SBIR/STTR 2009-1

National Aeronautics and Space Administration

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

Program Solicitations

Opening Date: July 7, 2009
Closing Date: September 3, 2009

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

TABLE OF CONTENTS

2009 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, the three program phases, and information for submitting responsive proposals is contained herein. The 2009 Solicitation period for Phase 1 proposals begins July 7, 2009, and ends September 3, 2009.

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 existing 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 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 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 program 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 products or proven concepts and modifications of existing products without substantive innovation.

Subject to the availability of funds, approximately 300 SBIR and 30 STTR Phase 1 proposals will be selected for negotiation of fixed-price contracts in November 2009. Historically, the ratio of Phase 1 proposals to awards is approximately 6:1 for SBIR and STTR, and approximately 45% of the selected Phase 1 contracts are selected for Phase 2 follow-on efforts.

NASA will not accept more than 10 proposals to either program from any one company 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 via the Internet at http://sbir.nasa.gov and include all relevant documentation. Unsolicited proposals will not be accepted.

1.2 Program Authority and Executive Order

SBIR: This Solicitation is issued pursuant to the authority contained in P.L. 106-554 in accordance with policy directives issued by the Small Business Administration. The current law authorizes the program through July 31,

2009. A new authorization is anticipated prior to this end date. Further information will be provided on the NASA Innovative Partnerships Program (IPP) Homepage when available (http://ipp.nasa.gov).

STTR: This Solicitation is issued pursuant to the authority contained in P.L. 107-50 in accordance with policy directives issued by the Small Business Administration. The current law authorizes the program through September 30, 2009.

Executive Order: This Solicitation complies with Executive Order 13329 (issued February 24, 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.

1.3 Program Management

The Innovative Partnerships Program Office 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 provides the overall procurement management for the programs. All of the NASA centers actively participate in the SBIR/STTR program 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 of Mission Directorate research topic descriptions.

The STTR Program Solicitation is aligned with needs associated with the 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 Mission Directorates	
Aeronautics Research	http://www.aeronautics.nasa.gov/
Exploration Systems	http://www.nasa.gov/exploration/home/index.html
Science	http://nasascience.nasa.gov
Space Operations	http://www.nasa.gov/directorates/somd/home/

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.

1.4.1 Phase 1

The purpose of Phase 1 is to determine the scientific, technical, and commercial merit and feasibility of the proposed innovation, and the quality of the SBC's performance. Phase 1 work and results should provide a sound basis for the continued development, demonstration and delivery of the proposed innovation in Phase 2 and follow-on efforts. Successful completion of Phase 1 objectives is a prerequisite to consideration for a Phase 2 award.

Proposals must conform to the format described in Section 3.2. Evaluation and selection criteria are described in Section 4.1. NASA is solely responsible for determining the relative merit of proposals, their selection for award, and judging the value of Phase 1 results.

Maximum value and period of performance for Phase 1 contracts:

Phase 1 Contracts	SBIR	STTR
Maximum Contract Value	$ 100,000	$ 100,000
Maximum Period of Performance	6 months	12 months

1.4.2 Phase 2

The purpose of Phase 2 is the development, demonstration and delivery of the innovation. Only SBCs awarded Phase 1 contracts are eligible for Phase 2 funding agreements. Phase 2 projects are chosen as a result of competitive evaluations based on selection criteria provided in Section 4.2.

Maximum value and period of performance for Phase 2 contracts:

Phase 2 Contracts	SBIR	STTR
Maximum Contract Value	$ 600,000	$ 600,000
Maximum Period of Performance*	24 months	24 months

* Nominal period of performance is 24 months. If your period of performance is less than 18 months, you may not be eligible for a Phase 2 Enhancement as described below.

Phase 2 Enhancement: The objective of the Phase 2-E Option is an incentive to Phase 3 awards through providing cost share extension of the R&D efforts to the current Phase 2 contract, to meet the product/process/software requirements of a NASA program/project or third party investor to accelerate and/or enhance the infusion/commercial potential of the Phase 2 project. Under this option, NASA will match with SBIR/STTR funds up to $150,000 of non-SBIR/non-STTR investment from a NASA project, NASA contractor, or third party commercial investor to extend an existing Phase 2 project for up to 4 months to perform additional research. The total cumulative award for the Phase 2 contract plus the Phase 2-E match is not expected to exceed $750,000.00 of SBIR/STTR funding. The non-SBIR or non-STTR contribution is not limited since it is regulated under the guidelines for Phase 3 award.

Regarding active Phase 2 awards only, NASA may enter into negotiations awardees to create an option for "Phase 2 Enhancement" (Phase 2-E) that will encourage transition of SBIR/STTR projects into NASA programs and projects. Additional details, including how to apply for the Phase 2 enhancement, will be provided no later than the 12th month of the performance of the Phase 2 contract. Application packages will not be accepted before the 15th month of the Phase 2 contract from selected awardees for a potential Phase 2 award but no later than the end of the 22nd month of the award.

1.4.3 Phase 3

NASA may award Phase 3 contracts for products or services with non-SBIR/STTR funds. The competition for SBIR/STTR Phase 1 and Phase 2 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 3 project is not required to conduct another competition in order to satisfy those statutory provisions. Phase 3 work may be for products, production, services, R/R&D, or any combination thereof that is derived from, extends, or logically concludes efforts performed under prior SBIR funding agreements. A Federal agency may enter into a Phase 3 agreement at any time with a Phase 1 or Phase 2 awardee.

There is no limit on the number, duration, type, or dollar value of Phase 3 awards made to a business concern. There is no limit on the time that may elapse between a Phase 1 or Phase 2 and a Phase 3 award. The small business size limits for Phase 1 and Phase 2 awards do not apply to Phase 3 awards.

1.5 Eligibility Requirements

1.5.1 Small Business Concern

Only firms qualifying as SBCs, as defined in Section 2.17, are eligible to participate in these programs. Socially and economically disadvantaged and women-owned SBCs are particularly encouraged to propose.

STTR: SBCs shall submit a cooperative research agreement with a Research Institution (RI).

1.5.2 Place of Performance

For both Phase 1 and Phase 2, the R/R&D must be performed in the United States (Section 2.22). 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.

1.5.3 Principal Investigator

The primary employment of the Principal Investigator (PI) must be with the SBC under the SBIR Program, while under the STTR Program the PI may be employed by either the SBC or RI. Primary employment means that more than half of the PI's total employed time (including all concurrent employers, consulting, and self-employed time) is spent with the SBC. 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, the offeror must explain how these requirements will be met if the proposal is selected for contract negotiations that may lead to an award. U.S. Citizenship is not a requirement for selection. Co-PI's are not permitted.

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	If the PI is not an employee of the SBC, the offeror must describe the management process to ensure SBC control of the project
Co-Principal Investigators	Not Acceptable	Not Acceptable
Misrepresentation of Qualifications	Will result in rejection of the proposal or termination of the contract	Will result in rejection of the proposal or termination of the contract
Substitution of PIs	Must receive advanced written approval from NASA	Must receive advanced written approval from NASA

1.6 General Information

1.6.1 Solicitation Distribution

This 2009 SBIR/STTR Program Solicitation is available via the NASA SBIR/STTR Website (http://sbir.nasa.gov). SBCs are encouraged to check this website for program updates and information. Any updates or corrections to the Solicitation will be posted there. If the SBC has difficulty accessing the Solicitation, contact the Help Desk (Section 1.6.2).

1.6.2 Means of Contacting NASA SBIR/STTR Program

(1) NASA SBIR/STTR Website: **http://sbir.nasa.gov**

(2) The websites of the NASA Mission Directorates and the NASA Centers as listed in Section 1.3 provide information on NASA plans and mission programs relevant to understanding the topics/subtopics and needs described in Section 9.

(3) Help Desk:

E-mail: sbir@reisys.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.

(4) 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

1.6.3 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 1 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 Commercialization

Commercialization is a process of developing markets and producing and delivering products or services for sale (whether by the originating party or by others). As used here, commercialization includes both Government and non-Government markets.

2.3 Cooperative Research or Research and Development (R/R&D) Agreement

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

2.4 Cooperative Research or 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 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.

2.6 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.

2.7 HUBZone-Owned SBC

"HUBZone" is an area that is located in one or more of the following:

- A qualified census tract (as defined in section 42(d)(5)(C)(i)(1) of the Internal Revenue Code of 1986);
- A qualified "non-metropolitan county" that is: not located in a metropolitan statistical area (as defined in section 143(k)(2)(B) of the Internal Revenue Code of 1986), and
    - in which the median household income is less than 80 percent of the non-metropolitan State median household income, or
    - that based on the most recent data available from the Secretary of Labor, has an unemployment rate that is not less than 140 percent of the statewide average unemployment rate for the State in which the county is located;
- Lands within the external boundaries of an Indian reservation.

To participate in the HUBZone Empowerment Contracting Program, a concern must be determined to be a "qualified HUBZone small business concern." A firm can be found to be a qualified HUBZone concern, if:

- It is small,
- It is located in a "historically underutilized business zone" (HUBZone),
- It is owned and controlled by one or more U.S. Citizens, and
- At least 35% of its employees reside in a HUBZone.

2.8 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.

2.9 Innovation

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.

2.10 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 2.14), ideas, designs, know-how, business, technical and research methods, and 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.

2.11 Principal Investigator (PI)

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

2.12 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.

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

Any activity that is (1) a systematic, intensive study directed toward greater knowledge or understanding of the subject studied, (2) a systematic study directed specifically toward applying new knowledge to meet a recognized need, or (3) a systematic application of knowledge toward the production of useful materials, devices, systems, or methods, including the 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).

2.14 SBIR/STTR Technical Data

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

2.15 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.

2.16 Service Disabled Veteran-Owned Small Business

A Service-Disabled Veteran-Owned SBC) is a concern-
(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) The management and daily business operations of 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) That 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)

2.17 Small Business Concern (SBC)

An SBC is one that, at the time of award of Phase 1 and Phase 2 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.

2.18 Socially and Economically Disadvantaged Individual

A member of any of the following groups: African American, Hispanic American, Native American, Asian-Pacific American, Subcontinent-Asian American, other groups designated from time to time by SBA to be socially disadvantaged, or any other individual found to be socially and economically disadvantaged by SBA pursuant to Section 8(a) of the Small Business Act, 15 U.S.C. 637(a).

2.19 Socially and Economically Disadvantaged Small Business Concern

A socially and economically disadvantaged SBC is one that is: (1) at least 51 percent owned by (i) an Indian tribe or a native Hawaiian organization: or, (ii) one or more socially and economically disadvantaged individuals; and (2) whose management and daily business operations are controlled by one or more socially and economically disadvantaged individuals. See 13 CFR Parts 124.103 and 124.104.

2.20 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.

2.21 Technology Readiness Level (TRLs)

Technology Readiness Level (TRLs) are 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.

2.22 United States

Means 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.

2.23 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.

2.24 Women-Owned Small Business

A women-owned SBC is a small business that is at least 51 percent owned by a woman or women who also control and operate it. "Control" in this context means exercising the power to make policy decisions. "Operate" in this context means being actively involved in the day-to-day management.

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, and may submit more than one 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.

STTR: All Phase 1 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 RI into a product or service that meets a need described in a Solicitation research topic.

Contract Deliverables

All Phase 1 contracts shall require the delivery of interim and final reports that present (1) the work and results accomplished, (2) the scientific, technical and commercial merit and feasibility of the proposed innovation and Phase 1 results, (3) its relevance and significance to one or more NASA needs (Section 9), and (4) the strategy for development and transition of the proposed innovation and Phase 1 results into products and services for NASA mission programs and other potential customers. Phase 1 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.

Phase 2 contracts require the deliverable of interim and final reports. The delivery of a prototype unit, software package, or a complete product or service, for NASA testing and utilization is highly desirable and, if proposed, must be described and listed as a deliverable in the proposal. The Phase 2 reports shall present (1) the work and results accomplished, (2) the scientific, technical and commercial merit and feasibility of the proposed innovation and Phase 2 results, (3) its relevance and significance to one or more NASA needs (Section 9), and (4) the progress towards transitioning the proposed innovation and Phase 2 results into follow-on investment, development, testing and utilization for NASA mission programs and other potential customers.

Report deliverables for Phase 1 and Phase 2 shall be submitted electronically via the SBIR/STTR website. NASA requests the submission of report deliverables in PDF format. Other acceptable formats are MS Word, MS Works, and WordPerfect.

Technology Infusion Form

In order to help the contractor and NASA make better use of the SBIR/STTR products, it is highly recommended that the Phase 1 and 2 contractor (with help from designated NASA personnel) update their Technology Infusion Form to: identify one or more specific NASA projects, project points of contacts, and project problems. The NASA project points of contacts will also have electronic access to these subsequent deliverables for comment.

3.2 Phase 1 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, 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.

Page Limitation
A Phase 1 proposal shall not exceed a total of 25 standard 8 1/2 x 11 inch (21.6 x 27.9 cm) pages inclusive of the technical content and the required forms. Proposal items required in Section 3.2.2 will be included within this total. 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). **Proposals exceeding the 25-page limitation are subject to rejection during administrative screening.**

Website references, product samples, videotapes, slides, or other ancillary items will not be considered during the review process. Offerors are requested not to use the entire 25-page allowance unless necessary.

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.

