the following:

- High temperature, high efficiency conversion greater than 10%.
- Long life, minimal degradation.

Photovoltaic Energy Conversion

Photovoltaic cell, blanket, and array technologies that lead to significant improvements in overall solar array performance (i.e., conversion efficiency >33%, array mass specific power >300watts/kilogram, decreased stowed volume, reduced initial and recurring cost, long-term operation in high radiation environments, high power arrays, and a wide range of space environmental operating conditions) are solicited. Technologies specifically addressing the following mission needs are highly sought:

- Photovoltaic cell and blanket technologies capable of low intensity, low-temperature operation applicable to outer planetary (low solar intensity) missions.

- Photovoltaic cell, blanket and array technologies capable of enhancing solar array operation in a high intensity, high-temperature environment (i.e., inner planetary and solar probe-type missions).
- Lightweight solar array technologies applicable to solar electric propulsion missions. Current missions being studied require solar arrays that provide 1 to 20 kilowatts of power at 1 AU, are greater than 300 watts/kilogram specific power, can operate in the range of 0.7 to 3 AU, provide operational array voltages up to 300 volts and have a low stowed volume.

Note to Proposer: Topic H8 under the Human Exploration and Operations Mission Directorate also addresses power. Proposals more aligned with very high power or with exploration mission requirements should be proposed in H8.

S3.03 Propulsion Systems

Lead Center: GRC

Participating Center(s): JPL, MSFC

OCT Technology Area: [TA02](#)

The Science Mission Directorate (SMD) needs spacecraft with more demanding propulsive performance and flexibility for more ambitious missions requiring high duty cycles, more challenging environmental conditions, and extended operation. Planetary spacecraft need the ability to rendezvous with, orbit, and conduct in situ exploration of planets, moons, and other small bodies in the solar system (http://solarsystem.nasa.gov/multimedia/download-detail.cfm?DL_ID=742). Future spacecraft and constellations of spacecraft will have high-precision propulsion requirements, usually in volume- and power-limited envelopes.

This subtopic seeks innovations to meet SMD propulsion requirements, which are reflected in the goals of NASA's In-Space Propulsion Technology program to reduce the travel time, mass, and cost of SMD spacecraft. Advancements in chemical and electric propulsion systems related to sample return missions to Mars, small bodies (like asteroids, comets, and Near-Earth Objects), outer planet moons, and Venus are desired. Additional electric propulsion technology innovations are also sought to enable low cost systems for Discovery class missions, and eventually to enable radioisotope electric propulsion (REP) type missions. Roadmaps for propulsion technologies can be found from the National Research Council (http://www.nap.edu/openbook.php?record_id=13354&page=168) and NASA's Office of the Chief Technologist (http://www.nasa.gov/pdf/501329main_TA02-InSpaceProp-DRAFT-Nov2010-A.pdf).

The focus of this solicitation is for next generation propulsion systems and components, including chemical rocket technologies, low cost/low mass electric propulsion technologies, and micro-propulsion. Propulsion technologies related specifically to sample return vehicles will be sought under S5.04 Spacecraft Technology for Sample Return Missions. Propulsion technologies related specifically to Power Processing Units will be sought under S3.04 Power Electronics and Management, and Energy Storage

Chemical Propulsion Systems

Technology needs include:

- Alternative manufacturing processes for low cost production of components of propulsion systems less than 200 lbf class.
- Catalytic and non-catalytic ignition technologies that provide reliable long-life ignition of high-performance ($I_{sp} > 240$ sec), toxic and nontoxic monopropellants.

Electric Propulsion Systems

This subtopic also seeks proposals that explore uses of technologies that will provide superior performance in for high specific impulse/low mass electric propulsion systems at low cost. These technologies include:

- Long-life thrusters and related system components with efficiencies $> 55\%$ and up to 1 kW of input power that operate with a specific impulse between 1600 to 3500 seconds.

- Any electric propulsion technology under 10 kW/thruster that would either significantly reduce system costs or increase system efficiency over a wide throttling range.

Micro-Propulsion Systems

This subtopic also seeks proposals that address the propulsion for spacecraft <180 kg. It is desired that the capability of plane-changing or de-orbiting in a timely manner be achieved. These system or component technologies would likely be:

- Low mass and low volume fractions.
- Wide range of ΔV capability to provide 100-1000s of m/s.
- Wide range of specific impulses up to 1000s of seconds.
- Precise thrust vectoring and low vibration for precision maneuvering.
- Efficient use of onboard resources (i.e., high power efficiency and simplified thermal and propellant management).
- Affordability.
- Safety for users and primary payloads.

Proposals should show an understanding of the state of the art, how their technology is superior, and of one or more relevant science needs. The proposals should provide a feasible plan to fully develop a technology and infuse it into a NASA program.

Note to Proposer: Topic H2 under the Human Exploration and Operations Directorate also addresses advanced propulsion. Proposals more aligned with exploration mission requirements should be proposed in H2.

S3.04 Power Electronics and Management, and Energy Storage

Lead Center: GRC

Participating Center(s): ARC, GSFC, JPL, JSC

OCT Technology Area: [TA03](#)

Future NASA science objectives will include missions such as Earth Orbiting, Venus, Europa, Titan/Enceladus Flagship, Lunar Quest and Space Weather. Under this subtopic, proposals are solicited to develop energy storage and power electronics to enable or enhance the capabilities of future science missions. The unique requirements for the power systems for these missions can vary greatly, with advancements in components needed above the current State of the Art (SOA) for high energy density, high power density, long life, high reliability, low mass/volume, radiation tolerance, and wide temperature operation. Other subtopics that could potentially benefit from these technology developments include S4.01 – Planetary Entry, Descent and Landing Technology. Battery development could also be beneficial to H8.02 – Ultra High Specific Energy Batteries, which is investigating some similar technologies in the secondary battery area but with very different operational requirements. This subtopic is also directly tied to S3.03 – Propulsion Systems for the development of advanced Power Processing Units and associated components.

Power Electronics and Management

The 2009 Heliophysics roadmap (http://sec.gsfc.nasa.gov/2009_Roadmap.pdf), the 2010 SMD Science Plan (<http://science.nasa.gov/about-us/science-strategy/>), the 2010 Planetary Decadal Survey White Papers & Roadmap Inputs (http://sites.nationalacademies.org/SSB/CurrentProjects/ssb_052412), the 2011 PSD Relevant Technologies document, the 2006 Solar System Exploration (SSE) Roadmap (<http://nasascience.nasa.gov/about-us/science-strategy>), and the 2003 SSE Decadal Survey describe the need for lighter weight, lower power electronics along with radiation hardened, extreme environment electronics for planetary exploration. Radioisotope power systems (RPS) and Power Processing Units (PPUs) for Electric Propulsion (EP) are two programs of interest that would directly benefit from advancements in this technology area. Advances in electrical power technologies are required for the electrical components and systems for these future platforms to address program size, mass, efficiency, capacity, durability, and reliability requirements. In addition, the Outer Planet Assessment Group has called out high power density/high efficiency power electronics as needs for the Titan/Enceladus Flagship and planetary exploration

missions. These types of missions, including Mars Sample Return using Hall thrusters and PPUs, require advancements in radiation hardened power electronics and systems beyond the state-of-the-art. Of importance are expected improvements in energy density, speed, efficiency, or wide-temperature operation (-125 °C to over 450 °C) with a number of thermal cycles. Novel approaches to minimizing the weight of advanced PPUs are also of interest. Advancements are sought for power electronic devices, components and packaging for programs with power ranges of a few watts for minimum missions to up to 20 kilowatts for large missions. In addition to electrical component development, RPS has a need for intelligent, fault-tolerant Power Management And Distribution (PMAD) technologies to efficiently manage the system power for these deep space missions.

SMD's In-space Propulsion Technology and Radioisotope Power Systems programs are direct customers of this subtopic, and the solicitation is coordinated with the 2 programs each year.

Overall technologies of interest include:

- High voltage, radiation hardened, high temperature components.
- High power density/high efficiency power electronics.
- High temperature devices and components/power converters (up to 450 °C).
- Intelligent, fault-tolerant electrical components and PMAD systems.
- Advanced electronic packaging for thermal control and electromagnetic shielding.

Energy Storage

Future science missions will require advanced primary and secondary battery systems capable of operating at temperature extremes from -100 °C for Titan missions to 400 ° to 500 °C for Venus missions, and a span of -230 °C to +120 °C for Lunar Quest. The Outer Planet Assessment Group and the 2011 PSD Relevant Technologies Document have specifically called out high energy density storage systems as a need for the Titan/Enceladus Flagship and planetary exploration missions. In addition, high energy-density rechargeable electrochemical battery systems that offer greater than 50,000 charge/discharge cycles (10 year operating life) for low-earth-orbiting spacecraft, 20 year life for geosynchronous (GEO) spacecraft, are desired. Advancements to battery energy storage capabilities that address one or more of the above requirements for the stated missions combined with very high specific energy and energy density (>200 Wh/kg for secondary battery systems), along with radiation tolerance are of interest.

In addition to batteries, other advanced energy storage/load leveling technologies designed to the above mission requirements, such as flywheels, supercapacitors or magnetic energy storage, are of interest. These technologies have the potential to minimize the size and mass of future power systems.

Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II, and when possible, deliver a demonstration unit for NASA testing at the completion of the Phase II contract. Phase II emphasis should be placed on developing and demonstrating the technology under relevant test conditions. Additionally, a path should be outlined that shows how the technology could be commercialized or further developed into science-worthy systems.

A method for growing arrays of large-area device-size films of step-free (i.e., atomically flat) SiC surfaces for semiconductor electronic device applications is disclosed. This method utilizes a lateral growth process that better overcomes the effect of extended defects in the seed crystal substrate that limited the obtainable step-free area achievable by prior art processes. The step-free SiC surface is particularly suited for the heteroepitaxial growth of 3C (cubic) SiC, AlN, and GaN films used for the fabrication of both surface-sensitive devices (i.e., surface channel field effect transistors such as HEMT's and MOSFET's) as well as high-electric field devices (pn diodes and other solid-state power switching devices) that are sensitive to extended crystal defects.

S3.05 Unmanned Aircraft and Sounding Rocket Technologies

Lead Center: GSFC

Participating Center(s): ARC, DFRC, GRC, JPL, KSC, LaRC

OCT Technology Area: [TA04](#)

All proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

Unmanned Aircraft Systems

Unmanned Aircraft Systems (UAS) offer significant potential for Suborbital Scientific Earth Exploration Missions over a very large range of payload complexities, mission durations, altitudes, and extreme environmental conditions. To more fully realize the potential improvement in capabilities for atmospheric sampling and remote sensing, new technologies are needed. Scientific observation and documentation of environmental phenomena on both global and localized scales that will advance climate research and monitoring; e.g., U.S. Global Change Research Program as well as Arctic and Antarctic research activities (Ice Bridge, etc.).

NASA is increasing scientific participation to understand impacts associated with worldwide environmental changes. Capability for suborbital unmanned flight operations in either the North or South Polar Regions are limited because of technology gaps for remote telemetry capabilities and precision flight path control requirements. It is also highly desirable to have UAS ability to perform atmospheric and surface sampling.

Telemetry, Tracking and Control

Low cost over-the-horizon global communications and networks are needed. Efficient and cost effective systems that enable unmanned collaborative multi-platform Earth observation missions are desired.

Avionics and Flight Control

Precise/repeatable flight path control capabilities are needed to enable repeat path observations for Earth monitoring on seasonal and multi-year cycles. In addition, long endurance atmospheric sampling in extreme conditions (hurricanes, volcanic plumes) can provide needed observations that are otherwise not possible at this time:

- Precision flight path control solutions in smooth atmospheric conditions.
- Attitude and navigation control in highly turbulent atmospheric conditions.
- Low cost, high precision inertial navigation systems ($< 0.10^\circ$ accuracy, resolution).

UA Integrated Vehicle Health Management

- Fuel Heat/Anti-freezing.
- Unmanned platform icing detection and minimization.

Guided Dropsondes

NASA Earth Science Research activities can benefit from more capable dropsondes than are currently available. Specifically, dropsondes that can effectively be guided through atmospheric regions of interest such as volcanic plumes could enable unprecedented observations of important phenomena. Capabilities of interest include:

- Compatibility with existing dropsonde dispensing systems on NASA/NOAA P-3's, the NASA Global Hawk, and other unmanned aircraft.
- Guidance schemes, autonomous or active control.
- Cross-range performance and flight path accuracy.
- Operational considerations including airspace utilization and de-confliction.

Novel Platforms and Systems

Innovative fixed wing, rotary wing, or lighter than air platforms and associated systems offering unique capabilities for Earth science research and environmental monitoring are desired. Commercially viable concepts that may have alternative short-term utility for other civil research agencies are in-scope. Systems that are tailored to support new miniaturized instruments for Earth science research, for example those developed under subtopic S1.08 (Airborne Measurement Systems), are encouraged.

Sounding Rockets

The NASA Sounding Rocket Program (NSRP) provides low-cost, sub-orbital access to space in support of space and Earth sciences research and technology development sponsored by NASA and other users by providing payload development, launch vehicles, and mission support services. NASA utilizes a variety of vehicle systems comprised of military surplus and commercially available rocket motors, capable of lofting scientific payloads, up to 1300lbs, to altitudes from 100km to 1500km.

NASA launches sounding rocket vehicles worldwide, from both land-based and water-based ranges, based on the science needs to study phenomenon in specific locations.

NASA is seeking innovations to enhance capabilities and operations in the following areas:

- Autonomous vehicle environmental diagnostics system capable of monitoring flight loading (thermal, acceleration, stress/strain) for solid rocket vehicle systems.
- Location determination systems to provide over-the-horizon position of buoyant payloads to facilitate expedient location and retrieval from the ocean.
- Flotation systems, ranging from tethered flotation devices to self-encapsulation systems, for augmenting buoyancy of sealed payload systems launched from water-based launch ranges.

TOPIC: S4 Robotic Exploration Technologies

NASA is pursuing technologies to enable robotic exploration of the Solar System including its planets, their moons, and small bodies. NASA has a development program that includes technologies for the atmospheric entry, descent, and landing, mobility systems, extreme environments technology, sample acquisition and preparation for in situ experiments, and in situ planetary science instruments. Robotic exploration missions that are planned include a Europa Jupiter System mission, Titan Saturn System mission, Venus In Situ Explorer, sample return from Comet or Asteroid and lunar south polar basin and continued Mars exploration missions launching every 26 months including a network lander mission, an Astrobiology Field Laboratory, a Mars Sample Return mission and other rover missions. Numerous new technologies will be required to enable such ambitious missions. The solicitation for in situ planetary instruments can be found in the in situ instruments section of this solicitation. See URL: (<http://solarsystem.nasa.gov/missions/index.cfm>) for mission information. Planetary protection requirements vary by planetary destination, and additional backward contamination requirements apply to hardware with the potential to return to Earth (e.g., as part of a sample return mission). Technologies intended for use at/around Mars, Europa (Jupiter), and Enceladus (Saturn) must be developed so as to ensure compliance with relevant planetary protection requirements. Constraints could include surface cleaning with alcohol or water, and/or sterilization treatments such as dry heat (approved specification in NPR 8020.12; exposure of hours at 115 °C or higher, non-functioning); penetrating radiation (requirements not yet established); or vapor-phase hydrogen peroxide (specification pending).

S4.01 Planetary Entry, Descent and Landing Technology

Lead Center: JPL

Participating Center(s): ARC, JSC, LaRC

OCT Technology Area: [TA09](#)

NASA seeks innovative sensor technologies to enhance success for entry, descent and landing (EDL) operations on missions to Mars. This call is not for sensor processing algorithms. Sensing technologies are desired that determine

the entry point of the spacecraft in the Mars atmosphere; provide inputs to systems that control spacecraft trajectory, speed, and orientation to the surface; locate the spacecraft relative to the Martian surface; evaluate potential hazards at the landing site; and determine when the spacecraft has touched down. Appropriate sensing technologies for this topic should provide measurements of physical forces or properties that support some aspect of EDL operations. NASA also seeks to use measurements made during EDL to better characterize the Martian atmosphere, providing data for improving atmospheric modeling for future landers. Proposals are invited for innovative sensor technologies that improve the reliability of EDL operations.

Products or technologies are sought that can be made compatible with the environmental conditions of spaceflight, the rigors of landing on the Martian surface, and planetary protection requirements. Successful candidate sensor technologies can address this call by:

- Providing critical measurements during the entry phase (e.g., pressure and/or temperature sensors embedded into the aeroshell).
- Improving the accuracy on measurements needed for guidance decisions (e.g., surface relative velocities, altitudes, orientation, localization).
- Extending the range over which such measurements are collected (e.g., providing a method of imaging through the aeroshell or terrain-relative navigation that does not require imaging through the aeroshell).
- Enhancing situational awareness during landing by identifying hazards (rocks, craters, slopes) and/or providing indications of approach velocities and touchdown.
- Substantially reducing the amount of external processing needed to calculate the measurements.
- Significantly reducing the impact of incorporating such sensors on the spacecraft in terms of volume, mass, placement, or cost.
- For a sample-return mission, monitoring local environmental (weather) conditions on the surface prior to landing of a “fetch” rover or launch of a planetary ascent vehicle, via appropriate low-mass sensors.

Proposals should show an understanding of one or more relevant science needs and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S4.02 Robotic Mobility, Manipulation and Sampling

Lead Center: JPL

Participating Center(s): ARC, GSFC, JSC

OCT Technology Area: [TA04](#)

New technologies for robotic mobility, manipulation, and sampling are needed to enable access to sites of interest and acquisition and handling of samples for in-situ analysis or return to Earth from planetary and solar system small bodies including Mars, Venus, comets, asteroids, and planetary moons.

Mobility technologies are needed to enable access to crater walls, canyons, gullies, sand dunes, and high rock density regions for planetary bodies where gravity dominates, such as the Moon and Mars. Trafficability challenges include steep terrain, obstacle size, and low soil cohesion. Tethered systems, non-wheeled systems, and marsupial systems are examples of mobility technologies that are of interest. Technologies to enable mobility on small bodies in micro-gravity environments are also of interest.

Manipulation technologies are needed to enable deployment of sampling tools and handling of samples. Mars mission sample-handling technologies are needed to enable transfer and storage of a range of rock and regolith cores approximately 1cm long and up to about 10cm long. Small-body mission manipulation technologies are needed to deploy sampling tools to the surface and transfer samples to in-situ instruments and sample storage containers.

Sample acquisition tools are needed to acquire samples on planetary and small bodies. For Mars, a coring tool is needed to acquire rock and regolith cores approximately 1cm diameter and up to 10cm long which also supports transfer of the samples to a sample handling system. Abrading bits for the tool are needed to provide rock-surface abrasion capability to better than 0.2mm scale roughness. A deep drill is needed to enable sample acquisition from the subsurface including rock cores to 3m depth and icy samples from deeper locations. Tools for sampling from asteroids and comets are needed which support transfer of the sample for in-situ analysis or sample return. Tools for

acquisition and transfer of icy samples on Europa are also of interest. Minimization of mass and ability to work reliably in the harsh mission environment are important characteristics for the tools. Example environmental conditions include microgravity for small-body missions, high pressure and temperature (460 °C, 93bar) on Venus, and at Europa the radiation environment is estimated at 2.9 Mrad total ionizing dose (TID) behind 100 mil thick aluminum.

Contamination control and planetary protection are important considerations for sample acquisition and handling technologies. Contamination may include Earth-source contaminants produced by the sampling tool, handling system, or deposited on the sampling location from another source on the rover. Consideration should be given to:

- Innovative “cleaning to sterility” technologies that will be compatible with spacecraft materials and processes.
- Surface cleaning validation methods that can be used routinely to quantify trace amount ($\sim\text{ng}/\text{cm}^2$) of organic contamination and submicron particle ($\sim 100\text{nm}$ size) contamination.

Priority will be given to the cleaning and sterilization methods that have potential for in-situ applications. Avoiding cross contamination between samples is also a priority. Innovative mechanical or system solutions—e.g., single-use sample “sleeves” or fully integrated sample acquisition and encapsulation systems are also needed to ensure sample integrity.

Innovative component technologies for low-mass, low-power, and modular systems tolerant to the in situ environment are of particular interest. Technical feasibility should be demonstrated during Phase I and a full capability unit of at least TRL 4 should be delivered in Phase II. Proposals should show an understanding of relevant science needs and engineering constraints and present a feasible plan to fully develop a technology and infuse it into a NASA program. Specific areas of interest include the following:

- Steep terrain adherence for vertical and horizontal mobility.
- Tether play-out and retrieval systems including tension and length sensing.
- Low-mass tether cables with power and communication.
- Sampling system deployment mechanisms.
- Low mass/power vision systems and processing capabilities that enable faster surface traverse while maintaining safety over a wide range of surface environments.
- Robotics autonomy.
- Modular actuators with 1000:1 scale gear ratios.
- Coring tool for 1cm X 10cm rock and regolith cores.
- Small body sampling tool.
- Cleaning to sterility technologies that will be compatible with spacecraft materials and processes.
- Surface cleaning validation technology to quantify trace amount ($\sim\text{ng}/\text{cm}^2$) of organic contamination and submicron particle ($\sim 100\text{nm}$ size) contamination.
- Sample handling technologies that minimize cross contamination and preserve mechanical integrity of samples.

S4.03 Spacecraft Technology for Sample Return Missions

Lead Center: GRC

Participating Center(s): ARC, DFRC, GSFC, JPL, LaRC, MSFC

OCT Technology Area: [TA04](#)

NASA plans to perform sample return missions from a variety of targets including Mars, outer planet moons, and small bodies such as asteroids and comets. In terms of spacecraft technology, these types of targets present a variety challenges. Some targets, such as Mars and some moons, have relatively large gravity wells and will require ascent propulsion. Other targets are small bodies with very complex geography and very little gravity, factors that present difficult navigation and maneuvering challenges. In addition, the spacecraft will be subject to extreme environmental conditions including low temperatures (-270°C), dust, and ice particles. Technology innovations should either enhance vehicle capabilities (e.g., increase performance, decrease risk, and improve environmental operational margins) or ease mission implementation (e.g., reduce size, mass, power, cost, increase reliability, or

increase autonomy). Specific areas of interest are listed below. SMD's In-space Propulsion technology program is a direct customer of this subtopic, and the solicitation is coordinated with the ISPT program each year. The ISPT program views this subtopic as a fertile area for providing possible Phase III efforts. Many of the Planetary Decadal Survey white papers/studies evaluating technologies needed for various planetary, small body, and sample return missions refer to the need for sample return spacecraft technologies.

Small Body Missions:

- Autonomous operation.
- Terrain based navigation.
- Guidance and control technology for landing and touch-and-go.
- Anchoring concepts for asteroids.
- Propulsion technology for proximity or landed operations.
- Low-power, long-life cryogenic sample storage.
- Earth Entry Vehicles for Sample Return Missions.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

TOPIC: S5 Information Technologies

NASA Missions and Programs create a wealth of science data and information that are essential to understanding our earth, our solar system and the universe. Advancements in information technology will allow many people within and beyond the Agency to more effectively analyze and apply these data and information to create knowledge. For example, modeling and simulation are being used more pervasively throughout NASA, for both engineering and science pursuits, than ever before. These are tools that allow high fidelity simulations of systems in environments that are difficult or impossible to create on Earth, allow removal of humans from experiments in dangerous situations, provide visualizations of datasets that are extremely large and complicated, and aid in the design of systems and missions. In many of these situations, assimilation of real data into a highly sophisticated physics model is needed. Information technology is also being used to allow better access to science data, more effective and robust tools for analyzing and manipulating data, and better methods for collaboration between scientists or other interested parties. The desired end result is to see that NASA data and science information are used to generate the maximum possible impact to the nation: to advance scientific knowledge and technological capabilities, to inspire and motivate the nation's students and teachers, and to engage and educate the public.

S5.01 Technologies for Large-Scale Numerical Simulation

Lead Center: ARC

Participating Center(s): GSFC

OCT Technology Area: [TA11](#)

NASA scientists and engineers are increasingly turning to large-scale numerical simulation on supercomputers to advance understanding of complex Earth and astrophysical systems, and to conduct high-fidelity aerospace engineering analyses. The goal of this subtopic is to increase the mission impact of NASA's investments in supercomputing systems and associated operations and services. Specific objectives are to:

- Decrease the barriers to entry for prospective supercomputing users.
- Minimize the supercomputer user's total time-to-solution (e.g., time to discover, understand, predict, or design).
- Increase the achievable scale and complexity of computational analysis, data ingest, and data communications.
- Reduce the cost of providing a given level of supercomputing performance on NASA applications.
- Enhance the efficiency and effectiveness of NASA's supercomputing operations and services.

Expected outcomes are to improve the productivity of NASA's supercomputing users, broaden NASA's supercomputing user base, accelerate advancement of NASA science and engineering, and benefit the supercomputing community through dissemination of operational best practices.

The approach of this subtopic is to seek novel software and hardware technologies that provide notable benefits to NASA's supercomputing users and facilities, and to infuse these technologies into NASA supercomputing operations. Successful technology development efforts under this subtopic would be considered for follow-on funding by, and infusion into, NASA's high-end computing (HEC) projects: the High End Computing Capability project at Ames and the Scientific Computing project at Goddard. To assure maximum relevance to NASA, funded SBIR contracts under this subtopic should engage in direct interactions with one or both HEC projects, and with key HEC users where appropriate. Research should be conducted to demonstrate technical feasibility and NASA relevance during Phase I and show a path toward a Phase II prototype demonstration.

Offerors should demonstrate awareness of the state-of-the-art of their proposed technology, and should leverage existing commercial capabilities and research efforts where appropriate. Open Source software and open standards are strongly preferred. Note that the NASA supercomputing environment is characterized by: HEC systems operating behind a firewall to meet strict IT security requirements, communication-intensive applications, massive computations requiring high concurrency, complex computational workflows and immense datasets, and the need to support hundreds of complex application codes – many of which are frequently updated by the user/developer. As a result, solutions that involve the following must clearly explain how they would work in the NASA environment: Grid computing, web services, client-server models, embarrassingly parallel computations, and technologies that require significant application re-engineering. Projects need not benefit all NASA HEC users or application codes, but demonstrating applicability to an important NASA discipline, or even a key NASA application code, could provide significant value.

Specific technology areas of interest:

- **Efficient Computing:** In spite of the rapidly increasing capability and efficiency of supercomputers, NASA's HEC facilities cannot purchase, power, and cool sufficient HEC resources to satisfy all user demands. This subtopic element seeks dramatically more efficient and effective supercomputing approaches in terms of their ability to supply increased HEC capability or capacity per dollar and/or per Watt for real NASA applications. Examples include:
 - Novel computational accelerators and architectures.
 - Cloud supercomputing with high performance interconnects (e.g., InfiniBand).
 - Enhanced visualization technologies.
 - Improved algorithms for key codes.
 - Power-aware "Green" computing technologies and techniques.
- **Approaches to effectively manage and utilize many-core processors** including algorithmic changes, compiler techniques and runtime systems.
- **User Productivity Environments:** The user interface to a supercomputer is typically a command line in a text window. This subtopic element seeks more intuitive, intelligent, user-customizable, and integrated interfaces to supercomputing resources, enabling users to more completely leverage the power of HEC to increase their productivity. Such an interface could enhance many essential supercomputing tasks: accessing and managing resources, training, getting services, developing and porting codes (e.g., debugging and performance analysis), running computations, managing files and data, analyzing and visualizing results, transmitting data, collaborating, etc.
- **Ultra-Scale Computing:** Over the next decade, the HEC community faces great challenges in enabling its users to effectively exploit next-generation supercomputers featuring massive concurrency to the tune of millions of cores. To overcome these challenges, this subtopic element seeks ultra-scale computing technologies that enable resiliency/fault-tolerance in extreme-scale (unreliable) systems both at job startup and during execution. Also of interest are system and software co-design methodologies, to achieve performance and efficiency synergies. Finally, tools are sought that facilitate verification and validation of ultra-scale applications and systems.

S5.02 Earth Science Applied Research and Decision Support

Lead Center: SSC

Participating Center(s): ARC, DFRC, GSFC, JPL

OCT Technology Area: [TA11](#)

The NASA Applied Sciences Program (<http://nasascience.nasa.gov/earth-science/applied-sciences>) seeks innovative and unique approaches to increase the utilization and extend the benefit of Earth Science research data to better meet societal needs. One area of interest is new decision support tools and systems for a variety of ecological applications such as managing coastal environments, natural resources or responding to natural disasters.

This subtopic seeks proposals for utilities, plug-ins or enhancements to geobrowsers that improve their utility for Earth science research and decision support. Examples of geobrowsers include Google Earth, Microsoft Virtual Earth, NASA World Wind (http://worldwindcentral.com/wiki/Main_page) and COAST (<http://www.coastal.ssc.nasa.gov/coast/COAST.aspx>). Examples include, but are not limited to, the following:

- Visualization of high-resolution imagery in a geobrowser.
- Enhanced geobrowser animation capabilities to provide better visual-analytic displays of time-series and change-detection products.
- Discovery and integration of content from web-enabled sensors.
- Discovery and integration of new datasets based on parameters identified by the user and/or the datasets currently in use.
- Innovative mechanisms for collaboration and data layer sharing.
- Applications that subset, filter, merge, and reformat spatial data.
- Statistical tools and interfaces needed to downscale coarser resolution climate datasets for regional applications
- Rapid delivery of satellite data products and alerts concepts and architectures in case of emergency situation

This subtopic also seeks proposals for advanced information systems and decision environments that take full advantage of multiple data sources and platforms. Special consideration will be given to proposals that provide enhancements to existing, broadly used decision support tools or platforms. Tailored and timely products delivered to a broad range of users are needed to address air quality, public health and agriculture mapping and food security issues. Additional areas of interest will be to protect vital ecosystems such as coastal marshes, barrier islands and seagrass beds; monitor and manage utilization of critical resources such as water and energy; provide quick and effective response to manmade and natural disasters such as oil spills, earthquakes, hurricanes, floods and wildfires; and promote sustainable, resilient communities and urban environments.

Proposals shall present a feasible plan to fully develop and apply the subject technology.

S5.03 Algorithms and Tools for Science Data Processing, Discovery and Analysis, in State-of-the-Art Data Environments

Lead Center: GSFC

Participating Center(s): ARC, JPL, KSC, LaRC, MSFC, SSC

OCT Technology Area: [TA11](#)

The size of NASA's observational data sets is growing dramatically as new missions come on line. In addition, NASA scientists continue to generate new models that regularly produce data sets of hundreds of terabytes or more. It is growing ever increasingly difficult to manage all of the data through its full lifecycle, as well as provide effective data analytical methods to analyze the large amount of data. For example, the HypIRI mission is expected to produce an average science data rate of 800 Million bits per second (Mbps), JPSS-1 will be 300 Mbps and NPP is already producing 300 Mbps, compared to 150 Mbps for the EOS-Terra, Aqua and Aura missions. Other examples are SDO with a rate of 150 Mbps and 16.4 Gigabits for a single image from the HiRise camera on the Mars Reconnaissance Orbiter (MRO).

This subtopic area seeks innovation and unique approaches to solve issues associated around the use of “Big Data” within NASA. The emphasis of this subtopic is on tools that leverage existing systems, interfaces, and infrastructure, where it exists and where appropriate. Reuse of existing NASA assets is strongly encouraged.