3.2.2 Format Requirements
All required items of information must be covered in the proposal. 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 25 page limit;
(2) Proposal Summary (Form B), counts as 1 page towards the 25 page limit;
(3) Budget Summary (Form C), counts as 1 page towards the 25 page limit;
(4) Cooperative R/R&D Agreement between the SBC and RI **(STTR only)**, counts as 1 page towards the 25 page limit;
(5) Technical Content (11 parts in order as specified in Section 3.2.4, **not to exceed 22 pages for SBIR and 21 pages for STTR**), including all graphics, with a table of contents,
(6) Briefing Chart (Not included in the 25-page limit and must not contain proprietary data).

3.2.3 Forms

3.2.3.1 Cover Sheet (Form A)
A sample Cover Sheet form 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 25-page limit.

3.2.3.2 Proposal Summary (Form B)
A sample Proposal Summary form 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 25-page limit.

Technical Abstract
Summary of the offeror's proposed project is limited to 200 words and shall summarize the implications of the approach and the anticipated results of both Phase 1 and Phase 2 including an assessment of technology readiness levels (TRLs) at the beginning and end of the Phase 1 contract. *NASA will reject a proposal if the technical abstract is judged to be non-responsive to the subtopic.*

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 at the end of Section 9.

Potential NASA and non-NASA commercial applications of the technology must also be presented.

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

3.2.3.3 Budget Summary (Form C)
The offeror shall complete the Budget Summary, following the instructions provided with the form (Section 8). The total requested funding for the Phase 1 effort shall not exceed $100,000. 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 budget is fair and reasonable. The government is not responsible for any monies expended by the applicant before award of any contract. Form C counts as one page towards the 25-page limit.

Property
Proposed costs for materials may be included. "Materials" means property that may be incorporated or attached to a deliverable end item or that may be consumed or expended in performing the contract. It includes assemblies, components, parts, raw materials, and small tools that may be consumed in normal use. Any purchase of equipment or products under an SBIR/STTR contract using NASA funds should be American-made to the extent possible. NASA will not fund the purchase of equipment, instrumentation, or facilities under SBIR/STTR contracts as a direct cost (Section 5.16).

Phase 1 Travel
The NASA SBIR/STTR program does not require or expect to incur travel expenses during the performance of a Phase 1 contract. For this reason, travel expenses should not be included in the proposed budget for a Phase 1 proposal. If the Technical Monitor and Contracting Officer determine that travel is necessary, the budget can be altered during contract negotiations.

Phase 1 Delivery Schedule
The standard reporting requirements for Phase 1 are an interim technical report due at contract mid-point after award, a final report and new technology report due upon contract completion plus any other required deliverables.

Profit
A profit or fee may be included in the proposed budget as noted in Section 5.11.

Cost Sharing
See Section 5.10.

3.2.4 Technical Content
This part of the submission shall not contain any budget data and must consist of all eleven parts listed below in the given order. All parts must be numbered and titled; parts that are not applicable must be noted as "Not Applicable."

Part 1: Table of Contents

The technical content shall begin with a brief table of contents indicating the page numbers of each of the parts of the proposal. The required table of contents is provided below:

Phase 1 Table of Contents

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 1 R/R&D effort including the technical questions that must be answered to determine the feasibility of the proposed innovation.

Part 4: Work Plan

Include a detailed description of the Phase 1 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. At least 40 percent of the work (amount requested including cost sharing, less fee, if any) is to be performed by the SBC as the prime contractor, and at least 30 percent of the work is to be performed by 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. At the offeror's option, this section may include bibliographic references.

Part 6: Key Personnel and Bibliography of Directly Related Work

Identify key personnel involved in Phase 1 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 1 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 substitute 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 (Section 1.5.3), and indicate the extent to which other proposals recently submitted or planned for submission in 2009 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.

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 1 and Phase 2). Discuss the significance of the Phase 1 effort in providing a foundation for the Phase 2 R/R&D effort and for follow-on development, application and commercialization efforts (Phase 3).

Part 8: Company Information and Facilities

Provide adequate information to allow the evaluators to assess the ability of the offeror to carry out the proposed Phase 1 and projected Phase 2 and Phase 3 activities. The offeror should describe the relevant facilities and equipment, their availability, and those to be acquired, to support the proposed activities. *NASA will not fund the purchase of equipment, instrumentation, or facilities under Phase 1 contracts as a direct cost.* Special tooling may be allowed. (Section 5.16)

The capability of the offeror to perform the proposed activities and to accomplish the commercialization of the proposed innovation and R/R&D results must be presented. Qualifications of the offeror in performing R/R&D activities and technology commercialization must be presented.

Note: Government wide SBIR and STTR policies prohibit the use of any SBIR/STTR funds for the use of Government equipment and facilities. This does not preclude an SBC from utilizing a Government facility or Government equipment, but any charges for such use may not be paid for with SBIR/STTR funds (SBA SBIR Policy Directive, Section 9 (f)(3)). NASA may not and cannot fund the use of the Federal facility or personnel for the SBIR project with non-SBIR money. In rare and unique circumstances, SBA may issue a case-by-case waiver to this provision after review of an agency's written justification. NASA cannot guarantee that a waiver from this policy can be obtained from SBA.

The following information is required for consideration of a waiver:

(1) An explanation of why the SBIR 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.
(2) The concurrence of the SBC's chief business official to use the Federal facility or personnel.

If a proposed project or product demonstration requires the use of unique Government facilities or equipment to be funded by the SBIR 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. The proposal should also include relevant information on the funding source(s) private, internal, or other Government. Failure to provide this explanation and the site manager's written authorization of use may invalidate any proposal selection. If the offeror proposes the use of SBIR/STTR funds for Government equipment or facilities, this explanation will be provided to SBA during the Agency waiver process.

Additional information on the use of NASA facilities, facility programs, and equipment is available at http://sbir.nasa.gov/SBIR/facilities.html.

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. Documentation of subcontract costs must be made available during negotiations to substantiate the budget estimate.

Subcontractors' and consultants' work must be performed in the United States. The following restrictions apply to the use of subcontracts/consultants:

SBIR	STTR
The proposed subcontracted business arrangements must not exceed one-third of the research and/or analytical work (as determined by the total cost of the proposed effort, before any cost sharing or fee/profit proposed by the firm, which corresponds to Item 6 in the Budget Summary, Total Costs).	The proposed subcontracted business arrangements with individuals or organizations other than the RI must not exceed 30 percent of the work (as determined by the total cost of the proposed effort, before any cost sharing or fee/profit proposed by the firm, which corresponds to Item 6 in the Budget Summary, Total Costs).

Part 10: Potential Post Applications (Commercialization)

The Phase 1 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 11: Similar Proposals and Awards

A firm may elect to submit proposals for essentially equivalent work to other Federal program solicitations (Section 2.5). Firms may also choose to resubmit previously unsuccessful Phase 1 proposals to NASA. However, it is unlawful to receive funding for essentially equivalent work already funded under any Government program. The Office of Inspector General has full access to all proposals submitted to NASA. The offeror must inform NASA of related proposals and awards and clearly state whether the SBC has submitted currently active proposals for similar work under other Federal Government program solicitations, or intends to submit proposals for such work to other agencies. For all such cases, the following information is required:

(1) The name and address of the agencies to which proposals have been or will be submitted, or from which awards have been received (including proposals that have been submitted to previous NASA SBIR Solicitations);
(2) Dates of such proposal submissions or awards;
(3) Title, number, and date of solicitations under which proposals have been or will be submitted or awards received;
(4) The specific applicable research topic for each such proposal submitted or award received;
(5) Titles of research projects;
(6) Name and title of the PI/project manager for each proposal that has been or will be submitted, or from which awards have been received;
(7) If resubmitting to NASA, please briefly describe how the proposal has been changed and/or updated since it was last submitted.

Note: All eleven (11) parts of the technical proposal must be included. 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.

3.2.5 Cooperative R/R&D Agreement (Applicable for STTR proposals only)
The Cooperative R/R&D Agreement (different from the Allocation of Rights Agreement, Section 4.1.4) 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 Cooperative R/R&D Agreement should be submitted as required in Section 6. This agreement counts toward the 25-page limit.

3.2.6 Prior Awards Addendum (Applicable for SBIR awards only)
If the SBC has received more than 15 Phase 2 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 2. The addendum is not included in the 25-page limit and content should be limited to information requested above. Offerors are encouraged to use spreadsheet format.

3.2.7 Phase 3 Awards resulting from NASA SBIR/STTR Awards
If the SBC has received any Phase 3 awards resulting from work on any NASA SBIR or STTR awards, provide the related Phase 1 or Phase 2 contract number, name of Phase 3 awarding agency, date of award, funding agreement number, amount, project title, period of performance and current commercialization status for each award. This listing is not included in the 25-page limit and content should be limited to information requested above. Offerors are encouraged to use a spreadsheet format.

3.2.8 Briefing Chart
A one-page briefing chart is required to assist in the ranking and advocacy of proposals prior to selection. It is not counted against the 25-page limit, and *must not* contain any proprietary data or ITAR restricted data. An example chart is provided in Section 8, Appendix A.

3.3 Phase 2 Proposal Requirements

3.3.1 General Requirements
The Phase 1 contract will serve as a request for proposal (RFP) for the Phase 2 follow-on project. Phase 2 proposals are more comprehensive than those required for Phase 1. Submission of a Phase 2 proposal is in accordance with Phase 1 contract requirements and is voluntary. NASA assumes no responsibility for any proposal preparation expenses.

A competitive Phase 2 proposal will clearly and concisely (1) describe the proposed innovation relative to the state of the art and the market, (2) address Phase 1 results relative to the scientific, technical merit and feasibility of the proposed innovation and its relevance and significance to the NASA needs as described in Section 9, and (3) provide the planning for a focused project that builds upon Phase 1 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.

Page Limitation
A Phase 2 proposal shall not exceed a total of 50 standard 8 1/2 x 11 inch (21.6 x 27.9 cm) pages. All items required in Section 3.3.2 will be included within this total. 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). **Proposals exceeding the 50-page limitation are subject to rejection during administrative screening.**

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.

3.3.2 Format Requirements
All required items of information must be covered in the proposal. 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;
(3) Budget Summary (Form C), counts as 1 page towards the 50 page limit;
(4) Cooperative R/R&D Agreement between the SBC and RI **(STTR only)**, counts as 1 page towards the 50 page limit;
(5) Technical Content (11 Parts in order as specified in Section 3.3.4, **not to exceed 47 pages for SBIR and 46 pages for STTR**), including all graphics, and starting with a table of contents,
(6) Briefing Chart (Not included in the 50-page limit and must not contain proprietary data).

3.3.3 Forms

3.3.3.1 Cover Sheet (Form A)
A sample copy of the Cover Sheet 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 50-page limit.

3.3.3.2 Proposal Summary (Form B)
A sample Proposal Summary form 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 50-page limit.

Technical Abstract
Summary of the offeror's proposed project is limited to 200 words and shall summarize the implications of the approach and the anticipated results of both Phase 1 and Phase 2 including an assessment of technology readiness levels (TRLs) at the beginning and end of the Phase 2 contract. *NASA will reject a proposal if the technical abstract is judged to be non-responsive to the subtopic.*

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 at the end of Section 9.

Potential NASA and non-NASA commercial applications of the technology must also be presented.

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

3.3.3.3. Budget Summary (Form C)
The offeror shall complete the Budget Summary, following the instructions provided with the form (Section 8), not to exceed $600,000. 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 budget is fair and reasonable. The Government is not responsible for any monies expended by the applicant before award of any funding agreement. Form C counts as one page towards the 50-page limit.

Property
Proposed costs for materials may be included. "Materials" means property that may be incorporated or attached to a deliverable end item or that may be consumed or expended in performing the contract. It includes assemblies, components, parts, raw materials, and small tools that may be consumed in normal use. Any purchase of equipment or products under an SBIR/STTR contract using NASA funds should be American-made to the extent possible. NASA will not fund the purchase of equipment, instrumentation, or facilities under SBIR/STTR contracts as a direct cost (Section 5.16).

Phase 2 Travel
Travel during a Phase 2 contract is an acceptable cost when it is part of accomplishing the work. Proposed travel expenses will be reviewed for reasonableness. Proposed travel shall describe the purpose, benefit and necessity for proving technical feasibility. The proposed budget shall include a detailed breakdown of all proposed travel expenses. All travel and related expenses are subject to negotiation and approval by the Contracting Officer and COTR.

Phase 2 Deliverables
All proposed deliverables (other than interim and final reports) must be listed. This may include a prototype unit, software package, or a complete product or service, for NASA testing and utilization.

Profit
A profit or fee may be included in the proposed budget as noted in Section 5.11.

Cost Sharing
See Section 5.10.

Requirement for Approved Accounting System
Offerors should have an accounting system that in the Defense Contract Audit Agency's (DCAA) opinion is adequate for accumulating costs. An approved accounting system can track costs to final cost objectives and segregate costs between direct and indirect. If you currently do not have an adequate accounting system, it is recommended that you take action to implement such a system.. For more information about cost proposals and

accounting standards, please see the DCAA publication entitled "Information for Contractors" which is available at http://www.dcaa.mil/dcaap7641.90.pdf.

3.3.4 Technical Proposal

This part of the submission shall not contain any budget data and must consist of all eleven parts listed below in the given order. All parts must be numbered and titled; parts that are not applicable must be noted as "Not Applicable."

Part 1: Table of Contents

The technical content shall begin with a brief table of contents indicating the page numbers of each of the parts of the proposal. The required table of contents is provided below:

Phase 2 Table of Contents

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

Part 2: Identification and Significance of the Innovation and Results of the Phase 1 Proposal

Drawing upon Phase 1 results, 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;
(3) the proposed innovation relative to the state of the market and 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 2 research and technical approach.

Part 4: Work Plan

Provide a detailed work plan defining specific tasks, performance schedules, project milestones, and deliverables.