Specifically, innovations are being sought in the following areas:

- *Parallel Processing for Data Analytics* – Open source tools like the Hadoop Distributed File Systems (HDFS) have shown promise for use in simple MapReduce operations to analyze model and observation data. In addition to HDFS, there is a rapid emergence and adoption of cloud software packages integrated with object stores, such as OpenStack and Swift. The goal is to accelerate these types of open source tools for use with binary structured data from observations and model output using MapReduce or a similar paradigm.
- *High Performance File System Abstractions* – NASA scientists currently use a large number of existing applications for data analysis, such as GrADS, python scripts, and more, that are not compatible with an object storage environment. If data were stored within an object storage environment, these applications would not be able to access the data. Many of these applications would require a substantial amount of investment to enable them to use object storage file systems. Therefore, a file system abstraction, such as FUSE (file system in user space) is needed to facilitate the use of existing data analysis applications with an object storage environment. The goal is to make a FUSE-like file system abstraction robust, reliable, and highly performing for use with large NASA data sets.
- *Data Management of Large-Scale Scientific Repositories* – With increasing size of scientific repositories comes an increasing demand for using the data in ways that may never have been imagined when the repository was conceived. The goal is to provide capabilities for the flexible repurposing of scientific data, including large-scale data integration, aggregation, representation, and distribution to emerging user communities and applications.
- *Server Side Data Processing* – Large data repositories make it necessary for analytical codes to migrate to where the data are stored. Hadoop does that at the level of a single HDFS. In a densely networked world of geographically distributed repositories, tiered intermediation is needed. The goal is to provide support for migratable codes and analytical outputs as first class objects within a provenance-oriented data management cyberinfrastructure.
- *Techniques for Data Analysis and Visualization* – New methods for data analytics that scale to extremely large data sets are necessary for data mining, searching, fusion, subsetting, discovery, visualization, and more. In addition, new algorithms and methods are needed to look for unknown correlations across large, distributed scientific data sets. The goal is to increase the scientific value of model and observation data by making analysis easier and higher performing. Among others, some of the topics of interest are:
 - Techniques for automated derivation of analysis products such as machine learning for extraction of features in large image datasets (e.g., volcanic thermal measurement, plume measurement, automated flood mapping, disturbance mapping, change detection, etc.).
 - Workflows for automated data processing, interpretation, and distribution.
- *Accelerated Large Scale Data Movement* – There are a multitude of large distributed data stores across NASA that includes both observation and model data. The movement of data across the network must be optimized to take full advantage of large-scale data analytics, especially when comparing model to observation data. The goal is to optimize data movement in the following ways:
 - Accelerate and make it easier to move data over the wide area to facilitate large-scale data management and analysis.
 - Optimize the movement of data within more local environments, such as the usage of Remote Direct Memory Access (RDMA) within HDFS.
 - Virtualization of high-speed network interfaces for use within cloud environments.

Research proposed to this subtopic should demonstrate technical feasibility during Phase I, and in partnership with scientists, show a path toward a Phase II prototype demonstration, with significant communication with missions and programs to ensure a successful Phase III infusion. It is highly desirable that the proposed projects lead to software that is infused into NASA programs and projects.

Tools and products developed under this subtopic may be used for broad public dissemination or within a narrow scientific community. These tools can be plug-ins or enhancements to existing software, on-line data/computing services, or new stand-alone applications or web services, provided that they promote interoperability and use standard protocols, file formats and Application Programming Interfaces (APIs) or prevalent applications.

S5.04 Integrated Science Mission Modeling

Lead Center: GSFC

Participating Center(s): ARC, JPL

OCT Technology Area: [TA11](#)

NASA seeks innovative systems modeling methods and tools to:

- Define, develop and execute future science missions, many of which are likely to feature designs and operational concepts that will pose significant challenges to existing approaches and applications, and
- Enable disciplined system analysis for the ongoing management and decision support of the space science technology portfolio, particularly with regard to understanding technology alternatives, relationships, priorities, timing, availability, down-selection, maturation, investment needs, system engineering considerations, and cost-to-benefit ratios; to examine “what-if” scenarios; and to facilitate multidisciplinary assessment, coordination, and integration of the technology roadmaps as a whole.

Use of System Modeling Language (SysML) is encouraged but not required. SysML is a general purpose graphical modeling language for analyzing, designing and verifying complex systems that may include hardware, software, information, personnel, procedures and facilities. As a language, SysML represents requirements, structure, behavior, and equations in nine different diagram types, and can represent both hardware and software models. The language can be extended to provide metamodels for different disciplines, and is supported by multiple commercial tools. SysML is finding increased use throughout the agency to support systems engineering and analysis. Specific areas of interest include the following:

- *Integration of system and mission modeling tools with high-fidelity multidisciplinary design and modeling tools, supporting efficient analysis methods that accommodate uncertainty, multiple objectives, and large-scale systems* - This requires the development of robust interfaces between SysML and other tools, including CAD/CAE/PDM/PLM applications, used to support NASA science mission development, implementation and operations. The objective is to produce a unified environment supporting mixed systems-level and detailed analysis during any lifecycle phase, and rapid analysis of widely varying concepts/configurations using mixed-fidelity models, including geometry/mesh-based models when required. The human interface for such a system could be a “dashboard” (web-based is highly desirable) which initially allows for monitoring of the dataflow across a heterogeneous set of tools and finally allows for control of the data flow between the variety of applications.
- *Modeling and rapid integration of programmatic, operational, and risk elements* - Fully integrated system model representations must include non-physics based constructs such as cost, schedule, risk, operations, and organizational model elements. Novel methods and tools to model these system attributes are critical. In addition, approaches to integrate these in a meaningful way with other system model elements are needed. Methods that consider the development of these models as by-products of a collaborative and/or concurrent design process are particularly valuable.
- *Library of SysML models of NASA related systems* - Using a library of SysML models, engineers will be able to design their systems by reusing a set of existing models. Too often, these engineers have to begin from scratch the design of the systems. A library of verified and validated models would provide a way for the engineers to design a new spacecraft by assembling existing models that are domain specific, and therefore easy to adapt to the target system. In order to provide for seamless integration between SysML models each model must identify its level of abstraction both in terms of the modeling of time (progression: no ordering of events, qualitative ordering of events, metric time ordering of events) and the modeling of space (progression: lumped parameters models, distributed parameter models). Such levels of abstraction “certificates” for SysML will help determine integration interface requirements between any two models.
- *Profiles for spacecraft, space robotics, and scientific instruments* - Profiles provide a means of tailoring SysML for particular purposes. Extensions of the language can be inserted. This allows an organization to

create domain specific constructs which extend existing SysML modeling elements. By developing profiles for NASA domains such as Spacecraft, Space Robotics and Scientific Instruments, powerful mechanisms will be available to NASA systems engineers for designing future space systems.

- *Requirements Modeling* - SysML offers requirements modeling capabilities, thus providing ways to visualize important requirements relationships. There is a need to combine traditional requirements management, supported by tools including but not limited to DOORS and CRADLE, and SysML requirements modeling in a standardized and sustainable way.
- *Functional Modeling* - The intermediate data products between requirements and specification are detailed functional models that identify all of the functions required to achieve the mission profile(s). There is a critical need to model this layer as it is a key data product to provide traceability between requirements and implementation.
- *Model and Modeling Process Synthesis* - As model-based design broadens and integrates larger and more complex models, methods for how to sequence and operate the design synthesis , evaluation (e.g., V&V) and elaboration process will become more important, as will considerations of how model-based processes are made compatible with existing review and development cycles.

S5.05 Fault Management Technologies

Lead Center: MSFC

Participating Center(s): ARC, JPL

OCT Technology Area: [TA11](#)

As science missions are given increasingly complex goals and have more pressure to reduce operations costs, system autonomy increases. Fault Management (FM) is one of the key components of system autonomy. FM consists of the operational mitigations of spacecraft failures. It is implemented with spacecraft hardware, on-board autonomous software that controls hardware, software, information redundancy, and ground-based software and operations procedures.

Many recent Science Mission Directorate (SMD) missions have encountered major cost overruns and schedule slips during test and verification of FM functions. These overruns are due to a lack of understanding of FM functions early in the mission definition cycles and to FM architectures that do not provide attributes of transparency, verifiability, fault isolation capability, or fault coverage. The NASA FM Handbook is under development to improve the FM design, development, verification & validation and operations processes. FM approaches, architectures, and tools are needed to improve early understanding of needed FM capabilities by project managers and FM engineers and to improve the efficiency of implementing and testing FM.

Specific objectives are to:

- Improve ability to predict FM system complexity and estimate development and operations costs.
- Enable cost-effective FM design architectures and operations.
- Determine completeness and appropriateness of FM designs and implementations.
- Decrease the labor and time required to develop and test FM models and algorithms.
- Improve visualization of the full FM design across hardware, software, and operations procedures.
- Determine extent of testing required, completeness of verification planned, and residual risk resulting from incomplete coverage.
- Increase data integrity between multi-discipline tools.
- Standardize metrics and calculations across FM, SE, S&MA and operations disciplines.
- Increase reliability of FM systems.

Expected outcomes are better estimation and control of FM complexity and development costs, improved FM designs, and accelerated advancement of FM tools and techniques.

The approach of this subtopic is to seek the right balance between sufficient reliability and cost appropriate to the mission type and risk posture. Successful technology development efforts under this subtopic would be considered for follow-on funding by, and infusion into, SMD missions. Research should be conducted to demonstrate technical feasibility and NASA relevance during Phase I and show a path toward a Phase II prototype demonstration.

Offerors should demonstrate awareness of the state-of-the-art of their proposed technology, and should leverage existing commercial capabilities and research efforts where appropriate.

Specific technology in the forms listed below is needed to increase delivery of high quality FM systems. These approaches, architectures and tools must be consistent with and enable the NASA FM Handbook concepts and processes.

- *FM design tools* - System modeling and analyses significantly contributes to the quality of FM design; however, the time it takes to translate system design information into system models often decreases the value of the modeling and analysis results. Examples of enabling techniques and tools are modeling automation, spacecraft modeling libraries, expedited algorithm development, sensor placement analyses, and system model tool integration.
- *FM visualization tools* - FM systems incorporate hardware, software, and operations mechanisms. The ability to visualize the full FM system and the contribution of each mechanism to protecting mission functions and assets is critical to assessing the completeness and appropriateness of the FM design to the mission attributes (mission type, risk posture, operations concept, etc.). Fault trees and state transition diagrams are examples of visualization tools that could contribute to visualization of the full FM design.
- *FM verification and validation tools* - As complexity of spacecraft and systems increases, the extensiveness of testing required to verify and validate FM implementations can be resource intensive. Automated test case development, false positive/false negative test tools, model verification and validation tools, and test coverage risk assessments are examples of contributing technologies.
- *FM Design Architectures* - FM capabilities may be implemented through numerous system, hardware, and software architecture solutions. The FM architecture trade space includes options such as embedded in the flight control software or independent onboard software; on board versus ground-based capabilities; centralized or distributed FM functions; sensor suite implications; integration of multiple FM techniques; innovative software FM architectures implemented on flight processors or on Field Programmable Gate Arrays (FPGAs); and execution in real-time or off-line analysis post-operations. Alternative architecture choices could help control FM system complexity and cost and could offer solutions to transparency, verifiability, and completeness challenges.
- *Multi-discipline FM Interoperation* - FM designers, Systems Engineering, Safety and Mission Assurance, and Operations perform analyses and assessments of reliabilities, failure modes and effects, sensor coverage, failure probabilities, anomaly detection and response, contingency operations, etc. The relationships between multi-discipline data and analyses are inconsistent and misinterpreted. Resources are expended either in effort to resolve disconnects in data and analyses or worse, reduced mission success due to failure modes that were overlooked. Solutions that address data integrity, identification of metrics, and standardization of data products, techniques and analyses will reduce cost and failures.

9.2 STTR

The STTR Program Solicitation topics correspond to strategic technology research areas of interest at the NASA Centers. The subtopics reflect the current highest priority technology thrusts of the Centers in their particular area of interest.

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TOPIC: T1 Launch Propulsion Systems

Includes all propulsion technologies required to deliver space missions from the surface of the Earth to Earth orbit or Earth escape, including solid rocket propulsion systems, liquid rocket propulsion systems, air breathing propulsion systems, ancillary propulsion systems, and unconventional/other propulsion systems. The Earth to orbit launch industry is currently reliant on very mature technologies, to which only small incremental improvements are possible. Breakthrough technologies are not on the near horizon, therefore research and development efforts will require both significant time and financial investments.

T1.01 Launch Vehicle Propulsion Technologies

Lead Center: MSFC

Participating Center(s): SSC

OCT Technology Area: [TA01](#)

Heavy lift launch vehicles envisioned for exploration beyond low Earth orbit (LEO) will require large first stage propulsion systems. For some heavy lift vehicles, the total thrust produced at lift-off will exceed 6 million pounds. There are currently available practical propulsion options for such a vehicle. However, the cost for outfitting the booster with the required propulsion systems is in the hundreds of millions of dollars. This cost severely limits what missions NASA can perform. Low cost design concepts and manufacturing techniques are needed to make future exploration affordable. This topic seeks technologies that will fulfill the following objectives:

- Development of propulsion concepts whose cost is less than 50% of currently available but with similar performance.
- Development and demonstration of low-cost manufacturing techniques.
- Techniques for evaluating and analyzing low-cost, easily manufacturable design concepts.

Example technologies of interest include:

- Ablative materials and manufacturing techniques.
- Innovative chamber cooling concepts that reduce manufacturing complexity without reducing performance.
- Low-cost nozzle materials, manufacturing techniques, and coatings.
- Ignition concepts that require low part count and/or low energy to be used as either primary or redundant ignition sources.
- Manufacturing techniques that lower the cost of manufacturing complex components such as injectors and coolant channels. Examples include, but are not limited to, development and demonstration of rapid prototype techniques for metallic parts, powder metallurgy techniques, and application of nano-technology for manufacturing of near net shape manufacturing.
- Increased efficiency and fidelity analysis tools.

The development of future propulsion systems for deep-space exploration are directly dependent on the development of technologies such as those listed. Furthermore, affordable, reliable access to space technology is a strong need across all of NASA's space exploration activities (HEOMD, OCT, SMD). While revolutionary advances in launch vehicle technologies are not foreseen to be developed in the immediate future, a practice of employing methodical continuous technology development in the direction of lowering the cost and improving the reliability of launch propulsion systems will address this critical need of lowering the cost of earth-to-orbit launch systems and capabilities.

TOPIC: T2 In-Space Propulsion Technologies

Includes all propulsion technologies required to deliver space missions from the surface of the Earth to Earth orbit or Earth escape, including solid rocket propulsion systems, liquid rocket propulsion systems, air breathing propulsion systems, ancillary propulsion systems, and unconventional/other propulsion systems. The Earth to orbit launch industry is currently reliant on very mature technologies, to which only small incremental improvements are

possible. Breakthrough technologies are not on the near horizon, therefore research and development efforts will require both significant time and financial investments.

T2.01 Space Power and Propulsion

Lead Center: GRC

Participating Center(s): KSC

OCT Technology Area: [TA02](#)

Development of innovative technologies are sought that will result in durable, long-life, lightweight, high performance space power and in-space propulsion systems to substantially enhance or enable future missions.

Innovations in the form of advanced concepts, technology demonstrations and processes are sought for Space Power and Propulsion.

Space Power areas of particular interest include solar photovoltaic, nuclear power, power distribution and transmission, conversion and regulation, batteries and fuel cells. Solar photovoltaic cell, blanket, and array technologies are sought for improved efficiency, power density, specific power and mass, and application to NASA-unique environmental conditions (high radiation, extreme temperatures, varying light intensity, etc.). Nuclear power technologies that provide high efficiency, high specific power, and long life for deep space and planetary surface applications including radioisotope power generation for power levels between 100 watts and 1 kilowatt and fission power generation for power levels from kilowatts to megawatts. Battery technologies include novel battery chemistries that offer improvements in safety, volume and mass above and beyond those offered by Lithium-ion technology. Fuel cell (and electrolyzer) technologies include novel membrane materials and geometries and advanced concepts. Power management and distribution technologies include modular “smart” systems and advanced materials and component research and development.

In-Space Propulsion areas of particular interest include electric propulsion, micro-propulsion, nuclear thermal propulsion, and propellant storage and transfer, which were identified as the highest priority ISP technologies by the NRC's "NASA Space Technology Roadmaps and Priorities." Technologies for electric propulsion include high-power long-lived thrusters and low specific mass power processing systems. Micro-propulsion technologies include chemical or non-chemical systems for micro-satellites. Technologies for nuclear thermal propulsion include advanced high temperature fuel forms, innovative testing methods and non-nuclear subsystems. Propellant technologies include subsystems and components to enable long-duration storage in space and low-gravity liquid transfer.

TOPIC: T3 Space Power and Energy Storage

Space Power and Energy Storage is divided into four technology areas: power generation, energy storage, power management and distribution, and cross cutting technologies. NASA has many unique needs for space power and energy storage technologies that require special technology solutions due to extreme environmental conditions. These missions would all benefit from advanced technologies that provide more robust power systems with lower mass.

T3.01 Energy Harvesting Technology Development

Lead Center: SSC

Participating Center(s): JSC, KSC, GRC

OCT Technology Area: [TA03](#)

The NRC has identified a NASA Top Technical Challenge as the need to “Increase Available Power”. Additionally, a NASA Grand Challenge is “Affordable and Abundant Power” for NASA mission activities. As such, novel energy harvesting technologies are critical toward supporting future power generation systems to begin to meet these challenges. This subtopic addresses the potential for deriving power from waste engine heat, warm soil, liquids, kinetic motion, piezoelectric materials or other naturally occurring energy sources, etc. (re: TA-3; 2.2.1.1).

Development of energy harvesting (both capture and conversion) technologies would also address the national need for novel new energy systems and alternatives to reduce energy consumption.

Areas of special focus for this subtopic include consideration of:

- Innovative technologies for the efficient capture and/or conversion of acoustic, kinetic, and thermal energy types.
- Technologies which can work either under typical ambient environments for the above energy types and/or under high intensity energy environments for the above energy types as might be found in propulsion testing and launch facilities.
- Innovations in miniaturization and suitability for manufacturing of energy capture and conversion systems so as to be used towards eventual powering of assorted sensors and IT systems on vehicles and infrastructures.
- High efficiency and reliability for use in environments that may be remote and/or hazardous and having low maintenance requirements.
- Employ green technology considerations to minimize impact on the environment and other resource usage.

Rocket propulsion test facilities within NASA provide excellent test beds for testing and using the innovative technologies discussed above because they offer a wide spectrum of energy types and energy intensities to capture and convert. Additional Federal mandates require the optimization of current energy use and development of alternative energy sources to conserve on energy and to enhance the sustainability of these and other facilities.

TOPIC: T4 Robotics, Tele-Robotics and Autonomous Systems

The topic for Robotics, Tele-Robotics and Autonomous Systems, consists of seven technology subareas: Sensing and Perception; Mobility; Manipulation; Human-Systems Integration; Autonomy; Autonomous Rendezvous and Docking (AR&D); and Robotics, Tele-Robotics and Autonomous Systems Engineering. Robotics, Tele-Robotics and Autonomous Systems supports NASA space missions with the development of new capabilities, and can extend the reach of human and robotic exploration through a combination of dexterous robotics, better human/robotic interfaces, improved mobility systems, and greater sensing and perception. The Robotics, Tele-Robotics and Autonomous Systems topics focuses on several key issues for the future of robotics and autonomy: enhancing or exceeding human performance in sensing, piloting, driving, manipulating, and rendezvous and docking; development of cooperative and safe human interfaces to form human-robot teams; and improvements in autonomy to make human crews independent from Earth and make robotic missions more capable.

T4.01 Information Technologies for Intelligent and Adaptive Space Robotics

Lead Center: ARC

OCT Technology Area: [TA04](#)

The objective of this subtopic is to develop information technologies that enable robots to better support space exploration. Robots are already at work in all of NASA's Mission Directorates and will be critical to the success of future exploration missions. The NASA "Robotics, Tele-Robotics, and Autonomous Systems" roadmap (TA04) indicates that extensive and pervasive use of robots can significantly enhance exploration, particularly for missions that are progressively longer, complex, and operate with fewer ground control resources.

Intelligent robots can do a variety of work to increase the productivity of planetary exploration. Robots can perform tasks that are highly-repetitive, long-duration, or tedious. Robots can perform tasks that help prepare for subsequent human missions. Robots can perform "follow-up" work, completing tasks started by astronauts. Example robotic tasks include:

- Scouting.
- Site surveys.
- Sampling.
- Payload deployment.

- EVA close-out work.

The performance of intelligent robots is directly linked to the quality and capability of the information technologies used to build and operate them. Thus, proposals are sought that address the following technology needs:

- Advanced user interfaces for telerobotics, which facilitate distributed collaboration, geospatial data visualization, summarization and notification, and robot tasking. This does NOT include user interfaces for direct teloperation (e.g., joystick-based rate control), telepresence, or immersive virtual reality. The primary objective is to enable more effective and efficient interaction with semi-autonomous telerobots. (TA04 roadmap technical area 4.4).
- Mobile robot navigation (localization, hazard detection and avoidance, etc) for operations in man-made and unstructured environments. Emphasis on multi-sensor data fusion, obstacle detection, and proximity ops. The primary objective is to radically and significantly increase the performance of mobile robot navigation through advanced on-board software. (TA04 roadmap technical areas 4.1 and 4.2).
- Robot software architecture that radically reduces operator workload for remotely operating planetary rovers. This includes frameworks for adjustable autonomy, on-board health management and prognostics, automated data triage, and high-performance robot middleware. The primary objective is to facilitate the creation, extensibility and maintenance of complex robot systems. (TA04 roadmap technical area 4.5).

T4.02 Dynamic Servoelastic (DSE) Network Control, Modeling, and Optimization

Lead Center: DFRC

Participating Center(s): ARC, JPL, LaRC

OCT Technology Area: [TA04](#)

This subtopic addresses advanced control-oriented techniques for dynamic servoelastic (DSE) terrestrial, planetary, and space environment flight systems using distributed network sensor and control systems. Methods include modeling, simulation, optimization and stabilization of DSE systems to actively and/or adaptively control structural dynamic geometry/topology, vibration, atmospheric and intraspace disturbances, static/dynamic loads, and other structural dynamic objectives for enhanced dynamic servoelastic performance and stability characteristics.

- DSE control for performance enhancements while minimizing dynamic interaction.
- Flexible aircraft and spacecraft stabilization and performance optimization.
- Modeling and system identification of distributed DSE dynamics.
- Sensor/actuator developments and modeling for distributed DSE control.
- Uncertainty modeling of complex DSE system behavior and interactions.
- Distributed networked sensing and control for vehicle shape, vibration, and load control.

This subtopic also addresses capabilities enabling design solutions for performance and environmental challenges of future air and space vehicles. Research in revolutionary aerospace configurations include lighter and more flexible materials, improved propulsion systems, and advanced concepts for high lift/performance and drag/energy reduction. This subtopic targets efficiency and environmental compatibilities requiring performance challenges and novel control-oriented techniques for aero-servoelastic considerations which are gaining prevalence in advanced aerospace flight vehicles, atmospheric and extra-terrestrial.

Technical elements for the Phase I proposals may also include:

- Mission/maneuver adaptivity with dissipative optimal energy-force distribution.
- Data-driven multi-objective DSE control with physics-based sensing.
- Robust sensing-control-communication networks for sensor-based distributed control.
- Compressive information-based sensing and information structures.
- Evolving systems as applied to self-assembling and robotic maneuvering.
- Scalable and evolvable information networks with layering architectures.
- Modular architectures for distributed autonomous aerospace systems.
- Multi-objective, multi-level control and estimation architectures.
- Distributed multi-vehicle dynamics analysis and visualization with complex simulations.

Development of distributed sensory-driven control-oriented DSE systems is solicited to enable future flight vehicle concepts and designs that manage structural dynamic uncertainty on a vehicle's overall performance. Proposals should assist in revolutionizing improvements in performance to empower a new generation of air and space vehicles to meet the challenges of terrestrial and commercial space concerns with novel concepts and technology developments in systems analysis, integration and evaluation. Higher performance measures include energy efficiency to reduce fuel burn and operability technologies that enable information network decompositions that have different characteristics in efficiency, robustness, and asymmetry of information and control with tradeoff between computation and communication.

Advanced mission applicability in Phase II should show the ability of aerospace GN&C systems to achieve mission objectives as a function of GN&C sensor performance, vehicle actuation/power/energy, and the ability to jointly design them as onboard-capable, real-time computing platforms with applicable environmental effects and robust guidance algorithms. Goals are to:

- Provide capabilities that would enable new projects/missions that are not currently feasible.
- Impact multiple missions in NASA space operations and science, earth science, and aeronautics.
- Be influential across aerospace and non-aerospace disciplines with dynamic interactions.

New technologies proposed should have the potential to impact the following NASA missions:

- Data availability for science missions.
- Mission planning.
- Autonomous rendezvous/docking technology.
- Environmental monitoring for human habitation.

Apart from NASA missions, the aeronautics technology could be adapted for development and use in autonomous operation of wind/ocean energy and smart space power grid systems in dynamic environments.

There are number of advantages to exploring this subtopic technology:

- Increase in autonomy and fuel efficiency of coordinated robotic vehicles and sub-components.
- Improved science, atmospheric, and reconnaissance data.
- Cost, risk and reliability of flight vehicles for a terrestrial, planetary, or space mission.
- Inter-networks with improved dynamic behavior.

Potential technical impacts are:

- Vehicle energy efficiency with passive/active dissipativity for control and dynamic stability with extreme power constraints.
- Weight minimization through dynamic servoelectric control.
- Mission adaptivity and robustness with real-time, consensus-coordinated control dealing with computation, communication, and dynamics.

T4.03 Extreme Particle Flow Physics Simulation Capability

Lead Center: KSC

OCT Technology Area: [TA04](#)

Advanced computer modeling software is sought to provide the ability to predict the flow of granular materials in space and/or planetary environments. Proposals are sought for software capable of handling one or more of the following applications in one or more relevant environments for space exploration:

- Rovers driving on planetary regolith.
- Rocket engines blowing planetary regolith.
- Excavators and resource extraction systems moving and conveying planetary regolith.

- Technologies that burrow or drill into planets and asteroids for scientific access.
- Transport of granulated metal hydrides as hydrogen fuel systems.
- 3-D printing technologies that use powders in space manufacturing.

The relevant environments, or “extreme environments,” are the environments encountered in space exploration but not normally encountered in terrestrial industry. These may include supersonic gas flow, rarefied atmospheres, low gravity, or zero gravity, where we have less terrestrial experience in the behaviors of granular flow.

This modeling capability will be useful as part of the engineering design and checkout process for aerospace systems, notably the technologies that will interact with planetary soil. The technologies that are sought are different than prior state-of-the-art (SOA) in granular modeling insofar as prior SOA often utilized ad hoc algorithms, empirical relationships, and “rules of thumb” to estimate granular behavior, and relied on “tweaking” model parameters until the modeling approximated experimental data over a limited range of application. (Granular flow is challenging due to meso-scale granularity that produces a bewildering array of emergent, macro-scale phenomena.) Prior SOA was therefore not truly predictive and therefore of limited power, but it was useful for modest extrapolation around a range of behaviors that has been previously validated by experiment. In contrast, advances in granular physics theory over the past 5 years are surprisingly far ahead of expectations and it is now possible to develop new modeling methods that are truly predictive for the previously unpredictable regimes of solid-like, fluid-like and gas-like flow of granular materials integrated with gas flow and mechanical devices, including extreme environments (rarefied/supersonic flow, planetary surfaces, etc.). While it is still too early to expect a software package to be capable of modeling all granular phenomena across all ranges of behavior and all environments, it is now possible to create software packages capable of handling one or more of the areas that are important to NASA and necessary for NASA’s mission.

Relevant advances in granular physics that may be incorporated into the new software may include (but are not limited to):

- Granular gas theory equivalent to Boltzmann’s Transport Equation.
- Application of granular gas theory to continuous particle size distribution to predict transport coefficients.
- Successful prediction of dense flow as a function of particle shape.
- A useful technology will be one that can be applied in the real-world engineering design process for the design and checkout of NASA spaceflight technologies.

TOPIC: T5 Communication and Navigation

Communications and Navigation Systems, consists of six technology subareas: optical communication and navigation; radio frequency communication; internetworking; position, navigation and timing; integrated technologies; and revolutionary concepts. Communication links are the lifelines to spacecraft, providing commanding, telemetry, and science data transfers as well as navigation support. Therefore, the Communications and Navigation Systems Technology Area supports all NASA space missions. Advancement in communication and navigation technology will allow future missions to implement new and more capable science instruments, greatly enhance human missions beyond Earth orbit, and enable entirely new mission concepts.

T5.01 Autonomous Navigation in GNSS-Denied Environments

Lead Center: LaRC

Participating Center(s): KSC

OCT Technology Area: [TA05](#)

Current NASA research/development and mission capabilities for exploration of remote planetary surfaces and UASs are primarily focused on automated telerobotic systems dependent on human control. More fully autonomous systems will be required for future missions, particularly where communications with Earth may be limited, unavailable for extended periods of time and have significant delays.

This subtopic is to investigate the autonomous navigation capabilities required for land and possibly aerial vehicle operation in areas lacking GNSS and/or magnetic compass to expanded exploration roles within planetary environments. A specific area of interest is to investigate biologically inspired algorithms and capabilities, such as techniques used by insects, such as Honey Bees, to accomplish this goal. Optical flow, image motion across the field of vision, offers unique capabilities for hazard detection and avoidance, landmark navigation, distance judgment, cave navigation, speed regulation, and visual odometry. Current technology is very computationally intensive. It is desired that with hardware support, high speed optic flow measurements can be obtained to speed up and simplify the extraction of motion information from the visual scene, which would both enhance obstacle and hazard detection and avoidance, as well as speed up the navigation process. This will be very critical if VTOL flight [on Mars] can be achieved, as a fuel-limited, in-motion VTOL vehicle is ill positioned to wait for a complicated and time consuming image analysis to be accomplished. Additionally, current laser scanner/imaging technology used for generating terrestrial 3-D maps have mass and power requirements that are excessive for smaller planetary robotic exploration systems. Low mass, low power 3-D mapping systems accommodated on planetary missions could be employed to support autonomous vehicle navigation and maneuvering operations. One example would be a parent vehicle that could launch multiple smaller vehicles that would autonomously explore larger regions and then navigate back to the parent vehicle to transmit data and refuel. In addition to navigation, these vehicles could gather detailed, photorealistic 3-D maps that can be fused with associated science data and used by scientists, students, and the general public for “participatory exploration” activities.

Initial activities would include an assessment of current technology capabilities that could be compared to requirements to identify technology gaps and lay out a technology development roadmap. Subsequent activities would include component and system developments in accordance with the roadmap, leading to the development of a prototype system capable autonomous navigation in environments that do not allow GNSS or magnetic compass navigation and have limited or no communication between vehicles.

TOPIC: T6 Human Health, Life Support and Habitation Systems

Human Health, Life Support and Habitation Systems, includes technologies necessary for supporting human health and survival during space exploration missions and consists of five technology subareas: environmental control and life support systems and habitation systems; extravehicular activity systems; human health and performance; environmental monitoring, safety, and emergency response; and radiation. These missions can be short suborbital missions, extended microgravity missions, or missions to various destinations, and they experience what can generally be referred to as “extreme environments” including reduced gravity, high radiation and UV exposure, reduced pressures, and micrometeoroids and/or orbital debris.