Part 5: Related R/R&D

Describe R/R&D related to the proposed work and affirm that the stated objectives have not already been achieved and that the same development is not presently being pursued elsewhere under contract to the Federal Government.

Part 6: Key Personnel

Identify the key technical personnel for the project, confirm their availability for Phase 2, and discuss their qualifications in terms of education, work experience, and accomplishments relevant to the project.

Part 7: Phase 3 Efforts, Commercialization and Business Planning
Present a plan for commercialization (Phase 3) 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 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: Company Information and Facilities
Describe the capability of the offeror to carry out Phase 2 and Phase 3 activities, including its organization, operations, number of employees, R/R&D capabilities, and experience in technological innovation, commercialization and other areas relevant to the work proposed.

This section shall also provide adequate information to allow evaluators to assess the ability of the SBC to carry out the proposed Phase 2 activities. The offeror should describe the relevant facilities and equipment currently available, and those to be purchased, to support the proposed activities. NASA will not fund the acquisition of equipment, instrumentation, or facilities under Phase 2 contracts as a direct cost. Special tooling may be allowed. (Section 5.16)

Note: Government-wide SBIR and STTR policies prohibit the use of any SBIR/STTR award funds for the use of Government equipment and facilities. This does not preclude an SBC from utilizing a Government facility or Government equipment, but any charges for such use cannot be paid for with SBIR/STTR funds (SBA SBIR Policy Directive, Section 9 (f)(3)). NASA will not and cannot fund the use of the Federal facility or personnel for the SBIR project with non-SBIR money. In rare and unique circumstances, SBA may issue a case-by-case waiver to this provision after review of an agency's written justification. NASA cannot guarantee that a waiver from this policy can be obtained from SBA. The following information is required for consideration of a waiver:

(1) An explanation of why the SBIR 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.
(2) The concurrence of the SBC's chief business official to use the Federal facility or personnel.

If a proposed project or product demonstration requires the use of unique Government facilities or equipment that will be funded with SBIR dollars, 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. The proposal should also include relevant information on the funding source(s) private, internal, or other Government. Failure to provide this explanation and the site manager's written authorization of use may invalidate any proposal selection. If the offeror proposes the use of SBIR/STTR funds for Government equipment or facilities, this explanation will be provided to SBA during the Agency waiver process.

Additional information on the use of NASA facilities, facility programs, and equipment is available at http://sbir.nasa.gov/SBIR/facilities.html.

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. Documentation of subcontract costs must be made available during negotiations to substantiate the budget estimate.

Subcontractors' and consultants' work must be performed in the United States. The following restrictions apply to the use of subcontracts/consultants:

SBIR Phase 2 Proposal	STTR Phase 2 Proposal
A minimum of one-half of the work must be performed by the proposing SBC. (can be determined by deducting cost sharing or fee/profit from the proposed total cost on Form C , Budget Summary)	A minimum of 40 percent of the work (as determined by the total cost of the proposed effort, before any cost sharing or fee/profit proposed by the firm, which corresponds to Item 6 in the Budget Summary, Total Costs) must be performed by the proposing SBC and 30 percent by the RI.

Part 10: Potential Post Applications (Commercialization)
Building upon Section 3.3.4, 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 11: Similar Proposals and Awards
If applicable, provide updated material (Reference Phase 1 Proposal Requirements, Part 11).

3.3.5 Capital Commitments Addendum Supporting Phase 2 and Phase 3
Describe and document capital commitments from non-SBIR/STTR sources or from internal SBC funds for pursuit of Phase 2 and Phase 3. Offerors for Phase 2 contracts are strongly urged to obtain non-SBIR/STTR funding support commitments for follow-on Phase 3 activities and additional support of Phase 2 from parties other than the proposing firm. Funding support commitments must show that a specific, substantial amount will be made available to the firm to pursue the stated Phase 2 and/or Phase 3 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 Phase 3 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 2 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 2 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 2 proposal. This addendum will not be counted against the 50-page limitation.

3.3.6 Phase 3 Awards resulting from NASA SBIR/STTR Awards
If the SBC has received any Phase 3 awards resulting from work on any NASA SBIR or STTR awards, provide the related Phase 1 or Phase 2 contract number, name of Phase 3 awarding agency, date of award, funding agreement number, amount, project title, period of performance and current commercialization status for each award. This listing is not included in the 50-page limit and content should be limited to information requested above. Offerors are encouraged to use spreadsheet format.

3.3.7 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 Section 8, Appendix A.

3.4 SBA Data Collection Requirement

Each SBC applying for a Phase 2 award is required to update the appropriate information in the Tech-Net database for any of its prior Phase 2 awards. In addition, upon completion of Phase 2, the SBC is required to update the appropriate information in the Tech-Net database and is requested to update the information annually thereafter for a minimum period of five years. For complete information on what to enter, go to http://technet.sba.gov.

4. Method of Selection and Evaluation Criteria

All Phase 1 and 2 proposals will be evaluated and judged on a competitive basis. Proposals will be initially screened to determine responsiveness. Proposals passing this initial screening will be technically evaluated by NASA personnel to determine the most promising technical and scientific approaches. Each proposal will be judged 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 Phase 1 Proposals

Proposals judged 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 evaluated by evaluators with knowledge of the subtopic area.

4.1.1 Evaluation Process

Proposals shall provide all information needed for complete evaluation. Evaluators will not seek additional information. Evaluations will be performed by NASA scientists and engineers. 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 1 Evaluation Criteria

NASA plans to select for award those proposals offering the best value 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 judged 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 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 be shown to be adequate and any reliance on external sources, such as Government Furnished Equipment or Facilities, addressed (Section 5.16).

Factor 3: Effectiveness of the Proposed Work Plan
The work plan will be reviewed for its comprehensiveness, effective use of available resources, cost management and proposed schedule for meeting the Phase 1 objectives. The methods planned to achieve each objective or task should be discussed in detail. The proposed path beyond Phase 1 for further development and infusion into a NASA mission or program will also be reviewed.

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 funding sources, existing and projected commitments for Phase 3 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.

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 1 proposals, Technical Merit is more important than Commercial Merit.

4.1.3 Selection
Proposals recommended for award 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 as well as overall NASA priorities, program balance and available funding. The Source Selection Official has the final authority for choosing the specific proposals for contract negotiation.

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.

4.1.4 Allocation of Rights Agreement (STTR awards only)
No more than 10 working days after the Selection Announcement, 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.

In compliance with the SBA STTR Policy Directive 8.(c) (1) STTR proposers are notified that a completed Allocation of Rights Agreement (ARA), which has been signed by authorized representatives of the SBC, RI and subcontractors and consultants, as applicable is required to be completed and executed prior to commencement of work under the STTR program. 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. The SBC must certify in all proposals that the agreement is satisfactory to the SBC.

4.2 Phase 2 Proposals

4.2.1 Evaluation Process
The Phase 2 evaluation process is similar to the Phase 1 process. NASA plans to select for award those proposals offering the best value to the Government and the SBIR/STTR Program. 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.

4.2.2 Evaluation Factors

The evaluation of Phase 2 proposals under this Solicitation will apply the following factors:

Factor 1: Scientific/Technical Merit and Feasibility
The proposed R/R&D effort will be evaluated on its innovativeness, originality, and potential technical value, including the degree to which Phase 1 objectives were met, the feasibility of the innovation, and whether the Phase 1 results indicate a Phase 2 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 be shown to be adequate and any reliance on external sources, such as Government Furnished Equipment or Facilities, addressed (Section 5.16).

Factor 3: Effectiveness of the Proposed Work Plan
The work plan will be reviewed for its comprehensiveness, effective use of available resources, cost management and proposed schedule for meeting the Phase 2 objectives. The methods planned to achieve each objective or task should be discussed in detail.

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 3 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 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.

4.2.3 Evaluation and Selection

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 numerical scores of 85 percent or higher will be evaluated and rated for their commercial potential using the criteria listed in Factor 4 and by applying the same adjectival ratings as set forth for Phase 1 proposals. Where technical evaluations are essentially equal in potential, cost to the Government may be considered in determining successful offerors. For Phase 2 proposals, commercial merit is a critical factor.

Recommendations for award 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.

Note: Companies with Prior NASA SBIR/STTR Awards

NASA has instituted a comprehensive commercialization survey/data gathering process for companies with prior NASA SBIR/STTR awards. Information received from SBIR/STTR awardees completing the survey is kept confidential, and will not be made public except in broad aggregate, with no company-specific attribution.

Responding to the survey is strictly voluntary. However, the SBIR/STTR Source Selection Official does see the information contained within the survey as adding to the program's ability to use past performance in decision making as well as providing a database of SBIR/STTR results for management.

If you have not completed a survey, or if you would like to update a previously submitted response, please go on-line at http://sbir.nasa.gov/SBIR/survey.html.

4.3 Debriefing of Unsuccessful Offerors

After Phase 1 and Phase 2 selection decisions have been announced, debriefings for unsuccessful 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.

4.3.1 Phase 1 Debriefings

For Phase 1 proposals, debriefings will be automatically e-mailed to the designated business official within 60 days of the selection announcement. If you have not received your debriefing by this time, contact the SBIR/STTR Program Support Office at sbir@reisys.com.

4.3.2 Phase 2 Debriefings

To request debriefings on Phase 2 proposals, offerors must request via e-mail to the SBIR/STTR Program Support Office at sbir@reisys.com within 60 days after selection announcement. Late requests will not be honored.

5. Considerations

5.1 Awards

5.1.1 Availability of Funds

Both Phase 1 and Phase 2 awards are subject to availability of funds. NASA has no obligation to make any specific number of Phase 1 or Phase 2 awards based on this Solicitation, and may elect to make several or no awards in any specific technical topic or subtopic.

SBIR	STTR
➢ NASA plans to announce the selection of approximately 250 proposals resulting from this Solicitation, for negotiation of Phase 1 contracts with values not exceeding $100,000. Following contract negotiations and awards, Phase 1contracts will be fixed price and contractors will have up to 6 months to carry out their programs, prepare their final reports, and submit Phase 2 proposals. ➢ NASA anticipates that approximately 45 percent of the successfully completed Phase 1 projects from the SBIR 2009 Solicitation will be selected for Phase 2. Phase 2 agreements will be fixed-price contracts with performance periods not exceeding 24 months and funding not exceeding $600,000.	➢ NASA plans to announce the selection of approximately 30 proposals resulting from this Solicitation, for negotiation of Phase 1 contracts with values not exceeding $100,000. Following contract negotiations and awards, Phase 1 contracts will be fixed price and contractors will have up to 12 months to carry out their programs, prepare their final reports, and submit Phase 2 proposals. ➢ NASA anticipates that approximately 45 percent of the successfully completed Phase 1 projects from the STTR 2009 Solicitation will be selected for Phase 2. Phase 2 agreements will be fixed-price contracts with performance periods not exceeding 24 months and funding not exceeding $600,000.

5.1.2 Contracting

To simplify contract award and reduce processing time, all contractors selected for Phase 1 and Phase 2 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.
(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.
(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.
(5) Your firm HAS NOT proposed a Co-Principal Investigator.
(6) STTR awardees should execute their Allocation of Rights Agreement within 10 days of the Selection Announcement.
(7) Your firm timely responds to all communications from the NSSC Contracting Officer.

From the time of proposal selection 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.

5.2 Phase 1 Reporting

The interim technical reports are required as described in the contract. These reports shall document progress made on the project and activities required for completion to provide NASA the basis for determining whether the payment is warranted.

A final report must be submitted to NASA upon completion of the Phase 1 R/R&D effort in accordance with applicable contract provisions. It shall elaborate the project objectives, work carried out, results obtained, and assessments of technical merit and feasibility. The final report shall include a single-page summary as the first page, in a format provided in the Phase 1 contract, identifying the purpose of the R/R&D effort and describing the findings and results, including the degree to which the Phase 1 objectives were achieved, and whether the results justify Phase 2 continuation. The potential applications of the project results in Phase 3 either for NASA or commercial purposes shall also be described. The final project summary is to be submitted without restriction for NASA publication.

All reports are required to be submitted electronically via the SBIR/STTR Website.

5.3 Payment Schedule for Phase 1

All NASA SBIR and STTR contracts are firm-fixed-price contracts.

The exact payment terms for Phase 1 will be included in the contract, but payments are normally authorized as follows: one-third at the time of award, one-third at project mid-point, and the remainder upon acceptance of the final report, new technology report and any other deliverables by NASA. NASA will make payment within thirty days of NASA acceptance and approval of all required deliverables associated with the payment.

Invoices: All invoices submitted by the SBC shall be marked with the payment number for the invoice. For example, if the invoice submitted is the first submitted for a contract, it shall be marked as the First Invoice. All final invoices shall be marked Final Invoice.

5.4 Payment Schedule for Phase 2

All NASA SBIR and STTR contracts are firm-fixed-price contracts.

The exact payment terms for Phase 2 will be included in the contract. The progress payment method will not be utilized. Quarterly payment will be authorized upon receipt and acceptance of each quarterly report along with other applicable deliverables. Upon receipt and acceptance of the final report, final new technology report and/or final new technology summary report and any other deliverables, the final payment will be authorized. NASA will make payment within thirty days of NASA acceptance and approval of all required deliverables associated with the payment.

NOTE: If a bi-monthly payment schedule is negotiated, it could substantially delay a possible award.

Invoices: All invoices submitted by the SBC shall be marked with the contract number and invoice number. For example, if the invoice submitted is the first submitted for a contract, it shall be marked as the First Invoice. All final invoices shall be marked Final Invoice.

5.5 Release of Proposal Information

In submitting a proposal, the offeror agrees to permit the Government to disclose publicly the information contained on the Proposal Cover (Form A) and 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.

5.6 Access to Proprietary Data by Non-NASA Personnel

5.6.1 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.

5.6.2 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 access to proposals to other NASA contractor and subcontractor personnel. NASA will provide access to such data only under contracts that contain an appropriate Handling of Data clause that requires the contractors to fully protect the information from unauthorized use or disclosure.

5.7 Final Disposition of Proposals

The Government retains ownership of proposals accepted for evaluation, and such proposals will not be returned to the offeror. Copies of all evaluated Phase 1 proposals will be retained for a minimum of one year after the Phase 1 selections have been made. Successful proposals will be retained in accordance with contract file regulations.

5.8 Proprietary Information in the Proposal Submission

Information contained in unsuccessful proposals will remain the property of the applicant. The Government will, however, retain copies of all proposals. Public release of information in any proposal submitted will be subject to existing statutory and regulatory requirements. If proprietary information is provided by an applicant in a proposal, which constitutes a trade secret, proprietary commercial or financial information, confidential personal information or data affecting the national security, it will be treated in confidence to the extent permitted by law. This information must be clearly marked by the applicant as confidential proprietary information. NASA will treat in confidence pages listed as proprietary in the following legend that appears on 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 Cover (Form A), 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 A.

5.9 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 1 or Phase 2 contract. Any request to modify or eliminate this clause may substantially delay contract award and funding. The following is a brief description of FAR 52.227-20.

5.9.1 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. These 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.

5.9.2 Proprietary Data

When data that is required to be delivered under an SBIR/STTR contract qualifies as "proprietary," *i.e*., either data developed at private expense that embody trade secrets or are commercial or financial and confidential or privileged, or computer software developed at private expense that is a trade secret, the contractor, if the contractor desires to continue protection of such proprietary data, shall not deliver such data to the Government, but instead shall deliver form, fit, and function data.

5.9.3 Non Disclosure Period

For a period of 4 years after acceptance of all items to be delivered under this 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.

5.9.4 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.

5.9.5 Patents

The contractor may normally elect title to any inventions made in the performance of an SBIR/STTR contract. The Government receives a nonexclusive license to practice or have practiced for or on behalf of the Government each such invention throughout the world. Small business concerns normally may retain the principal worldwide patent rights to any invention developed with Government support. The Government receives a royalty-free license for Federal Government use, reserves the right to require the patent holder to license others in certain circumstances, and requires that anyone exclusively licensed to sell the invention in the United States must normally manufacture it domestically.

In accordance with the Patent Rights Clause (FAR 52.227-11), SBIR/STTR contractors must disclose all subject inventions, which means 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 disclosed, the contractor has up to 2 years to decide whether to elect title. If the contractor fails to do so within the 2-year time period, 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 allowable time to file a patent.

Costs associated with patent applications are not allowable.

5.9.6 Invention Reporting
NASA SBIR and STTR contracts will include the invention reporting requirements in the Patent Rights Clause at FAR 52.227-11, SBIR/STTR that contractors must disclose all subject inventions to NASA within two (2) months of the inventor's report to the awardees. This means 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 disclosed, the contractor has up to 2 years to decide whether to elect title. If the contractor fails to do so within the 2-year time period, 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.

The notification to NASA of an invention shall be provided in the form of a "New Technology Report" (NTR) by accessing the NASA eNTRe Website at http://invention.nasa.gov. This should be done for interim or final reports where a new discovery or invention has been determined. If there is no invention, a New Technology Summary Report (NTSR) must be submitted to eNTRe. Both reports shall also be uploaded to the SBIR/STTR Electronic Handbook (EHB) at https://ehb8.gsfc.nasa.gov/contracts/public/firmHome.do

5.10 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.

5.11 Profit or Fee

Both Phase 1 and Phase 2 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.

5.12 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 2.17. 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 25-page limit for the Phase 1 proposal.

5.13 Similar 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 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 acknowledge or report similar or duplicate efforts can lead to the termination of contracts or civil or criminal penalties.

5.14 Contractor Commitments

Upon award of a contract, the contractor will be required to make certain legal commitments through acceptance of numerous clauses in the Phase 1 contract. The outline of this section illustrates the types of clauses that will be included. This is not a complete list of clauses to be included in Phase 1 contracts, nor does it contain specific wording of these clauses. Copies of complete provisions will be made available prior to contract negotiations.

5.14.1 Standards of Work
Work performed under the contract must conform to high professional standards. Analyses, equipment, and components for use by NASA will require special consideration to satisfy the stringent safety and reliability requirements imposed in aerospace applications.

5.14.2 Inspection
Work performed under the contract is subject to Government inspection and evaluation at all reasonable times. Reference FAR 52.246-7 at http://www.acquisition.gov/far/current/html/52_246.html#wp1118822.

5.14.3 Examination of Records
The Comptroller General (or a duly authorized representative) shall have the right to examine any directly pertinent records of the contractor involving transactions related to the contract.

5.14.4 Default
The Government may terminate the contract if the contractor fails to perform the contracted work.

5.14.5 Termination for Convenience
The contract may be terminated by the Government at any time if it deems termination to be in its best interest, in which case the contractor will be compensated for work performed and for reasonable termination costs.

5.14.6 Disputes
Any disputes concerning the contract that cannot be resolved by mutual agreement shall be decided by the Contracting Officer with right of appeal.

5.14.7 Contract Work Hours
The contractor may not require a non-exempt employee to work more than 40 hours in a work week unless the employee is paid for overtime.

5.14.8 Equal Opportunity
The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, age, sex, or national origin.

5.14.9 Affirmative Action for Veterans
The contractor will not discriminate against any employee or applicant for employment because he or she is a disabled veteran or veteran of the Vietnam era.

5.14.10 Affirmative Action for Handicapped
The contractor will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.

5.14.11 Officials Not to Benefit
No member of or delegate to Congress shall benefit from an SBIR or STTR contract.

5.14.12 Covenant Against Contingent Fees
No person or agency has been employed to solicit or to secure the contract upon an understanding for compensation except bona fide employees or commercial agencies maintained by the contractor for the purpose of securing business.

5.14.13 Gratuities
The contract may be terminated by the Government if any gratuities have been offered to any representative of the Government to secure the contract.

5.14.14 Patent Infringement
The contractor shall report to NASA each notice or claim of patent infringement based on the performance of the contract.

5.14.15 American-Made Equipment and Products
Equipment or products purchased under an SBIR or STTR contract must be American-made whenever possible. Reference FAR 52.225-2 at http://www.acquisition.gov/far/current/html/52_223_226.html#wp1169013.

5.14.16 Export Control Laws
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, Raj Shea, at Raj.V.Shea@nasa.gov.

5.15 Additional Information

5.15.1 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.

5.15.2 Evidence of Contractor Responsibility
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.

5.15.3 Required Registrations and Submissions

5.15.3.1 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 strongly encouraged to register prior to submitting a proposal.**

Reference FAR 52.204-7 at http://www.acquisition.gov/far/current/html/52_200_206.html#wp1137850.

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).

5.15.3.2 ORCA Registration

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 all offerors to 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.

5.15.3.3 VETS 100 Reporting

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 $100,000.00. 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 $100,000.00 or greater must have a current VETS 100 report on file. Please visit the DOL VETS 100 website at https://vets100.vets.dol.gov/. NASA will not enter into any contract wherein the firm is not compliant with the requirements stipulated herein.

5.15.4 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” available online at http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=7150&s=2.

5.16 Property and Facilities

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. An SBC will furnish its own facilities to perform the proposed work as an indirect cost to the contract. Special tooling required for a project may be allowed as a direct cost.

When an SBC cannot furnish its own facilities to perform required tasks, an SBC may propose to acquire the use of available non Government facilities. Rental or lease costs may be considered as direct costs as part of the total funding for the project. If unique requirements force an offeror to acquire facilities under a NASA contract, they will be purchased as Government Furnished Equipment (GFE) and will be titled to the Government.

An offeror may propose the use of unique or one-of-a-kind Government facilities if essential for the research.

If a proposed project or product demonstration requires the use of unique Government facilities or equipment that will be funded with SBIR dollars, 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. The proposal should also include relevant information on the funding source(s) private, internal, or other Government. Failure to provide this explanation and the site manager’s written authorization of use may invalidate any proposal selection. If the offeror proposes the use of SBIR/STTR funds for Government equipment or facilities, this explanation will be provided to SBA during the Agency waiver process.

Contractors are ordinarily required to furnish all property necessary to perform Government contracts. In compliance with FAR Part 45, Contracting Officers will only approve use of Government property or Government facilities when the justification provided in the proposal meets the requirements at FAR 45.102. Proposers are notified that the NASA SBIR and STTR programs cannot assist in the approval process for use of Government property or facilities. Further, any proposer requiring the use of government property or facilities must, within five (5) days of notification of selection, provide to the NASA Shared Services Center Contracting Officer all required documentation, to include, an Agreement by and between the Contractor and the appropriate Government 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. Proposers are advised that the exceptions to government property responsibility and liability stipulated at FAR 45.104 do not apply to NASA SBIR and STTR contracts.

Additional information on the use of NASA facilities, facility programs, and equipment is available at http://sbir.nasa.gov/SBIR/facilities.html.

5.17 Human and/or Animal Subject

Due to the complexity of the approval process, use of human and/or animal subjects is not recommended in Phase 1 and may significantly delay contract award for Phase 2.

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:
http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?sid=6e185775053b8aba7be1544f2f3d9d09&c=ecfr&tpl=/ecfrbrowse/Title14/14cfrv5_02.tpl

5.18 Toxic Chemical

Submission of this certification is a prerequisite for making or entering into this contract imposed by Executive Order 12969, August 8, 1995. Offerors shall identify the use of toxic chemical on Form A. Reference FAR 52.223-13 at http://www.acquisition.gov/far/current/html/52_223_226.html#wp1168933.

5.19 Hazardous Materials

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 nonresponsible and ineligible for award. Offerors shall identify the use of hazardous materials on Form A. Reference FAR 52.223-3 at http://www.acquisition.gov/far/current/html/52_223_226.html#wp1168787.

5.20 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).
See: http://www.arnet.gov/far/current/html/Subpart%202_1.html#wp1145507

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://ec.msfc.nasa.gov/hq/gic/gic06-02.html

5.21 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.

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. 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.

For successful proposal submission, SBCs must complete all three forms online, upload their technical proposal in an acceptable format, and have the Business Official 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 for Phase 1 and 3.3.4 for Phase 2.

STTR: The Research Institution is required to electronically endorse the Cooperative 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, and the briefing chart must be submitted via the Submissions EHB located on the NASA SBIR/STTR website.

(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) Firms must also upload a briefing chart, which is not included in the page count (See Sections 3.2.7 and 3.3.6).

Note: Other forms of submissions such as postal, paper, fax, diskette, or e-mail attachments are not acceptable.

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. Other acceptable formats are MS Works, MS Word, and WordPerfect. Note: Due to PDF difficulties with non-standard fonts, Unix and TeX users should output technical proposal files in DVI format.

Graphics

For reasons of space conservation and simplicity the offeror is encouraged, but not required, to embed graphics within the document. For graphics submitted as separate files, the acceptable file formats (and their respective extensions) are: Bit-Mapped (.bmp), Graphics Interchange Format (.gif), JPEG (.jpg), PC Paintbrush (.pcx), WordPerfect Graphic (.wpg), and Tagged-Image Format (.tif). 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. 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 1 Proposal Receipt

All Phase 1 proposal submissions must be received no later than 5:00 p.m. EDT on Thursday, September 3, 2009, via the NASA SBIR/STTR Website (http://sbir.nasa.gov). The server/electronic handbook will not be available for Internet submissions after this deadline. **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, and the uploaded technical proposal and 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 2009 Phase 1 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 official selection announcement is currently scheduled for November 23, 2009, 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@reisys.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 at the address 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 information 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 Innovative Partnerships Program (IPP): http://www.ipp.nasa.gov/
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, an agency of the Department of Commerce, is the Federal Government's largest central resource for government-funded scientific, technical, engineering, and business related information. For information about 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

Form A – SBIR Cover Sheet

Subtopic Number

1. PROPOSAL NUMBER: **09 -** _ _ . _ _ _ _ _ _
2. SUBTOPIC TITLE:
3. PROPOSAL TITLE:
4. SMALL BUSINESS CONCERN (SBC):
   NAME:
   MAILING ADDRESS:
   CITY/STATE/ZIP:
   PHONE: FAX:
   EIN/TAX ID: DUNS + 4: CAGE CODE:
5. AMOUNT REQUESTED $ ________________ DURATION: __________ MONTHS
6. CERTIFICATIONS: OFFEROR CERTIFIES THAT:

As defined in Section 1 of the Solicitation, the offeror certifies:		
a. The Principal Investigator is "primarily employed" by the organization as defined in the SBIR Solicitation. Note: Co-PI is not acceptable.	Yes	No
As defined in Section 2 of the Solicitation, the offeror qualifies as a:		
b. SBC Number of employees: _____	Yes	No
c. The firm is owned and operated in the United States	Yes	No
d. Socially and economically disadvantaged SBC	Yes	No
e. Women-owned SBC	Yes	No
f. HUBZone-owned SBC	Yes	No
g. Veteran-Owned SBC	Yes	No
h. Service Disabled Veteran-Owned SBC	Yes	No
As defined in Section 3.2.4 Part 11 of the Solicitation indicate if		
i. Work under this project has been submitted for Federal funding only to the NASA SBIR Program	Yes	No
j. Funding has been received for work under this project by any other Federal grant, contract, or subcontract	Yes	No
As described in Section 3 of this solicitation, the offeror meets the following requirements completely:		
k. All 11 parts of the technical proposal are included in part order	Yes	No
l. Subcontracts/consultants proposed?	Yes	No
i) If yes, limits on subcontracts/consultants met	Yes	No
m. Government equipment or facilities required (cannot use SBIR funds)?	Yes	No
i) If yes, signed statement enclosed in Part 8	Yes	No
ii) If yes, non-SBIR funding source identified in Part 8?	Yes	No
In accordance with Section 5.14.16 of the Solicitation as applicable:		
n. The offeror will comply with export control regulations	Yes	No
In accordance with Section 5 of the Solicitation as applicable, indicate if any of the following will be used (must comply with federal regulations):		
o. Human Subject	Yes	No
p. Animal Subject	Yes	No
q. Toxic Chemicals	Yes	No
r. Hazardous Materials	Yes	No

7. ACN NAME: PHONE: E-MAIL:
8. 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.

9. ENDORSEMENT BY SBC OFFICIAL:

NAME:	TITLE:
PHONE:	E-MAIL:
ENDORSED BY:	DATE:

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.