T6.01 Space Synthetic Biology and Food Production Technologies for Space Exploration

Lead Center: ARC

Participating Center(s): JSC, KSC

OCT Technology Area: [TA06](#)

Space Synthetic Biology: Synthetic Biology (SB) provides a unique opportunity to design organisms that reliably perform necessary functions for future exploration activities. NASA is interested in harnessing this emerging field to create technological advances that will benefit both spaceflight and future surface missions in a variety of enabling areas. Of particular interest is the use of SB, including bioelectrical systems/organisms and technologies, that will reduce the required up-mass and dependence on consumables, resupply, and energy. This may be done through in situ resource utilization (ISRU) and/or the development of more sustainable and efficient systems. Specifically, ISRU technologies should address how SB-based systems may use in situ resources (e.g., regolith, CO₂) to fabricate advanced materials and/or produce building materials, fuels and plastics. SB-based food production is another area of interest. SB based Environmental Control and Life Support Systems (ECLSS) should focus on increasing efficiency/reliability/regenerability of air, water and waste management. Prototype hardware to support SB-based systems and modified cell lines - (particularly BES) with potential application for ISRU, ECLSS and food production would all be of interest to NASA. A prototype DNA “writer” technology for transmitting new DNA sequences to SB systems would be considered an enabling technology.

Food Production Technologies for Space Exploration: NASA is interested in food production and related food safety technologies for both near term transit (μ -gravity) missions and eventual surface missions (fractional gravity). Of special interest is the use of plants (e.g., crops) to photosynthetically produce food, and contribute to cabin O_2 production and CO_2 removal. Food production technologies should address how quantum and/or radiation use efficiency will be improved to reduce energy costs, including advanced lighting concepts. Improved concepts for gravity independent watering techniques will also be needed. Complementary approaches might consider selecting or adapting the plants for optimal performance for the constraints of space environments, which could include smaller growing volumes, micro to fractional g, elevated radiation, super-elevated CO_2 concentrations (e.g., >5000 ppm or 0.5 kPa), and narrow band light spectra. Related technologies for sanitizing or reducing the microbial loads to reduce the safety risks of preparing and consuming space grown foods are also needed. All systems should consider minimizing power, mass, consumables, and biologically produced waste, while maximizing reliability and efficiency.

TOPIC: T7 Human Exploration Destination Systems

Reserved for future Solicitations.

TOPIC: T8 Science Instruments, Observatories and Sensor Systems

Science Instruments, Observatories, and Sensor Systems addresses technologies that are primarily of interest for missions sponsored by NASA's Science Mission Directorate and are primarily relevant to space research in Earth science, heliophysics, planetary science, and astrophysics. This topic consists of three Level 2 technology subareas: remote sensing instruments/sensors, observatories, and in situ instruments/sensors.

T8.01 Innovative Subsystems for Small Satellite Applications

Lead Center: GSFC

Participating Center(s): ARC

OCT Technology Area: [TA08](#)

This STTR solicitation is to help provide advanced technologies for satellites with masses less than approximately 20 kg and volumes less than approximately 10,000 cm³. Components or subsystems are sought that demonstrate a capability that is applicable to orbital missions to 800 km and mission durations up to 2 years. New approaches, subsystems, and components are sought that will:

- Substantially reduce the resources (cost, mass, volume, or power).
- Provide satellite bus capabilities that increase the capabilities of very small satellites while meeting the significant constraints imposed by the very limited size and mass of the observatory.

Components and subsystems are required that consider the severe mass, volume, and power constraints imposed by very small spacecraft.

T8.02 Technologies for Planetary Compositional Analysis and Mapping

Lead Center: JPL

OCT Technology Area: [TA08](#)

This subtopic addresses the need for low mass, low power technologies that support orbital and in situ compositional analysis and mapping. The focus is on developing and demonstrating technologies that can be proposed to future planetary missions. Technologies that can increase instrument resolution, precision and sensitivity, or achieve new & innovative scientific measurements, are solicited. Two areas are of particular interest: micro-scale analysis and mapping of the mineralogy, organic compounds, chemistry and elemental composition of planetary materials, related to rock fabrics and textures; and remote mapping of geologic outcrops and features. Such technologies are particularly relevant for future landed missions to the Moon, comets, asteroids, Mars, Europa, Titan, and other planetary bodies. For example missions, see (<http://science.hq.nasa.gov/missions>). For details of the specific

requirements see the National Research Council's, Vision and Voyages for Planetary Science in the Decade 2013-2022 (<http://solarsystem.nasa.gov/2013decadal/>).

Possible areas of interest include:

- Improved sources such as lasers, LEDs, X-ray tubes, etc. for imaging and spectroscopy instruments (including Laser Induced Breakdown Spectroscopy, Raman Spectroscopy, Deep UV Raman and Fluorescence spectroscopy, Hyperspectral Imaging Spectroscopy, and X-ray Fluorescence Spectroscopy).
- Improved detectors for imaging and spectroscopy instruments (e.g., flight-compatible iCCDS and other time-gated detectors that provide gain, robot arm compatible PMT arrays and other detectors requiring high voltage operation, detectors with improved UV and near-to-mid IR performance, near-to-mid IR detectors with reduced cooling requirements).
- Technologies for 1-D and 2-D raster scanning from a robot arm.
- Novel approaches that could help enable in situ organic compound analysis from a robot arm (e.g., ultra-miniaturized Matrix Assisted Laser Desorption-Ionization Mass Spectrometry).
- "Smart software" for evaluating imaging spectroscopy data sets in real-time on a planetary surface to guide rover targeting, sample selection (for missions involving sample return), and science optimization of data returned to Earth.
- Other technologies and approaches (e.g., improved cooling methods) that could lead to lower mass, lower power, and/or improved science return from instruments used to study the elemental, chemical, and mineralogical composition of planetary materials.

Projects selected under this subtopic should address at least one of the above areas of interest. Multiple-area proposals are encouraged. Proposers should specifically address:

- The suitability of the technology for flight applications, e.g., mass, power, compatibility with expected shock and vibration loads, radiation environment, interplanetary vacuum, etc.
- Advantages of the proposed technology compared to the competition.
- Relevance of the technology to NASA's planetary exploration science goals.

T8.03 Science Instruments for Small Missions (SISM)

Lead Center: ARC

OCT Technology Area: [TA08](#)

Advancements in supporting spacecraft technologies are making small spacecraft more and more capable. Features such as extensive computing power, attitude determination and control systems, and even propulsion are allowing mission designers to consider small and very small spacecraft to perform operational and scientific investigations. However, one area that is lagging is the miniaturization of instrument systems that would be compatible with this new class of small spacecraft. Until science instruments can be downsized in order for them to be accommodated on small spacecraft, the utility of cubesats, nanosats, and mini-spacecraft platforms will be limited.

To stimulate and create scientific instrument technologies that are compatible with small spacecraft, this subtopic seeks to identify, develop, and prepare for flight demonstration, scientific instruments compatible with one or more of the small spacecraft platforms described at the end of this solicitation. Science applications may be in Astrophysics, Earth Science, Heliophysics, Planetary Science, or Astrobiology.

Examples for proposals sought include, but are not limited to:

Astrophysics:

- *Need* - Ability to view diffuse / dispersed / low-intensity astrophysical phenomena requiring zero light background without high spatial resolution; good for full-sky mapping applications.
- *Instrument* - Multiband / hyperspectral imaging compact telescope
- *Measurement* - ERE emission from bright ionized (HII) regions, e.g., Orion Bar ionization edge, and correlation of ERE and PAH emissions from any orbit with at least multi-month lifetime.

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- *Impact* - Understanding of astrophysical phenomena, esp. those relevant to carbon sources. Such measurement will demonstrate the science capability on small spacecraft.

Earth Science:

- *Need* - Mapping terrestrial phenomena with multiple low-cost imagers for short-revisit period capability.
- *Instrument* - Hyperspectral Earth imager (including constellations of multiple imagers)
- *Measurement* - Ocean color due to algal blooms and other natural phenomena, or anthropogenic impact due to deforestation, CO₂ emissions, etc. Such measurements may require spectral mapping of large areas with short re-map period. Demonstration may be from a sun synchronous low earth orbit.
- *Impact* - Better tracking / understanding of algal blooms sources, CO₂ sources, etc. Such measurement will demonstrate science capability on small spacecraft.

Earth Science:

- *Need* - Long-path atmospheric analysis (using sun as light source)
- *Instrument* - Compact (FT)IR spectrometer w/ telescope
- *Measurement* - Assess highly dilute inorganics or organics in upper atmosphere due to pollution or meteoritic infall, from Low Earth Orbit.
- *Impact* - Improved understanding of pollutant dynamic mobility/ degradation and/or cosmic organic sources. Such measurement will demonstrate science capability on small spacecraft.

Planetary Science:

- *Need* -
 - Evaluating the reactivity / habitability of extraterrestrial surfaces.
 - On orbit analysis of materials exposed to the space environment.
- *Instrument* - Compact XPS (X-ray photoelectron spectrometer) for surface chemistry analysis - moon, Mars, NEOs, beyond.
- *Measurement* - Characterization of regolith chemical reactivity: quantify reactive inorganic ions & radicals incl. oxyhalides, peroxides, superoxides, odd-O/odd-H species; regolith organic alteration products. Subsurface measurement of supports for and threats to life: energy sources; possible toxic & reactive compounds; soluble anions/cations& dissolved gases.
- *Impact* - Buy down of long term risk. Demonstrating on-orbit material analysis capability, for technology that will be deployed on landers or rovers, will lead to better understanding of surface conditions that impact survival of organics, biomarkers, and life.

Planetary Science:

- *Need* -
 - Investigating the Reactivity / habitability / evolution of extraterrestrial surfaces.
 - On orbit analysis of materials exposed to the space environment.
- *Instrument* - Compact SIMS (secondary ion mass spectrometer) or LDMS (laser desorption mass spec) for surface mass & chemistry analysis - moon, Mars, NEOs, beyond.
- *Measurement* - Characterization of regolith chemical reactivity: quantify reactive inorganic ions & radicals incl. oxyhalides, peroxides, superoxides, odd-O/odd-H species; regolith organic alteration products. Subsurface measurement of supports for and threats to life: energy sources; possible toxic & reactive compounds; soluble anions/cations& dissolved gases.
- *Impact* - Buy down of long term risk. Demonstrating on-orbit material analysis capability, for technology that will be deployed on landers or rovers, will lead to better understanding of surface conditions that impact survival of organics, biomarkers, and life.

Astrobiology:

- *Need* - Evaluate rates and nature of mutations caused by the space environment.

- *Instrument* - Miniaturized DNA sequencer to study mutations
- *Measurement* - Cultures of cells or small organisms supported in space radiation environment for months: evaluate genetic profile after 1000's of generations Location would be High Earth Orbit, geo-syn, or various libration points.
- *Impact* - Understand how mutation can play a role in rapid evolution in response to radiation stressors. Miniaturization and demonstration on a small spacecraft mission may eventually lead to a compact sequencer for personalized medicine.

Proposals are sought that significantly advance state of the art for scientific measurements. Proposals for science instruments that represent only incremental improvements in the state-of-the-art capabilities, or are of interest to relatively few users are not appropriate for this solicitation. Proposed concepts should show a relevance to external customers or stakeholders needs.

Proposer shall describe the proposed design, development, analysis, testing and evaluation needed for the technology; and outline a concept of operations for demonstration of the technology on a small mission platform. How the proposed technology is differentiated from currently available technologies must be clearly communicated.

Phase I contracts will be expected to demonstrate feasibility, and Phase II contracts will be expected to fabricate and complete ground testing on an actual instrument/test article for potential demonstration on a small mission.

Small Spacecraft Platforms

Cubesats - Cubesats are usually 10 x 10 x 10 cm (for a 1U) or 10 x 10 x 30 cm (for a 3U) nanosatellites. Other sizes are also in development, such as a 6U. Cubesats are typically launched as auxiliary spacecraft. Multiple cubesats may also be launched simultaneously in order to create constellations and other useful space architectures.

Specifications and standards for cubesats may be found at (<http://www.cubesat.org/>).

University Nanosats - University Nanosats are typically 50 x 50 x 60 cm and weigh less than 50 kg. They are also auxiliary spacecraft launched with other spacecraft on rideshare missions, typically using 15" or 8" Lightband deployment systems (see <http://www.planetarysystems.com/> for more info on Lightband and Planetary Systems, Corp.).

The Air Force Research Lab has sponsored the development of these spacecraft via the University Nanosat Program (see <http://pr.s.af.mil/UNP/>).

Technology Demonstration Spacecraft - A larger spacecraft platform for the demonstration of a number of instrument payloads was illustrated by the recent NASA/MSFC FASTSAT mission. FASTSAT is an ESPA-class spacecraft, deployed via a 15" Lightbanddeployer, and is designed to accommodate a number of independent instrument systems. FASTSAT provides basic power, data/communications, and thermal management support for these payloads as part of an integrated space flight demonstration mission.

TOPIC: T9 Entry, Descent and Landing Systems

Entry, Descent, and Landing, consists of four sub-technology areas:

- Aeroassist and entry.
- Descent.
- Landing.
- Vehicle systems technology.

Entry, Descent and Landing (EDL) is a critical technology that enables many of NASA's landmark missions, including Earth reentry, Moon landings, and robotic landings on Mars. The EDL topic defines entry as the phase from arrival through hypersonic flight, with descent being defined as hypersonic flight to the terminal phase of

landing, and landing being from terminal descent to the final touchdown. EDL technologies can involve all three of these mission phases, or just one or two of them.

T9.01 Technologies for Aerospace Experimental Capabilities

Lead Center: DFRC

Participating Center(s): ARC, JSC, KSC, LaRC

OCT Technology Area: [TA09](#)

The emphasis of this subtopic is proving feasibility, developing, and demonstrating technologies for advanced Aerospace research experimentation that matures new methodologies, technologies, and concepts. It seeks advancements that promise significant gains in NASA's experimental research capabilities or addresses barriers to measurements, operations, safety, and cost in all flight regimes from low sub-sonic to high supersonic to space. This subtopic solicits innovative technologies that enhance experimental research competencies by advancing capabilities for ground and in-flight experimentation. Proposals that demonstrate and confirm reliable application of concepts and technologies suitable for flight research and the test environment are a high priority.

Measurement techniques are needed to acquire aerodynamic, structural, flight control, and propulsion system performance characteristics to safely expand the flight envelope of aerospace vehicles. Spacecraft guidance, navigation and Control validation techniques are needed. The goals are to improve the effectiveness of flight-testing by simplifying and minimizing sensor installation, measuring parameters in novel ways, improving the quality of measurements, and minimizing the disturbance to the measured parameter from the sensor presence. Sensors and systems are required to have fast response, low volume, minimal intrusion, and high accuracy and reliability. Special areas of interest include:

- Testing and Validation for Lightweight structures and materials.
- Methods and associated technologies for conducting flight research and acquiring test information in flight.
- Numerical methods for the planning, prediction, analysis and validation of flight-test experimentation.
- Sensors and data systems that have fast response, low volume, minimal intrusion, and increased accuracy and reliability.
- Innovative techniques that decrease turn-around time for inspections and assessments for safe operations of aircraft and spacecraft (e.g., non destructive examination of composites through ultrasonic techniques).
- Advanced design and manufacturing techniques for improved upper stage performance for nano- & small-satellite booster technologies (e.g., manufacturability, affordability, and performance of a small upper-stage booster rocket motors for small & nano-satellites).
- Aerodynamic boundary layer and laminar flow control and drag reduction.
- Precision landing systems.
- Autonomous, fault-tolerant GN&C.
- Autonomous Rendezvous and Docking.