Guidelines for Completing SBIR Cover Sheet

Complete Cover Sheet Form A electronically.

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

2. Subtopic Title: Enter the title of the subtopic that this proposal will address. Use abbreviations as needed.

3. 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."

4. Small Business Concern: Enter the full name of the company submitting the proposal. If a joint venture, list the company chosen to negotiate and receive contracts. If the name exceeds 40 keystrokes, please abbreviate.

Address:	Must match CCR address. 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
DUNS + 4:	9-digit Data Universal Number System plus a 4-digit suffix given by parent concern
CAGE Code:	Commercial Government and Entity Code (Issued by Central Contractor Registration (CCR))

5. Amount Requested: Proposal amount from Budget Summary. The amount requested should not exceed $100,000 (see Sections 1.4.1, 5.1.1).

   Duration: Proposed duration in months. The requested duration should not exceed 6 months (see Sections 1.4.1, 5.1.1).

6. Certifications: Answer Yes or No as applicable for certifications 6a – 6r (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.

   6j. SBCs should choose “No” to confirm that work under this project has not been funded under any other Federal grant, contract or subcontract.

   6l. Subcontracts/consultants proposed? 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) If yes, limits on subcontracting and consultants met: By answering yes, the SBC certifies that business arrangements with other entities or individuals do not exceed one-third of the work (amount requested including cost sharing if any, less fee, if any) and is in compliance with Section 3.2.4, Part 9.

   6m. Government furnished equipment required? By answering yes, the SBC certifies that unique, one-of-a-kind Government Furnished Facilities or Government Furnished Equipment are required to perform the proposed activities (see Sections 3.2.4 Part 8, 3.3.4 Part 8, 5.16). By answering no, the SBC certifies that no such Government Furnished Facilities or Government Furnished Equipment is required to perform the proposed activities.

   i) If yes, signed statement enclosed in Part 8: By answering yes, the SBC certifies that a statement describing the uniqueness of the facility and its availability to the offeror at specified times, signed by the appropriate Government official, is enclosed in the proposal.
   ii) If yes, non-SBIR funding source identified in Part 8: By answering yes, the SBC certifies that it has a confirmed, non-SBIR funding source for whatever charges may be incurred when utilizing the required Government facility.

   6n. 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.

7. ACN Name, Telephone Number and E-mail: Name, telephone number and e-mail address of Authorized Contract Negotiator.

8. Endorsement of this form certifies understanding of this statement.

9. Endorsement: An official of the firm must electronically endorse the proposal cover.

Form B – SBIR Proposal Summary

Subtopic Number

1. Proposal Number **09 -** _ _ . _ __ _ _ _ _.
2. Subtopic Title
3. Proposal Title
4. Small Business Concern
   Name:
   Address:
   City/State:
   Zip:
   Phone:
5. Principal Investigator/Project Manager
   Name:
   Address:
   City/State:
   Zip:
   Phone:
   E-mail:
6. Estimated Technology Readiness Level (TRL) at beginning and end of contract:
7. Technical Abstract (Limit 2,000 characters, approximately 200 words)
8. Potential NASA Application(s): (Limit 1,500 characters, approximately 150 words)
9. Potential Non-NASA Application(s): (Limit 1,500 characters, approximately 150 words)
10. Technology Taxonomy (Select only the technologies relevant to this specific proposal)

Guidelines for Completing SBIR Proposal Summary

Complete Proposal Summary Form B electronically.

1. **Proposal Number:** Same as Cover Sheet.

2. **Subtopic Title:** Same as Cover Sheet.

3. **Proposal Title:** Same as Cover Sheet.

4. **Small Business Concern:** Same as Cover Sheet.

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

6. **Technology Readiness Level (TRL):** Provide the estimated Technology Readiness Level (TRL) at beginning and end of contract. See Section 2.21 and Appendix B for TRL definitions.

7. **Technical Abstract:** Summary of the offeror's proposed project in 200 words or less. The abstract must not contain proprietary information and must describe the NASA need addressed by the proposed R/R&D effort.

8. **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. Limit your response to 150 words or 1,500 characters, whichever is less.

9. **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. Limit your response to 150 words or 1,500 characters, whichever is less.

10. **Technology Taxonomy:** Selections for the Technology Taxonomy are limited to technologies supported or relevant to the specific proposal.

Form C – SBIR Budget Summary

PROPOSAL NUMBER:
SMALL BUSINESS CONCERN:

DIRECT LABOR:

Category	Hours	Rate	Cost	
			TOTAL DIRECT LABOR: (1)	$ ______
OVERHEAD COST ______% of Total Direct Labor or $ ______			OVERHEAD COST: (2)	$ ______

OTHER DIRECT COSTS (ODCs):

Category	Cost	
	$	
	TOTAL OTHER DIRECT COSTS: (3)	$ ______

Explanation of ODCs
____
____
____

(1)+(2)+(3)=(4)	SUBTOTAL: (4)	$ ______
GENERAL & ADMINISTRATIVE (G&A) COSTS ______% of Subtotal or $ ______	G&A COSTS: (5)	$ ______
(4)+(5)=(6)	TOTAL COSTS (6)	$ ______
ADD PROFIT or SUBTRACT COST SHARING (As applicable)	PROFIT/COST SHARING: (7)	$ ______
(6)+(7)=(8)	AMOUNT REQUESTED: (8)	$ ______

PHASE 1 DELIVERABLES: Upon selection, SBCs will be required to submit mandatory deliverables such as technical reports, final report and New Technology report as per their contract. Samples of all required contract deliverables are available in the NASA SBIR/STTR Firms Library via the NASA SBIR/STTR Website (http://sbir.nasa.gov). If your firm is proposing any additional deliverables, list them below:

Deliverable	Quantity	Project Delivery Milestone
______	______	______
______	______	______

If you require the use of a Government Facility or Equipment, identify it below as well as in Part 8 of your technical proposal. (See certification l on Form A)

____

AUDIT AGENCY: If a Federal agency has ever audited your accounting system, please identify the agency, office location, and contact information below:

Agency: ______________ Office/Location: ______________
Phone: ______________ Email: ______________

Guidelines for Preparing SBIR Budget Summary

Complete Budget Summary Form C electronically.

The offeror electronically submits to the Government a pricing proposal of estimated costs with detailed information for each cost element, consistent with the offeror's cost accounting 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 provided on the electronic form.

Firm: Same as Cover Sheet.

Proposal Number: Same as Cover Sheet.

Direct Labor: Enter labor categories proposed (e.g., Principal Investigator/Project Manager, Research Assistant/Laboratory Assistant, Analyst, Administrative Staff), labor rates and the hours for each labor category.

Overhead Cost: Specify current rate and base. Use current rate(s) negotiated with the cognizant Federal auditing agency, if available. If no rate(s) has (have) been negotiated, a reasonable indirect cost (overhead) rate(s) may be requested for Phase 1 for acceptance by NASA. Show how this rate is determined. The offeror may use whatever number and types of overhead rates are in accordance with the firm's accounting system and approved by the cognizant Federal negotiating agency, if available. Multiply Direct Labor Cost by the Overhead Rate to determine the Overhead Cost.

<u>Example</u>: A typical SBC might have an overhead rate of 30 percent. If the total direct labor costs proposed are $50,000, the computed overhead costs for this case would be .3x50,000=$15,000, if the base used is the total direct labor costs.

or provide a number for total estimated overhead costs to execute the project.

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):

- Materials and Supplies: Indicate types required and estimate costs.
- Documentation Costs or Page Charges: Estimate cost of preparing and publishing project results.
- Subcontracts: Include a completed budget including hours and rates and justify details. (Section 3.2.4, Part 9.)
- Consultant Services: Indicate name, daily compensation, and estimated days of service.
- Computer Services: Computer equipment leasing is included here.

List all other direct costs that are not otherwise included in the categories described above.

Explanations of all items identified as ODCs must be provided under “Explanation of ODCs.” Offeror should include the basis used for estimating costs (vendor quote, catalog price, etc.) For example, if “Materials” is listed as an ODC, include a description of the materials, the quantity required and basis for the proposed cost. Note that travel expenses shall not be included in the proposed budget for a Phase 1 proposal, and any travel expenses listed for a Phase 2 proposal must include a detailed accounting of all said expenses.

Note: NASA will not fund the purchase of capital equipment or supplies that are not to be delivered to the government or consumed in the production of a prototype. The cost of capital equipment should be depreciated and included in G&A if appropriate.

Subtotal (4): Sum of (1) Total Direct Labor, (2) Overhead and (3) ODCs

General and Administrative (G&A) Costs (5): Specify current rate and base. Use current rate negotiated with the cognizant Federal negotiating agency, if available. If no rate has been negotiated, a reasonable indirect cost (G&A)

rate may be requested for acceptance by NASA. Show how this rate is determined. If a current negotiated rate is not available, NASA will negotiate a reasonable rate with the offeror. Multiply (4) subtotal (Total Direct Cost) by the G&A rate to determine G&A Cost.

or provide an estimated G&A costs number for the proposal.

Total Costs (6): Sum of Items (4) and (5). Note that this value will be used in verifying the minimum required work percentage for the SBC.

Profit/Cost Sharing (7): See Sections 5.10 and 5.11. Profit to be added to total budget, shared costs to be subtracted from total budget, as applicable.

Amount Requested (8): Sum of Items (6) and (7), not to exceed $100,000.

Deliverables and Audit Information (9):

Deliverables: List any additional deliverables, if applicable. Include the deliverable name, quantity (include unit of measurement, i.e., 2 models or 1.5 lbs. of material), and the proposed delivery milestone (i.e., end of contract). This section should only be completed if the offeror is proposing a deliverable in addition to the mandatory deliverables (technical report, final report and New Technology Report).

Audit Agency: Complete the “Contact Information” section if your firm’s accounting system has been audited by a Federal agency. Provide the agency name, the office branch or location, and the phone number and/or email.

SBIR Check List

For assistance in completing your Phase 1 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** (Section 3.2.1).
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 3.2.7).
6. Certifications in Form A are completed, and agree with the content of the technical proposal.
7. Proposed funding does not exceed $100,000 (Sections 1.4.1, 5.1.1).
8. Proposed project duration does not exceed 6 months (Sections 1.4.1, 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.
11. **Proposals must be received no later than 5:00 p.m. EDT on Thursday, September 3, 2009** (Section 6.3).

Form A – STTR Cover Sheet

1. PROPOSAL NUMBER: **09 - _ _ . _ _ _ _ _ _**
2. RESEARCH TOPIC:
3. PROPOSAL TITLE:
4. SMALL BUSINESS CONCERN (SBC)
   NAME:
   ADDRESS:
   CITY/STATE/ZIP:
   PHONE: FAX:
   EIN/TAX ID:
   DUNS + 4: CAGE CODE:

   RESEARCH INSTITUTION (RI)
   NAME:
   ADDRESS:
   CITY/STATE/ZIP :
   PHONE: FAX:
   EIN/TAX ID:
5. AMOUNT REQUESTED: $_____________________ DURATION: _________ MONTHS
6. CERTIFICATIONS: THE ABOVE SBC CERTIFIES THAT:

As defined in Section 2 of the Solicitation, the offeror qualifies as a:

a.	SBC Number of employees: ____	Yes	No
b.	The firm is owned and operated in the United States	Yes	No
c.	Socially and economically disadvantaged SBC	Yes	No
d.	Woman-owned SBC	Yes	No
e.	HUBZone-owned SBC	Yes	No
f.	Veteran-Owned SBC	Yes	No
g.	Service Disabled Veteran-Owned SBC	Yes	No

As described in Section 2.11 of the Solicitation, the partnering institution qualifies as a:

h.	FFRDC	Yes	No
i.	Nonprofit research institute	Yes	No
j.	Nonprofit college or university	Yes	No

As described in Section 3 of the Solicitation, the offeror meets the following requirements completely:

k.	Cooperative Agreement signed by the SBC and RI enclosed	Yes	No
l.	All eleven parts of the technical proposal included in part order	Yes	No
m.	Subcontracts/consultants proposed? (Other than the RI)	Yes	No
	i) If yes, limits on subcontracts/consultants met	Yes	No
n.	Government equipment or facilities required (cannot use STTR funds)?	Yes	No
	i) If yes, signed statement enclosed in Part 8	Yes	No
	ii) If yes, non-STTR funding source identified in Part 8?	Yes	No
o.	A signed Allocation of Rights Agreement will be available for the Contracting Officer at time of selection	Yes	No

As defined in Section 3.2.4 of the Solicitation, indicate if:

p.	Work under this project has been submitted for funding only to the NASA STTR Program	Yes	No
q.	Funding has been received for work under this project by any other Federal grant, contract, or subcontract	Yes	No

In accordance with Section 5.14.16 of the Solicitation as applicable:

r.	The offeror will comply with export control regulations	Yes	No

In accordance with Section 5 of the Solicitation as applicable, indicate if any of the following will be used (must comply with federal regulations):

s.	Human Subject	Yes	No
t.	Animal Subject	Yes	No
u.	Toxic Chemicals	Yes	No
v.	Hazardous Materials	Yes	No

7. ACN NAME: PHONE: E-MAIL:
8. The SBC will perform ___% of the work and the RI will perform ___% of the work of this project.
9. 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.

10. ENDORSEMENT BY SBC OFFICIAL:

NAME:	TITLE:
PHONE:	E-MAIL:
ENDORSED BY:	DATE:

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.

Guidelines for Completing STTR Cover Sheet

Complete Cover Sheet Form electronically.

1. Proposal Number: This number does not change. The proposal number consists of the program year (i.e. 04) and unique four-digit system-generated number.

2. Research Topic: NASA research topic number and title (Section 9).

3. Proposal Title: A brief, descriptive title, avoid words like "development of" and "study of," and do not use acronyms or trade names.

4. Small Business Concern: Full name and address of the company submitting the proposal. If a joint venture, list the company chosen to negotiate and receive contracts. If the name exceeds 40 keystrokes, please abbreviate.

   Research Institution: Full name and address of the research institute.

Mailing Address:	Must Match CCR Address. 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
DUNS + 4:	9-digit Data Universal Number System plus a 4-digit suffix given by parent concern
CAGE Code:	Commercial Government and Entity Code (Issued by Central Contractor Registration (CCR)

5. Amount Requested: Proposal amount from Budget Summary. The amount requested should not exceed $100,000 (see Sections 1.4.1, 5.1.1).

   Duration: Proposed duration in months. The requested duration should not exceed 12 months (see Sections 1.4.1, 5.1.1).

6. Certifications: Answer Yes or No as applicable for certifications 6a – 6v (see Section 2 for definitions). Where applicable, SBCs should make sure that their certifications on Form A agree with the content of their technical proposal.

   6k. Cooperative Agreement signed by the SBC and RI: By answering yes, the SBC/RI certifies that a completed Cooperative Agreement, electronically endorsed by both SBC Official and RI Official, is submitted with the proposal (see Sections 3.2.2, 3.2.5).

   6m. Subcontracts/consultants proposed? By answering yes, the SBC/RI certifies that subcontracts/consultants have been proposed and arrangements have been made to perform on the contract, if awarded.

   i) If yes, limits on subcontracting and consultants met: By answering yes, the SBC/RI certifies that business arrangements with other entities or individuals do not exceed 30 percent of the work (amount requested including cost sharing if any, less fee, if any) and is in compliance with Section 3.2.4, Part 9.

   6n. Government furnished equipment required? By answering yes, the SBC/RI certifies that unique, one-of-a-kind Government Furnished Facilities or Government Furnished Equipment are required to perform the proposed activities (see Sections 3.2.4 Part 8, 3.3.4 Part 8, 5.16). By answering no, the SBC/RI certifies that no such Government Furnished Facilities or Government Furnished Equipment are required to perform the proposed activities.

   i) If yes, signed statement enclosed in Part 8: By answering yes, the SBC/RI certifies that a statement describing the uniqueness of the facility and its availability to the offeror at specified times, signed by the appropriate Government official, is enclosed in the proposal.

   ii) If yes, non-SBIR funding source identified in Part 8. By answering yes, the SBC certifies that it has confirmed, non-SBIR funding source for whatever charges may be incurred when utilizing the required Government facility.

   6q. SBCs should choose “No” to confirm that work under this project has not been funded under any other Federal grant, contract or subcontract.

   6r. 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.

7. ACN Name, Telephone Number and E-mail: Name, telephone number and e-mail address of Authorized Contract Negotiator.

8. Proposals submitted in response to this Solicitation must be jointly developed by the SBC and the RI, and at least **40 percent** of the work (amount requested including cost sharing, less fee, if any) is to be performed by the SBC as the prime contractor, and at least **30 percent** of the work is to be performed by the RI (see Section 3.2.4).

9. Endorsement of this form certifies understanding of this statement.

10. Endorsements: An official of the firm must electronically endorse the proposal cover.

Form B – STTR Proposal Summary

1. Proposal Number **09 - _ _ . _ _ _ _ _ _ .**
2. Research Topic:
3. Proposal Title:
4. Small Business Concern
   Name:
   Address:
   City/State:
   Zip:
   Phone:
5. Research Institution
   Name:
   Address:
   City/State:
   Zip:
   Phone:
6. Principal Investigator/Project Manager:
7. Estimated Technology Readiness Level (TRL) at beginning and end of contract:
8. Technical Abstract (Limit 2,000 characters, approximately 200 words)
9. Potential NASA Application(s): (Limit 1,500 characters, approximately 150 words)
10. Potential Non-NASA Application(s): (Limit 1,500 characters, approximately 150 words)
11. Technology Taxonomy (Select only the technologies relevant to this specific proposal)

Guidelines for Completing STTR Proposal Summary

Complete Form B electronically.

1. **Proposal Number:** Same as Cover Sheet

2. **Research Topic:** Same as Cover Sheet.

3. **Proposal Title:** Same as Cover Sheet.

4. **Small Business Concern:** Same as Cover Sheet.

5. **Research Institution:** Same as Cover Sheet.

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

7. **Technology Readiness Level (TRL):** Provide the estimated Technology Readiness Level (TRL) at beginning and end of contract. See Section 2.21 and Appendix B for TRL definitions.

8. **Technical Abstract:** Summary of the offeror's proposed project in 200 words or less. The abstract must not contain proprietary information and must describe the NASA need addressed by the proposed R/R&D effort.

9. **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. Limit your response to 150 words or 1,500 characters, whichever is less.

10. **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. Limit your response to 150 words or 1,500 characters, whichever is less.

11. **Technology Taxonomy:** Selections for the Technology Taxonomy are limited to technologies supported or relevant to the specific proposal.

Form C – STTR Budget Summary

PROPOSAL NUMBER:
SMALL BUSINESS CONCERN:

DIRECT LABOR:

Category	Hours	Rate	Cost	
			TOTAL DIRECT LABOR: (1)	$ ______
OVERHEAD COST _____% of Total Direct Labor or $ _____			OVERHEAD COST: (2)	$ ______

OTHER DIRECT COSTS (ODCs) including RI budget:

Category	Cost	
	$	
	TOTAL OTHER DIRECT COSTS: (3)	$ ______

Explanation of ODCs

____
____
____

(1)+(2)+(3)=(4)	SUBTOTAL: (4)	$ ______
GENERAL & ADMINISTRATIVE (G&A) COSTS ______% of Subtotal or $ ______	G&A COSTS: (5)	$ ______
(4)+(5)=(6)	TOTAL COSTS (6)	$ ______
ADD PROFIT or SUBTRACT COST SHARING (As applicable)	PROFIT/COST SHARING: (7)	$ ______
(6)+(7)=(8)	AMOUNT REQUESTED: (8)	$ ______

PHASE 1 DELIVERABLES: Upon selection, SBCs will be required to submit mandatory deliverables such as technical reports, final report and New Technology Report as per their contract. Samples of all required contract deliverables are available in the NASA SBIR/STTR Firms Library via the NASA SBIR/STTR Website (http://sbir.nasa.gov). If your firm is proposing any additional deliverables, list them below:

Deliverable	Quantity	Project Delivery Milestone
______________	______	______________
______________	______	______________

If you require the use of a Government Facility or Equipment, identify it below as well as in Part 8 of your technical proposal. (See certification m on Form A)

____

AUDIT AGENCY: If a Federal agency has ever audited your accounting system, please identify the agency, office location, and contact information below:

Agency: ______________________ Office/Location: ______________________
Phone: ______________________ Email: ______________________

Guidelines for Preparing STTR Budget Summary

Complete Summary Budget Form C electronically.

The offeror electronically submits to the Government a pricing proposal of estimated costs with detailed information for each cost element, consistent with the offeror's cost accounting 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 provided on the electronic form.

Small Business Concern - Same as Cover Sheet.

Principal Investigator/Project Manager - Same as Cover Sheet.

Direct Labor - Enter labor categories proposed (e.g., Principal Investigator/Project Manager, Research Assistant/Laboratory Assistant, Analyst, Administrative Staff), labor rates and the hours for each labor category.

Overhead Cost - Specify current rate and base. Use current rate(s) negotiated with the cognizant Federal auditing agency, if available. If no rate(s) has (have) been audited, a reasonable indirect cost (overhead) rate(s) may be requested for Phase 1 for acceptance by NASA. Show how this rate is determined. The offeror may use whatever number and types of overhead rates are in accordance with the firm's accounting system and approved by the cognizant Federal negotiating agency, if available. Multiply Direct Labor Cost by the Overhead Rate to determine the Overhead Cost.

<u>Example</u>: A typical SBC might have an overhead rate of 30%. If the total direct labor costs proposed are $50,000, the computed overhead costs for this case would be .3x50,000=$15,000, if the base used is the total direct labor costs.

> **or** provide a number for total estimated overhead costs to execute the project.

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) -
Include total cost for the Research Institution. Note that the proposal should include sufficient information from the Research Institution to determine how their budget was calculated.

- Materials and Supplies: Indicate types required and estimate costs.
- Documentation Costs or Page Charges: Estimate cost of preparing and publishing project results.
- Subcontracts: Include a completed budget including hours and rates and justify details. (Section 3.2.4, Part 9.)
- Consultant Services: Indicate name, daily compensation, and estimated days of service.
- Computer Services: Computer equipment leasing is included here.

List all other direct costs that are not otherwise included in the categories described above.

Explanations of all items identified as ODCs must be provided under "Explanation of ODCs." Offeror should include the basis used for estimating costs (vendor quote, catalog price, etc.) For example, if "Materials" is listed as an ODC, include a description of the materials, the quantity required and basis for the proposed cost. Note that travel expenses shall not be included in the proposed budget for a Phase 1 proposal, and any travel expenses listed for a Phase 2 proposal must include a detailed accounting of all said expenses.

Note: NASA will not fund the purchase of capital equipment or supplies that are not to be delivered to the government or consumed in the production of a prototype. The cost of capital equipment should be depreciated and included in G&A if appropriate.

Subtotal (4) - Sum of (1) Total Direct Labor, (2) Overhead and (3) ODCs

General and Administrative (G&A) Costs (5)- Specify current rate and base. Use current rate negotiated with the cognizant Federal negotiating agency, if available. If no rate has been negotiated, a reasonable indirect cost (G&A) rate may be requested for acceptance by NASA. If a current negotiated rate is not available, NASA will negotiate a reasonable rate with the offeror. Multiply (4) subtotal (Total Direct Cost) by the G&A rate to determine G&A Cost.

or provide an estimated G&A costs number for the proposal.

Total Costs (6) - Sum of Items (4) and (5). Note that this value will be used in verifying the minimum required work percentage for the SBC and RI.

Profit/Cost Sharing (7) - See Sections 5.10 and 5.11. Profit to be added to total budget, shared costs to be subtracted from total budget, as applicable.

Amount Requested (8) - Sum of Items (6) and (7), not to exceed $100,000.

Deliverables and Audit Information (9):

Deliverables: List any additional deliverables, if applicable. Include the deliverable name, quantity (include unit of measurement, i.e., 2 models or 1.5 lbs. of material), and the proposed delivery milestone (i.e., end of contract). This section should only be completed if the offeror is proposing a deliverable in addition to the mandatory deliverables (technical report, final report and New Technology Report).

Audit Agency: Complete the "Contact Information" section if your firm's accounting system has been audited by a Federal agency. Provide the agency name, the office branch or location, and the phone number and/or email.

Model Cooperative R/R&D 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 1 activities, at a minimum. If the______________________(Proposal Title)________ Project is selected to continue into Phase 2, the agreement may also be binding in Phase 2 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 3 activities that are funded by NASA.

After notification of Phase 1 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 __________________________, 200___.

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.

(c) 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.

2. Background Intellectual Property.

(a) "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.

(b) 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, <u>subject to any rights of the Government therein</u>, 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 1 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 Cooperative Agreement** (Sections 3.2.1, 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 3.2.7).
6. Certifications in Form A are completed, and agree with the content of the technical proposal.
7. Proposed funding does not exceed $100,000 (Sections 1.4.1, 5.1.1).
8. Proposed project duration does not exceed 12 months (Sections 1.4.1, 5.1.1).
9. Cooperative Agreement has been electronically endorsed by both the SBC Official and RI (Sections 3.2.5, 6.2).
10. Entire proposal including Forms A, B, C, and Cooperative Agreement submitted via the Internet.
11. Form A electronically endorsed by the SBC Official.
12. **Proposals must be received no later than 5:00 p.m. EDT on Thursday, September 3, 2009** (Section 6.3).
13. Signed Allocation of Rights Agreement available for Contracting Officer at 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 four NASA Mission Directorates (MDs):

Aeronautics Research
Exploration Systems
Science
Space Operations

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 that will lead to revolutionary concepts, technologies, and capabilities that 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 conducts cutting-edge research that produces concepts, tools, and technologies that enable the design of vehicles that fly safely through any atmosphere at any speed. In addition, ARMD is directly addressing fundamental research challenges that must be overcome in order to implement the Next Generation Air Transportation System (NextGen). This research will yield revolutionary concepts, capabilities, and technologies that will enable significant increases in the capacity, efficiency and flexibility of the National Air Space. 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 3) of developing a balanced overall program of science, exploration, and aeronautics, consistent with the redirection of the human spaceflight program to focus on exploration. 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.

http://www.aeronautics.nasa.gov/

TOPIC: A1 Aviation Safety

The Aviation Safety Program focuses on the Nation's future aviation safety challenges. This vigilance for safety must continue in order to meet the projected increases in air traffic capacity and realize the new capabilities envisioned for the Next Generation Air Transportation System (NextGen). The Aviation Safety Program will conduct research to improve the intrinsic safety attributes of legacy and future aircraft and their operations in the Next Generation Air Transportation system, and to eliminate safety-related technology barriers.