TOPIC: T10 Nanotechnology

Nanotechnology, addresses four subareas: engineered materials and structures, energy generation and storage, propulsion, and sensors, electronics, and devices. Nanotechnology describes the manipulation of matter and forces at the atomic and molecular levels and includes materials or devices that possess at least one dimension within a size range of 1-100nm. At this scale, quantum mechanical forces become important in that the properties of nano-sized materials or devices can be substantially different than the properties of the same material at the macro scale. Nanotechnology can provide great enhancement in properties, and materials engineered at the nano-scale will shift the paradigm in space exploration, sensors, propulsion, and overall systems design.

T10.01 Innovative Refractory Materials for Rocket Propulsion Testing

Lead Center: SSC

Participating Center(s): KSC

OCT Technology Area: [TA10](#)

NASA has identified the advancement of materials as a critical technological need in supporting future space flight and rocket test operations. Specifically, innovative materials for thermal management applications have been targeted with the additional goal of furthering nanotechnology. With the development of these new multi-functional, high-temperature materials comes the requirement for verification and validation of the predictability of their thermal behavior.

The current subtopic is to develop innovative refractory materials which use nano-particle additives and/or unconventional non-cement based refractories that can withstand the extreme plume heating environments experienced during rocket propulsion testing. The material should provide a revolutionary improvement over conventional castable refractories. Explicitly, the nano-based or multi-functional material should provide substantial improvements in several of the following areas:

- Compressive and flexural strength.
- Thermal, abrasion and corrosion resistance.
- Operating temperatures at or above 4000 °F.
- Excellent workability for potential lining of vertical walls/pipes.
- Ultra-low porosity.

Demonstration of the performance of these materials in environments similar to rocket plume environments will be a critical aspect of the success and usefulness of the proposed technology. In addition, verification and validation of the predictability of the material behavior during ablative heating is of high importance to the mission of NASA.

Other potential applications of nano-particle/multi-functional refractory materials might be use in expendable (or even reusable) rocket engine thrust chambers, control system thrusters, and nozzles to extend the life of the testing infrastructure and components. These engine components could be for launch or in-space propulsion systems. This application would add a requirement to be light weight and provide manufacturability for use in coatings or production of components.

TOPIC: T11 Modeling, Simulation, Information Technology and Processing

Modeling, Simulation, Information Technology and Processing consists of four technology subareas, including computing, modeling, simulation, and information processing. NASA's ability to make engineering breakthroughs and scientific discoveries is limited not only by human, robotic, and remotely sensed observation, but also by the ability to transport data and transform the data into scientific and engineering knowledge through sophisticated needs. With data volumes exponentially increasing into the petabyte and exabyte ranges, modeling, simulation, and information technology and processing requirements demand advanced supercomputing capabilities.

T11.01 Software Framework & Infrastructure Development of Spaceborne Hybrid Multicore/FPGA Architectures

Lead Center: GSFC

Participating Center(s): ARC, JPL, KSC

OCT Technology Area: [TA11](#)

Future high-performance on board computing systems will likely employ hybrid architectures consisting of both advanced multi-core processors and reconfigurable Field Programmable Gate Arrays (FPGAs), which may include additional embedded hard and/or soft core processors along with processing functions implemented in the FPGA logic. Advanced software architectures, software infrastructure elements and software design tools are needed to compliment these advanced hardware platforms and enable their efficient/effective use. The intent of this subtopic is to develop these software architectures, infrastructure elements and tools.

Desired technologies include multi-core software frameworks, multi-core operating system components, hardware/software abstraction layers & interfaces, and development systems/tools/simulators. Additionally, middleware/hypervisors are needed that can perform memory protection and run-time allocation of tasks to processing resources, and address performance optimization, energy management, and fault mitigation.

T11.02 Distributed Simulation for Design and Manufacturing

Lead Center: KSC

OCT Technology Area: [TA11](#)

NASA is embarking on missions to new environments with new technologies and new systems to take us far beyond where any human has gone before.

Understanding, managing and leveraging the associated complexity will require new tools, new methods, new ways of managing data and, in the long run, entirely new types of data as well. Simulation plays a key role in each of these areas with advanced tools and processes already in use to define architectures, study options and integrate alternatives into the overarching plan. However, today's tools, and even tomorrow's tools, lack the ability to integrate and share information on the physical and temporal scale necessary to efficiently and effectively enable these systems.

Desired product is a prototype suite of tools, systems and processes to allow researchers, innovators and operational organizations to share simulation based needs, technologies, concepts and opportunities over large distances (planets) and large increments of time (decades). The system should utilize existing Industry and NASA standards and interfaces for simulation data, suggest new ones, or both. Emphasis should be placed on interfaces like XML to both extend the lifecycle of data elements into the 50 year range as well as interface with the emerging set of NASA tools.

Distributed Simulation of this nature has been identified by the National Research Council as one of the 83 high priority technologies for NASA as a part of the OCT roadmap team efforts. It is a part of TA 11 (modeling, simulation, information technology and processing) and is one of the 4 high priority technologies identified for that roadmap. It directly supports any complex design and development efforts directly and supports technology push and pull by better communicating programmatic needs and technology solutions in relevant operational environments.

TOPIC: T12 Materials, Structures, Mechanical Systems and Manufacturing

Materials, Structures, Mechanical Systems, and Manufacturing This topic is extremely broad, covering five technology areas: materials, structures, mechanical systems, manufacturing, and cross-cutting technologies. The topic consists of enabling core disciplines and encompasses fundamental new capabilities that directly impact the increasingly stringent demands of NASA science and exploration missions.

T12.01 High Temperature Materials and Sensors for Propulsion Systems

Lead Center: GRC

OCT Technology Area: [TA12](#)

Advanced high temperature materials and sensors are crosscutting technologies which can be used in component and subsystem applications essential in the design, development and health maintenance/detection needs of future generations of aeronautical and space propulsion systems. Proposals are sought that address:

- Advanced high temperature materials technologies, both design and development, needed to meet application challenges associated with propulsion systems. Proposals must be linked to improvements in future performance indicators, such as vehicle weight, fuel consumption, noise, lift, drag, durability, and emissions for aircraft, and/or reduced mass components and thermal management properties to meet space vehicle propulsion needs. Technology interests include:
 - Innovative approaches to enhance the durability, processability, performance and reliability of advanced materials (super alloys, high strength fibers and environmental barrier coatings for ceramic matrix composites with temperature capability greater than 2700 °F, and corrosion/oxidation resistant coatings for turbine disk materials operating at temperatures in

- excess of 1400 °F, innovative joining methodologies for bonding powder metallurgy disk material to directionally solidified/single crystal rim alloy for a hybrid disk);
 - High temperature shape memory alloys and methods to integrate these materials into propulsion system structures for changing component shape and actuation devices;
 - High temperature magnets with greater than 500 °F capability;
 - Multifunctional high temperature materials, combining structural properties with a second capability, such as power harvesting, thermal management, self-sensing, and materials for wireless sensing and actuation;
 - Environmentally-friendly manufacturing processes for high temperature polymer materials with temperature capability 500 °F or higher.
- Innovative smart sensing methods and associated measurement techniques for the cost-effective, reliable assessment of the health of aerospace engine and vehicle components in harsh high-temperature environments (1900 °F – 3000 °F) allowing a proactive approach to maintain capability and safety. Engine and vehicle structures ground and flight testing applications can lead to thermal and other environmental conditions beyond the limits of current sensing technology. Sensors and systems are required to have fast response, low volume and weight, be minimally intrusive and possess high accuracy and reliability. Special areas of interest include:
 - Development and validation of innovative sensors and improved methods for attaching to advanced high-temperature materials and integrating sensors into systems (wireless, wired or fiber optic).
 - Approaches to measure strain, temperature, heat flux, deflection, acoustics and/or acceleration of structural components are sought.
 - Compact, non-contact, full-field sensing systems for structural information.
 - Nanotechnology offers a means to: a. develop higher-temperature/environmentally-resistant structural materials with engineered micro structures that can optimize material properties for propulsion hot section components; b. enables tailoring the thermal conductivity of materials, making them more efficient conductors or insulators; c. permits targeted sensor applications that can improve functional efficiency; d. supports developing nano-sensors that may be incorporated in hot section structures/systems that are smaller, more energy efficient and potentially providing more sensitive health assessments capability.
 - Design Methods/Tools, which are robust and efficient, to design advanced materials based on first principles and micro structural models that can be used in a multi-scale framework.

Proposed Deliverable to NASA: Advanced high temperature materials, high strength fibers, protective coatings; new sensors, attachment techniques, beta versions of sensor systems; and new computational models.

What would be the major implication of not having this subtopic? High temperature materials technologies are required to meet the flight vehicle hot surface needs and to enable development of the advanced aerospace propulsion systems necessary to the NASA mission success. Industry looks to NASA to provide these technologies and capabilities to help them meet/exceed the National goals - environmental regulations, contributing to green energy and meeting and customer performance requirements. Novel sensor systems are critical to moving the technology from the laboratory environment to ground test activities and flight vehicle applications.

NASA Relevance: High temperature materials and advanced sensors were each highlighted as high priority needs in both the National Aeronautics Plan for Aeronautics Research and the National Research Council's report, NASA Space Technology Roadmaps and Priorities, documents.

Aeronautics:

- Mobility R&D Goal 5 Far-term Objective 3
- National Security and Homeland Defense R&D Goal 3 Far-term Objective 1 and Goal 4 Far-term Objective 2
- Aviation Safety Goal 1 Far-term Objectives 1 and 3
- Energy and Environment R&D Goal 2 Far-term Objective 2, 3 and 4

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Space:

- Reduce vehicle mass and/or improve thermal management performance by employing nanotechnologies to develop lighter-weight multifunctional materials/ (structures) and sensors with unique capabilities and better performing.
- Structural health monitoring/sensors for long duration missions/responsive on-board systems:
 - Reduced propulsion structure mass.
 - Computational modeling design/analysis/simulation methods for materials certification/reliability.

Center relevance, i.e., project, program and mission:

- ARMD Programs.
- OCT.
- Space Exploration Mission Directorate.

List any commercialization plans or possible mission opportunities for technologies: Upcoming ARMD and reimbursable testing activities

Other potential government funding or applications:

- ARMD Seedling.
- Fundamental Aeronautics at higher TRL.
- OCT CIF.
- DOD.
- DOE.
- DARPA.

Identify OCT Mission Directorate and/or Field Center advocate(s) committed to support development through a Phase III award:

- Leslie A. Greenbauer-Seng (GRC/Deputy Structures and Materials Division).
- Tim Risch (DRFC/Deputy Chief Aerostructures Branch).

T12.02 Materials and Manufacturing Technologies

Lead Center: MSFC

Participating Center(s): GRC, JSC, LaRC

OCT Technology Area: [TA12](#)

NASA's science and exploration missions continue to seek materials and manufacturing techniques and capabilities that will allow missions of increased capability and reduced costs. These future missions depend highly on advancements such as lighter and stronger materials and manufacturing methods. Materials and manufacturing technologies have high value and make a significant contribution to the interests of others outside of NASA, specifically those that address broader national needs as well as the needs of the commercial space industry. The portfolio of advanced materials and manufacturing technologies is extremely broad and cross-cutting with complex interactions between core disciplines (e.g., materials and structures), applied R&D, innovation, and production.

In reference to the recent report from the National Research Council on the Space Technology Roadmaps produced by NASA's Office of Chief Technologist, the report ranks lightweight and Multifunctional Materials and Structures as an area of high priority development to be emphasized over the next 5 years. This topic seeks technologies that support these needs:

- Lightweight and multifunctional materials concepts including, advanced composite, metallic, and ceramic materials that significantly enhance future exploration and science missions and enable new missions.
- Digital/Model-based Manufacturing technologies that enable cost-effective manufacturing for reliable high-performance structures and made in low-unit production, including in-space manufacturing.

- In-space and additive manufacturing that offers the potential for game-changing weight savings and new mission opportunities.

University researchers are well-positioned to make a positive contribution within the time and funding allocation vis-a-vis a concept demonstration, enhancement of an existing component through a clever innovation, working prototype, etc. Also, this topic of materials and manufacturing technologies supports and is closely aligned with the President's National Strategic Plan for Advanced Manufacturing.

TOPIC: T13 Ground and Launch Systems Processing

The goal of this topic is to provide a flexible and sustainable US capability for ground processing as well as launch, mission, and recovery operations to significantly increase safe access to space. The Ground and Launch Systems Processing topic consists of four technology subareas, including: technologies to optimize the operational life-cycle, environmental and green technologies, technologies to increase reliability and mission availability, and technologies to improve mission safety/mission risk. The primary benefit derived from advances in this technology area is reduced cost, freeing funds for other investments.

T13.01 Risk Engineering, Sciences, Computation, and Informed Decisions

Lead Center: JSC

Participating Center(s): KSC

OCT Technology Area: [TA13](#)

Human spaceflight missions in the early twenty-first century are still inherently complex and risky. While it takes a very talented and courageous flight crew to achieve a mission's objectives, it takes many more people on the ground to plan, prepare, and support the flight crew during the mission to ensure the safety of the crew and the success of the mission. For every human spaceflight mission, many decisions are made before each mission and more decisions are made during the mission in responding to changes in the environments or space vehicle systems. As in many other complex operations in harsh environments on Earth, labor-intensive information research and analyses is necessary to weigh the benefits versus the risks of each alternative in order to make accurate risk-informed decisions. Often these decisions need to be made in a short period of time before space vehicle systems are out of consumables or the risk of continuing the mission becomes unacceptable. Sometimes a decision that reduces risk in one limited perspective or frame of reference inadvertently increases system-level or end-to-end mission risk due to impacts that were not foreseen due to limited human ability to consider and assess all relevant data.

This STTR subtopic seeks to advance the state-of-the-art in knowledge management, information management, information technology, and artificial intelligence leading toward the ability for computer systems to assist humans in timely and correctly identifying, quantifying, characterizing, mitigating, and communicating risks to inform decision makers of risks before the decisions are made. Application of advanced computer-based decision support technologies to identify and assess relevant data, identify alternatives, and model consequences will significantly reduce the cost of development, deployment, and sustainment of complex space systems and significantly increase safety of crew during space missions. Below are some examples of technologies that would be appropriate for this sub-topic:

- *Timely Risk Identification* - For several decades, the Failure Modes and Effects Analysis has been used to identify risks inherent in space system designs. Analysis results are frequently not available until the system design has matured to the point where it is ready for final development, test, and or deployment. Changes late in the design lifecycle often cannot be accommodated due to significant schedule delay and cost increase. Although designing out hazards is the most effective and preferred means of control, mitigations for identified risks at this time are usually limited to procedural controls which require recurring attention throughout the operational phase. This often results in operational complexity, higher risk, and higher sustaining cost. An automated failure modes and effects simulation technology would be a game-changer by identifying safety and technical risks of the design early and quickly so that design changes or trades may be made to eliminate these risks at a much lower lifecycle cost and significantly improve safety and system reliability.

- *Risk-Informed Decision Making* - As space systems become more complex and human space exploration destinations get farther away from Earth, the flight crew may be forced to make timely decisions in responding to imminent hazardous conditions without the assistance of the ground crew. Risk-informed decision support technologies would assist the flight crew by suggesting possible actions that have the highest probability of success.
- *Context-Based Software Risk Modeling* - Space system designers are considering incorporating or increasing levels of automation in their systems to achieve a sustainable human space exploration program. Although the desired outcome is a net reduction of overall mission risk, more automation will result in increasing the complexity of the software systems, and thus increase the proportion of risk attributable to software faults as a component of system risk. NASA is seeking Context-Based Software Risk Model technologies to address the risks of software required functionality that would be compatible and consistent with the standard Probabilistic Risk Assessment methodology now employed by NASA. An effective integration of the PRA and CSRM techniques would facilitate comparative evaluations of automation design options for effectiveness in reducing mission risks.

TOPIC: T14 Thermal Management Systems

Reserved for future Solicitations.