The program has focused on furthering our understanding of the fundamental questions that need to be addressed for mid- and long-term improvements to aviation safety through engineering analysis and technology design. The results at the fundamental level will be integrated at the discipline and multi-discipline levels to ultimately yield system-level integrated capabilities, methods, and tools for analysis, optimization, prediction, and design that will enable improved safety for a range of operating concepts, vehicle classes, and crew configurations. The Aviation Safety Program is divided into four complementary and highly interlinked projects:

- The Aircraft Aging and Durability Project performs foundational research in aging science that will ultimately yield multi-disciplinary analysis and optimization capabilities that will enable system-level integrated methods for the detection, prediction, and mitigation/management of aging-related hazards for future civilian and military aircraft.
- The Integrated Intelligent Flight Deck Project develops tools, methods, principles, guidelines, and technologies for revolutionary flight deck systems that enable transformations toward safer operations.
- The Integrated Resilient Aircraft Control Project conducts research to advance the state of aircraft flight control to provide onboard control resilience for ensuring safe flight in the presence of adverse conditions.
- The Integrated Vehicle Health Management Project develops validated tools, technologies and techniques for automated detection, diagnosis and prognosis that enable mitigation of adverse events during flight.

Examples areas of program interest include research directed at fundamental knowledge of legacy and future aircraft structures and systems durability; on-board detection, diagnosis, prognosis, prediction and mitigation of system failures and faults; monitoring vehicle and airspace issues to identify problems before they become accidents; understanding aircraft dynamics of current and future vehicles in damaged and upset conditions; robust control systems; aircraft guidance for emergency operation; airborne sensors and sensor systems for the detection and monitoring of external hazards to aircraft (e.g., in-flight icing conditions, wake vortices); design of robust collaborative work environments; effective and robust human-automation systems; and information management for effective decision making. In addition, general methods for dramatically advancing the community's capability for thorough, cost-effective and time-effective verification and validation of safety-critical systems are of interest to the program as a whole, including rigorous methods for validating design requirements for vehicles and aviation operations, verifying integrated and distributed aircraft and air traffic systems (including assumptions about human performance), and verifying software-intensive systems.

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 Mitigation of Aircraft Aging and Durability-Related Hazards
Lead Center: GRC
Participating Center(s): ARC, LaRC

The mitigation and management of aging and durability-related hazards in future civilian and military aircraft will require advanced materials, concepts, and techniques. NASA is engaged in the research of materials (metals, ceramics, and composites) and characterization/validation test techniques to mitigate aging and durability issues and to enable advanced material suitability and concepts.

Proposals are sought for the development of moisture-resistant resins and new surface treatments/primers. Novel chemistries are sought to improve the durability of aerospace adhesives with potential use on subsonic aircraft. This research opportunity is focused on the development of novel chemistries for coupling agents, surface treatments for adherends and their interfaces, leading to aerospace structural adhesives with improved durability. Work may involve chemical modification and testing of adhesives, coupling agents, surface treatments or combinations thereof and modeling to predict behavior and guide the synthetic approaches. Examples of adhesive characteristics to model and/or test may include, but are not limited to, hydrolytic stability of the interfacial chemistry, moisture permeability at the interface, and hydrophobicity of coupling agents and surface primers. Examples of adherends to model and/or test include carbon fiber/epoxy composites used in structural applications on subsonic aircraft, and aluminum, as well as their respective surface treatments. Additionally, proposals are sought for test techniques to fully characterize aging history and strain rate effects on thermoset and/or thermoplastic resins as well as on advanced composites manufactured of such resins and reinforced with 3D fiber preforms such as the triaxial braid used in advanced composite fan containment structures. Technology innovations may take the form of tools, models, algorithms, prototypes, and/or devices.

A1.02 Sensing and Diagnostic Capability for Aircraft Aging and Damage
Lead Center: LaRC
Participating Center(s): ARC, DFRC, GRC, MSFC

Many conventional nondestructive evaluation (NDE) techniques have been used for flaw detection, but have shown little potential for much broader application. One element in NASA's contribution to solving the problem of aging and damage processes in future vehicles is research to identify changes in fundamental material properties as indicators of material aging-related hazards before they become critical. Degraded and failing fiber composites can exhibit a number of micromechanisms such as fiber buckling and breakage, matrix cracking, and delamination.

Methodologies are being sought that allow engineers, using advanced modeling tools to predict the remaining useful life of components, the ability to make use of nondestructive evaluation (NDE) data more effectively. One proposed methodology would be an automated means of processing NDE data to extract defect characteristics (i.e. crack length and depth, or delamination size and location) and map these directly to a computer aided drafting model of the component being inspected. This model (which now contains defect information) could then be used by engineers to perform structural analysis on the component. A successful proposal should demonstrate the performance of the methodology proposed by using the data from at least one conventional NDE technique (i.e. Thermography, Ultrasonics, etc.) and a standard CAD drawing file format.

Additionally, actual NDE technologies are also being sought for the nondestructive characterization of age-related degradation in complex composite materials. Innovative and novel approaches to using NDE technologies to measure properties related to material aging (i.e. thermal diffusivity, elastic constants, density, microcrack formation, fiber buckling and breakage, etc.) in complex composite material systems, adhesively bonded/built-up and/or polymer-matrix composite sandwich structures. The anticipated outcome of successful proposals would be a both Phase 2 prototype NDE technology for the use of the developed technique to characterize age-related degradation and a demonstration of the technology showing its ability to measure a relevant material property in a carbon fiber/epoxy composite used for structural applications on subsonic aircraft.

A1.03 Prediction of Aging Effects
Lead Center: LaRC
Participating Center(s): ARC, GRC

In order to assess the long-term effects of potential hazards and aging-related degradation of new and emerging material systems/fabrication techniques, NASA is performing research to anticipate aging and to predict its effects on the designs of future aircraft. To support this predictive capability, structural integrity analytical tools, lifing methods, and material durability prediction tools are being developed. Physics-based and continuum-based models encapsulated as computational methods (software) are needed to provide the basis for these higher level (e.g., design) tools. Proposals are sought that apply innovative computational methods, models and analytic tools to the following specific applications:

- Probabilistic computational code is sought for improved structural analysis of complex metallic and composite airframe components. The methods used in these solutions need to detail the initiation and progression of damage to determine accurate estimates of residual life and/or strength of complex airframe structures.
- Software tools are needed to predict the onset and rates of type-II hot corrosion attack in nickel-based turbine disk superalloys that allow for prolonged disk operation at high temperatures. Typically hot corrosion of turbine alloys is a product of molten salt exposure and is manifested by a localized pitting corrosion attack. Prolonged high temperature exposures of turbine disk alloys to sulfur-rich low temperature melting eutectic salts can lead to an onset of Type II hot corrosion attack causing serious degradation to the durability of the turbine components.
- Computational software is sought to simulate of the response of advanced composite fan case/containment structures in aged conditions to jet engine fan blade-out events using impact mechanics and structural system dynamics modeling techniques.

The anticipated outcome of successful Phase 2 proposals would be analytic code (software) delivered to NASA suitable for use in material evaluation studies.

A1.04 Aviation External Hazard Sensor Technologies
Lead Center: LaRC
Participating Center(s): DFRC, GRC

NASA is concerned with new and innovative methods for detection, identification, evaluation, and monitoring of in-flight hazards to aviation. 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.

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 affordable sensors. 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. This subtopic solicits technology that is focused on developing capabilities to detect and evaluate hazards. The development of human interfaces, including displays and alerts, is not within the scope of this subtopic except where explicitly requested in association with special topics. 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, such as new sensor technologies in conjunction with existing X-band airborne radar, to improve hazard detection and quantification of hazard levels are of interest.

At this time, the following hazards are of particular interest: in-flight icing conditions, wake vortices, and turbulence. Proposals associated with sensor investigations addressing these hazards are encouraged, and some suggestions follow. Emphasis on vortices and icing is not intended to discourage proposals targeting other or additional hazards such as reduced visibility, terrain, airborne or ground obstacles, convective weather, gust fronts, cross winds, and wind shear.

To enable remote detection and classification of in-flight icing hazards for the future airspace system and emerging aircraft, NASA is soliciting proposals for the development of sensor systems for the detection of icing conditions. Examples include the following practical remote sensing systems:

- Low-cost, ground-based, vertical-pointing with potential scanning capability X-band radar that can operate unattended around the clock (24/7/365) and provide calibrated reflectivity and velocity data with hydrometer/cloud particle classification (based upon the reflectivity and velocity data).
- Low-cost, high-frequency (> 89 GHz) microwave or infrared radiometer technology capable of providing air temperature, water vapor, and liquid water measurements for both ground-based and airborne applications.

Wake vortex detection in the terminal area is of particular interest, because closer spacing between aircraft is necessary to facilitate the high-density operations expected in NextGen. 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.

Proposals are encouraged for the development of novel coherent and direct detection lidar systems and associated components that allow accurate meteorological wind and aerosol measurements suitable for wake vortex characterization. Proposed techniques shall provide range-resolved clear air wind and aerosol measurements in the near-IR wavelength region from 1.5 microns to 2.1 microns. Wind and aerosol measurement with <30 m resolution is preferred. Lidar development includes, but is not limited to, novel transceiver architectures, efficient signal processing methodologies, wake processing algorithms and real time data reduction and display schemes. Enhancements in size, weight, range system efficiency, sensitivity, and reliability based on emerging technologies are desired.

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.

A1.05 Crew Systems Technologies for Improved Aviation Safety
Lead Center: LaRC

NASA seeks highly innovative, crew-centered, technologies to improve aerospace system safety through the development of more effective joint human-automation systems in aviation. This is to be accomplished through increased awareness of operator and crew functional state (both in terms of functional readiness and in situ assessment), and through improved interactions among intelligent agents (human and automated). We seek proposals for the development of advanced technologies that:

- Effectively convey information and aid decision making to enable novel NextGen operational requirements (e.g., 4D trajectory-based operations, visual operations in non-visual meteorological conditions, etc. as described in http://www.faa.gov/about/initiatives/nextgen/media/NGIP_0130.pdf);
- Foster the appropriate use of automation and complex information sources by, for example, conveying constraints on automation reliability and information certainty/timeliness;
- Support effective joint cognitive systems by improving the communication and collaboration among multiple intelligent agents (human and automated, proximal and remote), and provide assessment techniques and metrics for evaluating mixed H/A team performance;
- Characterize the operational status of the human crew members, effectively modulate this state, and/or effectively adapt interfaces and automation in response to functional status (e.g., situationally-aware display

reconfiguration, aiding, and multi-modal presentation of information to maximize system performance and minimize information processing bottlenecks);
- Provide methods, metrics, and tools that help to assess the effectiveness of the above-mentioned technologies in human-in-the-loop simulation and/or flight studies.

Proposals should describe novel technologies with high potential to serve the objectives of the Robust Automation/Human Systems element of NASA's Aviation Safety Integrated Intelligent Flight Deck program (http://www.aeronautics.nasa.gov/avsafe/iifd/rahs.htm). Successful Phase 1 proposals should culminate in a final report that specifies, and a Phase 2 proposal that would realize, technology that improves the effectiveness of joint human-automation systems in aviation, or improves the ability to assess effectiveness of such systems.

A1.06 Technologies for Improved Design and Analysis of Flight Deck Systems
Lead Center: ARC

Information complexity in flight deck systems is increasing exponentially, and flight deck designers need tools to understand, manage, and estimate the performance and safety characteristics of these systems early in the design process - this is particularly true due to the multi-disciplinary nature of these systems. NASA seeks innovative design methods and tools for representing the complex human-automation interactions that will be part of future flight deck systems. In addition, NASA seeks tools and methods for estimating, measuring, and/or evaluating the performance of these designs throughout the lifecycle from preliminary design to operational use - with an emphasis on the early stages of conceptual design. Specific areas of interest include the following:

- Computational/modeling approaches to support determining appropriate human-automation function allocations with respect to safety and performance;
- Design tools and methods that improve the application of human-centered design principles to the design and certification of mixed human-automated systems;
- Tools and methods for modeling the complex information management systems required for future flight deck systems;
- Methods of data uncertainty estimation during the flight deck system design phase particularly as applied to predicting overall system integrity;
- Design and analysis methods or tools to better predict and assess human and system performance in relevant operational environments.

Proposals should describe novel design methods, metrics, and/or tools with high potential to serve the objectives of the System Design and Analysis element of NASA’s Aviation Safety Integrated Intelligent Flight Deck program (http://www.aeronautics.nasa.gov/avsafe/iifd/sda.htm). Successful Phase 1 proposals should culminate in a final report that specifies, and a Phase 2 proposal that would realize, tools that improve the design process for human-automation systems in aviation, or improves the ability to assess effectiveness of such systems during the design phase. All proposals should discuss means for verification and validation of proposed methods and tools in operationally valid, or end-user, contexts.