TOPIC: T15 Cross-cutting Aeronautics

A strong national program of research and development (R&D) for aeronautics technology forms the foundation of the U.S. aeronautics and aviation enterprise. Aeronautics R&D is critical for national security and homeland defense, an efficient national air transportation system, and the economic well-being and quality of life of our citizens. The National Aeronautics Research and Development Plan (Plan) lays out high-priority national aeronautics R&D challenges, goals, and supporting objectives to guide the conduct of U.S. The Plan includes an important new goal regarding the integration of unmanned aircraft systems into the National Airspace System. In addition, this R&D Plan:

- Supports the coordinated efforts of the Federal departments and agencies in the pursuit of stable and long-term foundational research.
- Ensures U.S. technological leadership in aeronautics for national security and homeland defense capabilities.
- Advances aeronautics research to improve aviation safety, air transportation, and reduce the environmental impacts of aviation.
- Promotes the advancement of fuel efficiency and energy independence in the aviation sector.
- Spurs the development of innovative technologies that enable new products and services.

Most of the R&D goals and objectives will require stable and long-term foundational research across a breadth of aeronautics disciplines to provide the underlying basis for new technological advances and breakthroughs. Such foundational research is often cross-cutting, resulting in technology advances that have applications across several Principles Moreover, new ideas and technologies that are generated by foundational research will help inform future updates to the National Aeronautics Research and Development Plan.

T15.01 Cross cutting Avionics for Beyond Earth Orbit Space Exploration

Lead Center: JSC

Participating Center(s): KSC, MSFC

As NASA human exploration and science missions move further from Earth and become increasingly more complex, they present unique challenges to the on-board avionics systems. Avionics systems in space vehicles are significant size, weight and power (SWaP) as well as cost drivers. Future destinations such as L2, near-earth asteroid, Mars, etc. are characterized by long durations, vast distances and harsh environments and call for significant advances in on-board processing, autonomy, reliability, fault-tolerance and redundancy. Advanced

technologies and approaches to avionics systems and its components are needed to support these challenging mission requirements and to safely bring crew back to Earth.

Avionics provides cross- capabilities across different sub-systems and is a prime candidate for commonality between different missions and programs leading to savings in the design, development and testing, logistics (sparing, reuse, and re-purposing of hardware) and operational costs.

To support exploration mission objectives and requirements, advances in emerging avionics technologies (processors, networks and network devices, memory cards, human interfaces including visual, tactile and auditory interfaces, etc.) and associated foundational technology are required. Areas addressing miniaturization, radiation and extreme temperature environments such as radiation hardened by design, Rad-hard extreme temperature technology, and electronics packaging, etc. are of particular interest.

The focus of this subtopic is to support the development and advancement of cost-effective avionics technologies while keeping a unified approach to promote commonality of systems between multiple missions and/or programs. The ultimate goal is to develop a common avionics framework and a catalog of components that can be integrated into a space vehicle in the next 6-10 years.

T15.02 Autonomous Systems for Atmospheric Flight

Lead Center: LaRC

Participating Center(s): KSC

With increasing levels of automation capabilities in the aviation arena, provides unique opportunities and challenges for civil aviation, and the aerial transport communities. Flight will be transformed as these capabilities mature and evolve in to integrated systems. In particular, autonomous and robotic, manned and unmanned civil aircraft systems will lead to a plethora of new markets, vehicle, and missions. These new systems with broad range of capabilities, and a huge diversity of shapes and sizes, must safely utilize the future National Airspace System. Both operational and machine autonomy will require tremendous breakthroughs through the new technology frontiers in machine intelligence, autonomy, robotics, and inter-connections of these technologies. Breakthroughs in these areas could lead to such societal capabilities as autonomous cargo carrying, surveillance, air taxis, small unmanned civil aircraft, Zip aircraft, on-demand VTOL aviation, airborne wind energy platforms and a host of other emerging distributed aviation systems.

The goal of this topic area is to develop technologies and capabilities that will lead to fully autonomous systems that are able to learn and adapt to changes in their environment that were not predicted, and yet still accomplish the mission goals, with minimal or no human involvement required.

For purposes of this solicitation, autonomous vehicles have varying levels of autonomy and range from automated capability to fully autonomous flight where the system has the ability to learn, reason, and adapt. Military applications have demonstrated the ability to do automated flight but their use in civil aviation requires additional research and development. The primary interest of this sub-topic is to advance the technologies for robotic and autonomous vehicle perception, cognition, as well as system integration. Proposals should be written around one of the following themes described below:

- Autonomous or robotic pilot - Autonomous systems can be applied far beyond remotely piloted aircraft. Maximum machine effectiveness can only be realized through vehicle autonomous systems ability to learn, reason and adapt. Current practice is to have a reliance on stored information, which is complemented by GPS position information. If there is an on-board, real-time means to sense and react to the local environment (including air and ground features and traffic), then autonomous and robotic air-vehicle can be fully utilized. But addressing how adaptive systems can still be ‘trusted’ in critical flight environments and achieve FAA certification is a technical issue that must be resolved. Proposals are sought to develop innovative approaches and enabling technologies for autonomous, robotic, and embodied intelligent air-vehicles. Example scenarios could include but are not limited to carrying passengers and cargo through the NAS, search, rescue, and surveillance operations, and sentries to patrol coastal waters, and land borders. Proposal should consider perception, cognition, as well as GPS enabled, GPS-denied, and cooperating and non-cooperating traffic environments.

- Autonomy for flight, the robotic test pilot. Adaptive and robust controllers designed to autonomously fly and optimize around multiple vehicles. Products would be aerodynamic coefficients such as coefficient of lift and drag as well as controller effectiveness.
- Autonomous intelligence, surveillance and reconnaissance. A next generation system would entail a “smart payload” with a UAS designed around it to accomplish specific missions. Example missions might include, but are not limited to disaster relieve, fire monitoring, launch vehicle tracking, or hurricane tracking. The payload would ultimately permit autonomous target acquisition, tracking, and aircraft attitude/orientation to optimize data collection, or ensuring mission completion. Initial activities would include an assessment of current technology capabilities that could be compared to requirements for a next generation autonomously controlled sensor and platform system to identify technology gaps and lay out a technology development road map. Subsequent activities would include component and system developments and integration in accordance with the road map, leading to the development of a prototype system capable of integrating with a UAS.

Appendices


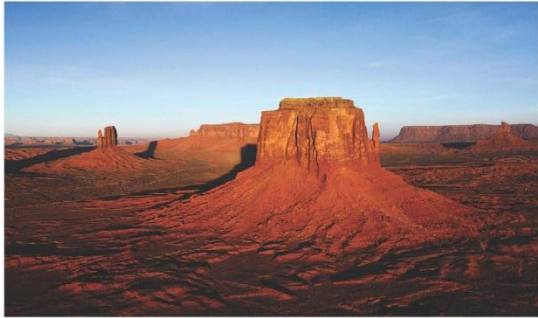
Appendix A: Sample Briefing Chart

All briefing charts are done electronically and are created using the “Briefing Chart” form that is linked in the Activity Worksheet of the Proposal Submission EHB. Each section should be completed and the “Submit” button selected to save changes.

Input: Below is a sample form of the required input:

Proposal Title:
PI Name: Firm Name: City, State:
Image:
Upload Image: Select Image Type (BMP, GIF, JPEG, TIF) : Browse Images:
Note: The uploaded image will be scaled 340x200 pixel size in the generated briefing chart.
Identification and Significance of Innovation: (Limit 1,000 characters or 15 lines, whichever is less)
Enter brief and concise text here related to the identification and significance of the innovation.
Technical Objectives and Work Plan: (Limit 1,500 characters or 20 lines, whichever is less)
Enter brief and concise text here related to the technical objectives and work plan.
NASA Applications: (Limit 500 characters or 6 lines, whichever is less)
Enter text here related to the technology’s NASA applications.
Non-NASA Application: (Limit 400 characters or 6 lines, whichever is less)
Enter text here related to the technology’s non-NASA applications.
Firm Contact: (Please check the main firm contact for the technology)
<input type="checkbox"/> Business Contact <input type="checkbox"/> Principle Investigator <input type="checkbox"/> Other, Specify Name: _____

Output: Once the input has been completed submitted online, a PDF version of the briefing chart is created automatically and is available for download. A sample of the electronic output is shown below:

NASA SBIR/STTR Technologies A1.01-9999 - Test Proposal for R*E*I												
PI: NASA SBIR TESTREI Systems Inc. - McLean, VA												
<u>Identification and Significance of Innovation</u> Enter text here related to the identification and significance of the innovation.												
Estimated TRL at beginning and end of contract: (Begin: 3 End: 4) <u>Technical Objectives and Work Plan</u> Enter text here related to the technical objectives and work plan.	<u>NASA Applications</u> Enter text here on NASA applications.											
	<u>Non-NASA Applications</u> Enter text here on Non-NASA applications.											
	<u>Firm Contacts</u> <table border="0"> <tr> <td>Test User</td> <td></td> </tr> <tr> <td>TESTREI Systems Inc.</td> <td></td> </tr> <tr> <td>P.O. Box 9183</td> <td></td> </tr> <tr> <td>McLean, VA, 20171-1111</td> <td></td> </tr> <tr> <td>PHONE: (703) 480-9100</td> <td></td> </tr> </table>		Test User		TESTREI Systems Inc.		P.O. Box 9183		McLean, VA, 20171-1111		PHONE: (703) 480-9100	
Test User												
TESTREI Systems Inc.												
P.O. Box 9183												
McLean, VA, 20171-1111												
PHONE: (703) 480-9100												
NON-PROPRIETARY DATA												

Appendix B: Technology Readiness Level (TRL) Descriptions

The Technology Readiness Level (TRL) describes the stage of maturity in the development process from observation of basic principals through final product operation. The exit criteria for each level documents that principles, concepts, applications or performance have been satisfactorily demonstrated in the appropriate environment required for that level. A relevant environment is a subset of the operational environment that is expected to have a dominant impact on operational performance. Thus, reduced-gravity may be only one of the operational environments in which the technology must be demonstrated or validated in order to advance to the next TRL.

TRL	Definition	Hardware Description	Software Description	Exit Criteria
1	Basic principles observed and reported.	Scientific knowledge generated underpinning hardware technology concepts/applications.	Scientific knowledge generated underpinning basic properties of software architecture and mathematical formulation.	Peer reviewed publication of research underlying the proposed concept/application.
2	Technology concept and/or application formulated.	Invention begins, practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture.	Practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture. Basic properties of algorithms, representations and concepts defined. Basic principles coded. Experiments performed with synthetic data.	Documented description of the application/concept that addresses feasibility and benefit.
3	Analytical and experimental critical function and/or characteristic proof of concept.	Analytical studies place the technology in an appropriate context and laboratory demonstrations, modeling and simulation validate analytical prediction.	Development of limited functionality to validate critical properties and predictions using non-integrated software components.	Documented analytical/experimental results validating predictions of key parameters.
4	Component and/or breadboard validation in laboratory environment.	A low fidelity system/component breadboard is built and operated to demonstrate basic functionality and critical test environments, and associated performance predictions are defined relative to the final operating environment.	Key, functionally critical, software components are integrated, and functionally validated, to establish interoperability and begin architecture development. Relevant Environments defined and performance in this environment predicted.	Documented test performance demonstrating agreement with analytical predictions. Documented definition of relevant environment.
5	Component and/or breadboard validation in relevant environment.	A medium fidelity system/component brassboard is built and operated to demonstrate overall performance in a simulated operational environment with realistic support elements that demonstrates overall performance in critical areas. Performance predictions are made for subsequent development phases.	End-to-end software elements implemented and interfaced with existing systems/simulations conforming to target environment. End-to-end software system, tested in relevant environment, meeting predicted performance. Operational environment performance predicted. Prototype implementations developed.	Documented test performance demonstrating agreement with analytical predictions. Documented definition of scaling requirements.

6	System/sub-system model or prototype demonstration in a relevant environment.	A high fidelity system/component prototype that adequately addresses all critical scaling issues is built and operated in a relevant environment to demonstrate operations under critical environmental conditions.	Prototype implementations of the software demonstrated on full-scale realistic problems. Partially integrate with existing hardware/software systems. Limited documentation available. Engineering feasibility fully demonstrated.	Documented test performance demonstrating agreement with analytical predictions.
7	System prototype demonstration in an operational environment.	A high fidelity engineering unit that adequately addresses all critical scaling issues is built and operated in a relevant environment to demonstrate performance in the actual operational environment and platform (ground, airborne, or space).	Prototype software exists having all key functionality available for demonstration and test. Well integrated with operational hardware/software systems demonstrating operational feasibility. Most software bugs removed. Limited documentation available.	Documented test performance demonstrating agreement with analytical predictions.
8	Actual system completed and "flight qualified" through test and demonstration.	The final product in its final configuration is successfully demonstrated through test and analysis for its intended operational environment and platform (ground, airborne, or space).	All software has been thoroughly debugged and fully integrated with all operational hardware and software systems. All user documentation, training documentation, and maintenance documentation completed. All functionality successfully demonstrated in simulated operational scenarios. Verification and Validation (V&V) completed.	Documented test performance verifying analytical predictions.
9	Actual system flight proven through successful mission operations.	The final product is successfully operated in an actual mission.	All software has been thoroughly debugged and fully integrated with all operational hardware/software systems. All documentation has been completed. Sustaining software engineering support is in place. System has been successfully operated in the operational environment.	Documented mission operational results.

Definitions

Proof of Concept: Analytical and experimental demonstration of hardware/software concepts that may or may not be incorporated into subsequent development and/or operational units.

Breadboard: A low fidelity unit that demonstrates function only, without respect to form or fit in the case of hardware, or platform in the case of software. It often uses commercial and/or ad hoc components and is not intended to provide definitive information regarding operational performance.

Brassboard: A medium fidelity functional unit that typically tries to make use of as much operational hardware/software as possible and begins to address scaling issues associated with the operational system. It does not have the engineering pedigree in all aspects, but is structured to be able to operate in simulated operational environments in order to assess performance of critical functions.

Proto-type Unit: The proto-type unit demonstrates form, fit, and function at a scale deemed to be representative of the final product operating in its operational environment. A subscale test article provides fidelity sufficient to

permit validation of analytical models capable of predicting the behavior of full-scale systems in an operational environment

Engineering Unit: A high fidelity unit that demonstrates critical aspects of the engineering processes involved in the development of the operational unit. Engineering test units are intended to closely resemble the final product (hardware/software) to the maximum extent possible and are built and tested so as to establish confidence that the design will function in the expected environments. In some cases, the engineering unit will become the final product, assuming proper traceability has been exercised over the components and hardware handling.

Mission Configuration: The final architecture/system design of the product that will be used in the operational environment. If the product is a subsystem/component, then it is embedded in the actual system in the actual configuration used in operation.

Laboratory Environment: An environment that does not address in any manner the environment to be encountered by the system, subsystem, or component (hardware or software) during its intended operation. Tests in a laboratory environment are solely for the purpose of demonstrating the underlying principles of technical performance (functions), without respect to the impact of environment.

Relevant Environment: Not all systems, subsystems, and/or components need to be operated in the operational environment in order to satisfactorily address performance margin requirements. Consequently, the relevant environment is the specific subset of the operational environment that is required to demonstrate critical "at risk" aspects of the final product performance in an operational environment. It is an environment that focuses specifically on "stressing" the technology advance in question.

Operational Environment: The environment in which the final product will be operated. In the case of space flight hardware/software, it is space. In the case of ground-based or airborne systems that are not directed toward space flight, it will be the environments defined by the scope of operations. For software, the environment will be defined by the operational platform.

Appendix C: NASA SBIR/STTR Technology Taxonomy

Aeronautics/Atmospheric Vehicles
Aerodynamics
Air Transportation & Safety
Airship/Lighter-than-Air Craft
Avionics (see also Control and Monitoring)
Analysis
Analytical Instruments (Solid, Liquid, Gas, Plasma, Energy; see also Sensors)
Analytical Methods
Astronautics
Aerobraking/Aerocapture
Entry, Descent, & Landing (see also Planetary Navigation, Tracking, & Telemetry)
Navigation & Guidance
Relative Navigation (Interception, Docking, Formation Flying; see also Control & Monitoring; Planetary Navigation, Tracking, & Telemetry)
Space Transportation & Safety
Spacecraft Design, Construction, Testing, & Performance (see also Engineering; Testing & Evaluation)
Spacecraft Instrumentation & Astrionics (see also Communications; Control & Monitoring; Information Systems)
Tools/EVA Tools
Autonomous Systems
Autonomous Control (see also Control & Monitoring)
Intelligence
Man-Machine Interaction
Perception/Vision
Recovery (see also Vehicle Health Management)
Robotics (see also Control & Monitoring; Sensors)
Biological Health/Life Support
Biomass Growth
Essential Life Resources (Oxygen, Water, Nutrients)
Fire Protection
Food (Preservation, Packaging, Preparation)
Health Monitoring & Sensing (see also Sensors)
Isolation/Protection/Radiation Shielding (see also Mechanical Systems)
Medical
Physiological/Psychological Countermeasures
Protective Clothing/Space Suits/Breathing Apparatus
Remediation/Purification
Waste Storage/Treatment
Communications, Networking & Signal Transport
Ad-Hoc Networks (see also Sensors)
Amplifiers/Repeaters/Translators
Antennas

Architecture/Framework/Protocols
Cables/Fittings
Coding & Compression
Multiplexers/Demultiplexers
Network Integration
Power Combiners/Splitters
Routers, Switches
Transmitters/Receivers
Waveguides/Optical Fiber (see also Optics)
Control & Monitoring
Algorithms/Control Software & Systems (see also Autonomous Systems)
Attitude Determination & Control
Command & Control
Condition Monitoring (see also Sensors)
Process Monitoring & Control
Sequencing & Scheduling
Telemetry/Tracking (Cooperative/Noncooperative; see also Planetary Navigation, Tracking, & Telemetry)
Teleoperation
Education & Training
Mission Training
Outreach
Training Concepts & Architectures
Electronics
Circuits (including ICs; for specific applications, see e.g., Communications, Networking & Signal Transport; Control & Monitoring, Sensors)
Manufacturing Methods
Materials (Insulator, Semiconductor, Substrate)
Superconductance/Magnetics
Energy
Conversion
Distribution/Management
Generation
Sources (Renewable, Nonrenewable)
Storage
Engineering
Characterization
Models & Simulations (see also Testing & Evaluation)
Project Management
Prototyping
Quality/Reliability
Software Tools (Analysis, Design)
Support
Imaging

3D Imaging
Display
Image Analysis
Image Capture (Stills/Motion)
Image Processing
Radiography
Thermal Imaging (see also Testing & Evaluation)
Information Systems
Computer System Architectures
Data Acquisition (see also Sensors)
Data Fusion
Data Input/Output Devices (Displays, Storage)
Data Modeling (see also Testing & Evaluation)
Data Processing
Knowledge Management
Logistics
Inventory Management/Warehousing
Material Handling & Packaging
Transport/Traffic Control
Manufacturing
Crop Production (see also Biological Health/Life Support)
In Situ Manufacturing
Microfabrication (and smaller; see also Electronics; Mechanical Systems; Photonics)
Processing Methods
Resource Extraction
Materials & Compositions
Aerogels
Ceramics
Coatings/Surface Treatments
Composites
Fluids
Joining (Adhesion, Welding)
Metallics
Minerals
Nanomaterials
Nonspecified
Organics/Biomaterials/Hybrids
Polymers
Smart/Multifunctional Materials
Textiles
Mechanical Systems
Actuators & Motors
Deployment

Exciters/Igniters
Fasteners/Decouplers
Isolation/Protection/Shielding (Acoustic, Ballistic, Dust, Radiation, Thermal)
Machines/Mechanical Subsystems
Microelectromechanical Systems (MEMS) and smaller
Pressure & Vacuum Systems
Structures
Tribology
Vehicles (see also Autonomous Systems)
Microgravity
Biophysical Utilization
Optics
Adaptive Optics
Fiber (see also Communications, Networking & Signal Transport; Photonics)
Filtering
Gratings
Lenses
Mirrors
Telescope Arrays
Photonics
Detectors (see also Sensors)
Emitters
Lasers (Communication)
Lasers (Cutting & Welding)
Lasers (Guidance & Tracking)
Lasers (Ignition)
Lasers (Ladar/Lidar)
Lasers (Machining/Materials Processing)
Lasers (Measuring/Sensing)
Lasers (Medical Imaging)
Lasers (Surgical)
Lasers (Weapons)
Materials & Structures (including Optoelectronics)
Planetary Navigation, Tracking, & Telemetry
Entry, Descent, & Landing (see also Astronautics)
GPS/Radiometric (see also Sensors)
Inertial (see also Sensors)
Optical
Ranging/Tracking
Telemetry (see also Control & Monitoring)
Propulsion
Ablative Propulsion
Atmospheric Propulsion

Extravehicular Activity (EVA) Propulsion
Fuels/Propellants
Launch Engine/Booster
Maneuvering/Stationkeeping/Attitude Control Devices
Photon Sails (Solar; Laser)
Spacecraft Main Engine
Surface Propulsion
Tethers
Sensors/Transducers
Acoustic/Vibration
Biological (see also Biological Health/Life Support)
Biological Signature (i.e., Signs Of Life)
Chemical/Environmental (see also Biological Health/Life Support)
Contact/Mechanical
Electromagnetic
Inertial
Interferometric (see also Analysis)
Ionizing Radiation
Optical/Photonic (see also Photonics)
Positioning (Attitude Determination, Location X-Y-Z)
Pressure/Vacuum
Radiometric
Sensor Nodes & Webs (see also Communications, Networking & Signal Transport)
Thermal
Software Development
Development Environments
Operating Systems
Programming Languages
Verification/Validation Tools
Spectral Measurement, Imaging & Analysis (including Telescopes)
Infrared
Long
Microwave
Multispectral/Hyperspectral
Non-Electromagnetic
Radio
Terahertz (Sub-millimeter)
Ultraviolet
Visible
X-rays/Gamma Rays
Testing & Evaluation
Destructive Testing
Hardware-in-the-Loop Testing

Lifetime Testing
Nondestructive Evaluation (NDE; NDT)
Simulation & Modeling
Thermal Management & Control
Active Systems
Cryogenic/Fluid Systems
Heat Exchange
Passive Systems
Vehicle Health Management
Diagnostics/Prognostics
Recovery (see also Autonomous Systems)

Appendix D: SBIR/STTR and the Space Technology Roadmaps

Research and technology topics/subtopics for the SBIR Program are identified annually by Mission Directorates and Center Programs. The Directorates identify high priority research and technology needs for respective programs and projects. Research and technology topics for the STTR Program are aligned with needs associated with the research interest and core competencies across NASA Centers. Both programs support a broad range of technologies defined by a list of topics and subtopics that vary in content within each annual solicitation.

The following table relates these SBIR/STTR topics and subtopics to the Technology Area Breakdown Structure (TABS) in the Space Technology Roadmaps (STR). The table is organized by the OCT Technology Area (first column), with the related SBIR/STTR topics (third column) and subtopics (fourth column) listed as well. The Aeronautics area is included for completeness, though this is beyond the scope of the STR.

TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA01	Launch Propulsion Systems	N/A	N/A	N/A
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		Launch Propulsion Systems	Launch Vehicle Propulsion Technologies	T1.01
TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA02	In-Space Propulsion Technologies	Spacecraft and Platform Subsystem	Propulsion Systems	S3.03
		Space Transportation	Cryogenic Fluid Management Technologies	H2.01
			In-Space Propulsion Systems	H2.02
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		In-Space Propulsion Technologies	Space Power and Propulsion	T2.01
TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA03	Space Power and Energy Storage	High Efficiency Space Power Systems	Fuel Cells and Electrolyzers	H8.01
			Ultra High Specific Energy Batteries	H8.02
			Space Nuclear Power Systems	H8.03
			Advanced Photovoltaic Systems	H8.04
		Spacecraft and Platform Subsystem	Power Generation and Conversion	S3.02
			Power Electronics and Management, and Energy Storage	S3.04
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		Space Power and Energy Storage	Energy Harvesting Technology Development	T3.01

TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA04	Robotics, Telerobotics and Autonomous Systems	Autonomous and Robotic Systems	Spacecraft Autonomy and Space Mission Automation	H6.01
			Human-Robotic Systems - Manipulation Subsystem	H6.03
			Unmanned Aircraft and Sounding Rocket Technologies	S3.05
		Robotic Exploration Technologies	Robotic Mobility, Manipulation and Sampling	S4.02
			Spacecraft Technology for Sample Return Missions	S4.03
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		Robotics, Tele-Robotics and Autonomous Systems	Information Technologies for Intelligent and Adaptive Space Robotics	T4.01
			Dynamic Servoelastic (DSE) Network Control, Modeling, and Optimization	T4.02
			Extreme Particle Flow Physics Simulation Capability	T4.03
TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA05	Communication and Navigation	Space Communications and Navigation	Long Range Optical Communications	H9.01
			Long Range Space RF Communications	H9.02
			CoNNeCT Experiments	H9.03
			Flight Dynamics Technologies and Software	H9.04
			Game Changing Technologies	H9.05
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		Communication and Navigation	Autonomous Navigation in GNSS-Denied Environments	T5.01
TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA06	Human Health, Life Support and Habitation Systems	Life Support and Habitation Systems	Advanced Technologies for Atmosphere Revitalization	H3.01
			Environmental Monitoring and Fire Protection for Spacecraft Autonomy	H3.02
			Crew Accommodations and Water Recovery for Long Duration Missions	H3.03
		Extra-Vehicular Activity Technology	Space Suit Pressure Garment and Airlock Technologies	H4.01

			Space Suit Life Support and Avionics Systems	H4.02
		Radiation Protection	Radiation Prediction (Integrated Advanced Alert/Warning Systems for Solar Proton Events)	H11.01
		Human Research and Health Maintenance	Exploration Countermeasure Capability - Portable Activity Monitoring System	H12.01
			Exploration Medical Capability - Medical Suction Capability	H12.02
			Behavioral Health and Performance - Innovative Technologies for A Virtual Social Support System for Autonomous Exploration Missions	H12.03
			Advanced Food Systems Technology	H12.04
			In-Flight Biological Sample Analysis	H12.05
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		Human Health, Life Support and Habitation Systems	Space Synthetic Biology and Food Production Technologies for Space Exploration	T6.01
TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA07	Human Exploration Destination-Systems	In-Situ Resource Utilization	In-Situ Resource Utilization	H1.01
		Ground Processing and ISS Utilization	ISS Demonstration & Development of Improved Exploration Technologies	H10.02
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		N/A	N/A	N/A
TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA08	Science Instruments, Observatories and Sensor Systems	Sensors, Detectors and Instruments	Lidar Remote Sensing Technologies	S1.01
			Microwave Technologies for Remote Sensing	S1.02
			Sensor and Detector Technology for Visible, IR, Far IR and Submillimeter	S1.03
			Detector Technologies for UV, X-Ray, Gamma-Ray and Cosmic-Ray Instruments	S1.04
			Particles and Field Sensors and Instrument Enabling Technologies	S1.05
			Cryogenic Systems for Sensors and Detectors	S1.06

			In Situ Sensors and Sensor Systems for Lunar and Planetary Science	S1.07
			Airborne Measurement Systems	S1.08
			Surface & Sub-surface Measurement Systems	S1.09
		Advanced Telescope Systems	Proximity Glare Suppression for Astronomical Coronagraphy	S2.01
			Precision Deployable Optical Structures and Metrology	S2.02
			Advanced Optical Component Systems	S2.03
			Optics Manufacturing and Metrology for Telescope Optical Surfaces	S2.04
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		Science Instruments, Observatories and Sensor Systems	Innovative Subsystems for Small Satellite Applications	T8.01
			Technologies for Planetary Compositional Analysis and Mapping	T8.02
			Science Instruments for Small Missions (SISM)	T8.03
TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA09	Entry, Descent and Landing Systems	Robotic Exploration Technologies	Planetary Entry, Descent and Landing Technology	S4.01
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		Entry, Descent and Landing Systems	Technologies for Aerospace Experimental Capabilities	T9.01
TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA10	Nanotechnology	N/A	N/A	N/A
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		Nanotechnology	Innovative Refractory Materials for Rocket Propulsion Testing	T10.01
TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA11	Modeling, Simulation, Information Technology and Processing	Autonomous and Robotic Systems	Radiation Hardened/Tolerant and Low Temperature Electronics and Processors	H6.02
		Spacecraft and Platform Subsystems	Command, Data Handling, and Electronics	S3.01

		Information Technologies	Technologies for Large-Scale Numerical Simulation	S5.01
			Earth Science Applied Research and Decision Support	S5.02
			Algorithms and Tools for Science Data Processing, Discovery and Analysis, in State-of-the-Art Data Environments	S5.03
			Integrated Science Mission Modeling	S5.04
			Fault Management Technologies	S5.05
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		Modeling, Simulation, Information Technology and Processing	Software Framework & Infrastructure Development of Spaceborne Hybrid Multicore/FPGA Architectures	T11.01
			Distributed Simulation for Design and Manufacturing	T11.02
TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA12	Materials, Structures, Mechanical Systems and Manufacturing	Lightweight Spacecraft Materials and Structures	Expandable/Deployable Structures	H5.01
			Advanced Manufacturing and Material Development for Lightweight Metallic Structures	H5.02
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		Materials, Structures, Mechanical Systems and Manufacturing	High Temperature Materials and Sensors for Propulsion Systems	T12.01
			Materials and Manufacturing Technologies	T12.02
TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic
TA13	Ground and Launch Systems Processing	Space Transportation	Advanced Technologies for Propulsion Testing	H2.03
		Ground Processing and ISS Utilization	Ground Processing Optimization and Technology Infusion	H10.01
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		Ground and Launch Systems Processing	Risk Engineering, Sciences, Computation, and Informed Decisions	T13.01
TA	STR Technology Area (TA) Level 1 Description	SBIR Topic	SBIR Subtopic Description	SBIR Subtopic

TA14	Thermal Management Systems	Life Support and Habitation Systems	Thermal Control Systems	H3.04
		Entry, Descent and Landing Technology	Ablative Thermal Protection Systems	H7.01
		STTR Topic	STTR Subtopic Description	STTR Subtopic
		N/A	N/A	N/A
		Aviation Safety	Aviation External Hazard Sensor Technologies	A1.01
		Aviation Safety	Inflight Icing Hazard Mitigation Technology	A1.02
		Aviation Safety	Flight Deck Interface Technologies for NextGen	A1.03
		Aviation Safety	Vehicle Level Diagnostics	A1.04
		Aviation Safety	Data Mining and Knowledge Discovery	A1.05
		Aviation Safety	Assurance of Flight-Critical Systems	A1.06
		Air Traffic Management Research and Development (ATM R&D)	Unmanned Aircraft Systems Integration into the National Airspace System Research	A2.01
		Air Vehicle Technologies	Structural Efficiency - Airframe	A3.01
		Air Vehicle Technologies	Quiet Performance	A3.02
		Air Vehicle Technologies	Low Emissions/Clean Power	A3.03
		Air Vehicle Technologies	Aerodynamic Efficiency - Drag Reduction Technology	A3.04
		Air Vehicle Technologies	Controls/Dynamics - Propulsion Systems	A3.05
		Air Vehicle Technologies	Physics-Based Conceptual Design Tools	A3.06
		Air Vehicle Technologies	Rotorcraft	A3.07
		Air Vehicle Technologies	Propulsion Efficiency - Turbomachinery Technology	A3.08
		Air Vehicle Technologies	Ground and Flight Test Techniques and Measurement Technologies	A3.09

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