A1.07 Adaptive Aeroservoelastic Suppression
Lead Center: DFRC
Participating Center(s): ARC, LaRC

NASA has initiated an Integrated Resilient Aircraft Control (IRAC) effort under the Aviation Safety Program. The main focus of the effort is to advance the state-of-the-art technology in adaptive controls to provide a design option that allows for increased resiliency to failures, damage, and upset conditions. These adaptive flight control systems will automatically adjust the control feedback and command paths to regain stability, maneuverability, and eventually a safe landing. One potential consequence of changing the control feedback and command paths is that an undesired aeroservoelastic (ASE) interaction could occur. The resulting limit cycle oscillation could result in structural damage or potentially total loss of vehicle control.

Current airplanes with non-adaptive control laws usually include roll-off or notch filters to avoid ASE interactions. These structural mode suppression filters are designed to provide 8 dB of gain attenuation at the structural mode frequency. Ground Vibration Testing (GVT), Structural Mode Interaction (SMI) testing, and finally full scale flight testing are performed to verify that no adverse ASE interactions occur. Until a significant configuration or control system change occurs, the structural mode suppression filters provide adequate protection.

When an adaptive system changes to respond to off-nominal rigid body behavior, the changes in control can affect the structural mode attenuation levels. In the case of a damaged vehicle, the frequency and damping of the structural modes can change. The combination of changing structural behavior with changing control system gains results in a system with a probability of adverse interactions that is very difficult to predict a priori. An onboard, measurement based method is needed to ensure that the system adjusts to attenuate any adverse ASE interaction before a sustained limit cycle and vehicle damage are encountered. This system must work in concert with the adaptive control system to allow the overall goal of re-gaining rigid body performance as much as possible without exacerbating the situation with ASE interactions.

A1.08 Engine Lifing and Prognosis for In-Flight Emergencies
Lead Center: GRC

The object of this research topic is to develop innovative methodologies and tools to determine the consumed life of an engine and the probability of an engine system failure for future operations.

Aircraft engine design and life are based on a theoretical operation flight profile that in practice is not seen by most engines in service. The ability to predict remaining engine life with a defined reliability in real time from sensor measurements is a condition precedent to emergency operation risk assessment. It is expected that this research will result in a demonstration of an integrated life monitoring and prognosis methodology that will utilize existing and under-development probabilistic codes for engine life usage and risk assessment for future operations that may require enhanced performance.

The expected outcome of the research will be an on-line simulation demonstration of an integrated engine life module for:

- Probabilistic engine life usage calculation.
- Methodologies for engine failure prediction for future operations.
- Risk assessment and trade-off tools for off-nominal operations.

NASA resources available for the research will be an engine component data base for turbine disks and blades, and probabilistic computer codes for life prediction and reliability.

A1.09 Pilot Interactions with Adaptive Control Systems under Off-Nominal Conditions
Lead Center: ARC

Adaptive control is a promising control technology that can enhance flight safety and performance. Adaptive control has been demonstrated to provide improved performance in many unmanned aerial systems. When operated in an autonomous mode such as in an autopilot, the behavior of an adaptive flight control system can be modeled and simulated with a sufficient degree of repeatability.

The presence of a pilot working in a closed-loop fashion with an adaptive flight control presents an important problem that has not been well addressed. Adaptive control generally requires sufficiently rich input signals to improve parameter convergence, as the adaptive control system adapts to parametric changes in the vehicle dynamics or exogenous disturbances. The condition for rich input signals is known as persistent excitation. During adaptation under off-nominal conditions such as aircraft with damage, the pilot provides persistently exciting signals to the adaptive control system. There is generally a trade-off between adaptation and stability due to persistent excitation. With a high persistent excitation in the pilot inputs, the speed of adaptation increases and in theory better handling performance could be achieved. However, in practice, the high persistent excitation in the control signals can potentially cause significant cross-coupling between different flight control axes and or excite unmodeled dynamics such as aeroservoelastic modes. The overall effect of high persistent excitation could aggravate stability robustness of an adaptive flight control system with a pilot in the loop that results in poor handling qualities.

Another aspect of pilot interactions with an adaptive control system is the potential interactions between two adaptive elements in a closed-loop fashion, because the pilot can also be viewed as an adaptive control system with a learning ability. With the pilot adaptive element providing high persistently exciting inputs into an adaptive flight control system with a predetermined adaptation rate, the issue of stability can be important and difficult to assess.

To enable an adaptive flight control system to be operated with a pilot in the loop, it is necessary to develop new research techniques that can assess the effects of pilot interactions with an adaptive flight control system. These techniques should address pilot control responses via an adaptive model with features that can capture relevant interactions with an adaptive flight control system. Techniques for assessing pilot interactions via metrics that can quantify the pilot-vehicle system responses with an adaptive flight control system are also needed. Other aspects of the research can include new methods and tools that can provide an advisory function to limit the pilot control inputs in order to trade off between command-following performance and stability robustness.

Research in adaptive control methods will address the system requirements to provide good flying characteristics when the human operator closes the control loop. In the presence of damage, failures, etc. the adaptive system must trade the stability requirements with closed loop handling requirements. Methods for selecting the best achievable handling are needed. The adaptation system needs to find a good compromise between suppression of coupling between the axis (i.e. pitch into roll, etc.) and good in-axis behavior. Better metrics to assess cross-coupled (asymmetric) behavior are needed. These metrics could provide a quantitative measurement of the severity of a given failure, as well as a measure of the improvement due to adaptation. As the adaptation changes the flying characteristics of the vehicle, some means of informing the operator is required to ensure that the system is not overdriven by a pilot who is expecting nominal performance.

A1.10 Detection of Aircraft Anomalies
Lead Center: GRC
Participating Center(s): ARC, DFRC, LaRC

Adverse events that occur in aircraft can lead to potentially serious consequences if they go undetected. This effort is to develop the technologies, tools, and techniques to detect in-flight anomalies from adverse events. This involves the integration of novel sensor and advanced analytical technologies for airframe, propulsion systems, and other subsystems within the aircraft. The emphasis of this work is not on diagnosing the exact nature of the failure but on identifying its presence. Proposals are solicited that address aspects of the following topics:

- Analytical and data-driven technologies required to interpret the sensor data to enable the detection of fault and failure events;
- Methods to differentiate sensor failure from actual system or component failure;
- Characterizing, quantifying, and interpreting multi-sensor outputs; and
- New sensors, sensory materials and sensor systems that improve the detection of an adverse event or permit increased sensory coverage for an adverse event.

Emphasis is on novel methods to detect failures in electrical, electromechanical, electronic, structural, and propulsion systems. Along with these system failures, condition sensors are desired for both the detection of internal engine icing as well as composite aircraft lightning strikes (location and intensity). Where possible, a rigorous mathematical framework should be employed to ensure the detection rates and detection time constants are acceptable according to published baselines as characterized by statistical measures. Understanding and addressing validation issues are critical components of this effort.

A1.11 Diagnosis of Aircraft Anomalies
Lead Center: LaRC
Participating Center(s): DFRC, GRC, SSC

The capability to identify faults is critical to determining appropriate mitigation actions to maintain aircraft safety. This effort is to develop innovative methods and tools for the diagnosis of aircraft faults and failures. It includes the development of integrated technologies, tools, and techniques to determine the causal factors, nature, and severity of an adverse event and to distinguish that event from within a family of potential adverse events. These requirements go beyond standard fault isolation techniques. The emphasis is on the development of mathematically rigorous diagnostic technologies that are applicable to structures, propulsion systems, software, and other subsystems within the aircraft. Technologies developed must be able to perform diagnosis given heterogeneous and asynchronous signals coming from the health management components of the vehicle and integrating information from each of these components.

The ability to actively query health management systems, use advanced decision making techniques to perform the diagnosis, and then assess the severity using these techniques are critical. As an example, the mathematical rigor of the diagnosis and severity assessment could be treated through a Bayesian methodology since it allows for characterization and propagation of uncertainties through models of aircraft failure and degradation.

Both computational and prototype hardware implementations of the diagnostic capabilities are expected outcomes of this effort. Other methods could also be employed that appropriately model the uncertainties in the subsystem due to noise and other sources of uncertainty. The ability to actively query the underlying health management systems (whether they are related to detection or not) is critical to reducing the uncertainty in the diagnosis. As an example, if there is ambiguity in the diagnosis about the type and location of a particular failure in the aircraft structure, the diagnostic engine should be able to actively query that system or related systems to determine the true location and severity of the anomaly. Where possible, a rigorous mathematical framework should be employed to provide a rank ordered list of diagnoses, an assessment of the severity of each diagnosed event, along with a measure of the certainty in the diagnosis. Understanding and addressing the system integration and validation issues are critical components of this effort.

A1.12 Prognosis of Aircraft Anomalies
Lead Center: ARC
Participating Center(s): DFRC, GRC, LaRC

The ability to accurately and precisely predict the remaining useful life (RUL) of aircraft components and subsystems enables decision making and action taking that can avert or mitigate failures, thereby enhancing aircraft safety. Furthermore, it can improve operational efficiency by facilitating condition-based maintenance and reducing unscheduled maintenance. This effort here addresses the development of innovative methods, technologies, and tools for the prognosis of aircraft faults and failures. The assessment of the RUL could be used by other aircraft systems to place additional restrictions, such as a new operating envelope, on the flight control systems or it could be used by flight or maintenance personnel to take preventative actions. Areas of interest include developing methods for making predictions of RUL which take into account operational and environmental uncertainties (pure data-driven approaches are discouraged); physics-based models of degradation; generation of aging and degradation datasets on relevant components or subsystems; and development of validation and verification methodologies for prognostics.

Research should be conducted to demonstrate technical feasibility during Phase 1 and to show a path toward a Phase 2 technology demonstration. Proposals are solicited that address aspects of the following areas:

- RUL prediction techniques that address a set of fault modes for a device or component, for example by modeling the physics of the most critical fault modes and using (typically less accurate) data-driven methods for the remainder.
- Physics-based damage propagation models for one or more relevant aircraft subsystems such as composite or metallic airframe structures, engine turbomachinery and hot structures, avionics, electrical power systems, electromechanical systems, and electronics. Proposals that focus on technologies envisioned for next generation aircraft are strongly encouraged.
- Uncertainty representation and management (reduction of prediction uncertainty bounds) methods. Proposers are encouraged to consider uncertainties due to measurement noise, imperfect models and algorithms, as well as uncertainties stemming from future anticipated loads and environmental conditions. Methods can also consider the fusion of different techniques but must show how this helps to improve the uncertainty using appropriate metrics.
- Aircraft relevant testbeds that can generate aging and degradation datasets for the development and testing of prognostic techniques.
- Verification and validation methods for prognostic algorithms.

A1.13 Healing Material System Concepts for IVHM
Lead Center: LaRC
Participating Center(s): ARC, DFRC, GRC

The development of integrated multifunctional self-sensing, self-repairing structures will enable the next generation of light-weight, reliable and damage-tolerant aerospace vehicle designs. Prototype multifunctional composite and/or metallic structures are sought to meet these needs, as are concepts for their analytical and experimental interrogation. Specifically, structural and material concepts are sought to enable in situ monitoring and repair of service damage (e.g., cracks, delaminations) to improve structural durability and enhance safe operation of aerospace structural systems. Emphasis is placed on the development of new materials and systems for the mitigation of structural damage and/or new concepts for activation of healing mechanisms using new or existing materials. These advanced structural and material concepts must be robust, consider all known damage modes for specific material systems and be validated through experiment.

A1.14 Verification and Validation of Flight-Critical Systems
Lead Center: ARC
Participating Center(s): DFRC, 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/nextgen.asp). 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.

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).

TOPIC: A2 Fundamental Aeronautics

The Fundamental Aeronautics Program (FAP) encompasses the principles of flight in any atmosphere, and at any speed. The program develops focused technological capabilities, starting with the most basic knowledge of underlying phenomena through validation and verification of advanced concepts and technologies at the component and systems level. Physics-based, multidisciplinary design, analysis, and optimization (MDAO) tools will be developed that make it possible to evaluate radically new vehicle designs and to assess, with known uncertainties, the potential impact of innovative technologies and concepts on a vehicle's overall performance. The development of advanced component technologies will realize revolutionary improvements in noise, emissions, and performance. The program also supports NASA's human and robotic exploration missions by advancing knowledge in aeronautical areas critical to planetary Entry, Descent, and Landing. NASA has defined a four-level approach to technology development: conduct foundational research to further our fundamental understanding of the underlying physics and our ability model that physics; leverage the foundational research to develop technologies and analytical tools focused on discipline-based solutions; integrate methods and technologies to develop multi-disciplinary solutions; and solve the aeronautics challenges for a broad range of air vehicles with system-level optimization, assessment and technology integration.

Structurally, the FAP is composed of four projects: hypersonic flight, supersonic flight, subsonic fixed-wing aircraft and subsonic rotary-wing aircraft.

Hypersonics

- Fundamental research in all disciplines to enable very-high speed flight (for airbreathing launch vehicles) and re-entry into planetary atmospheres;
- High-temperature materials, thermal protection systems, air-breathing propulsion, aero-thermodynamics, multi-disciplinary analysis and design, GNC, experimental capabilities.

Supersonics

- Eliminate environmental and performance barriers that prevent practical supersonic vehicles (cruise efficiency, noise and emissions, vehicle integration and control);
- Supersonic deceleration technology for Entry, Descent, and Landing into Mars.

Subsonic Fixed Wing (SFW)

- Develop revolutionary technologies and aircraft concepts with highly improved performance while satisfying strict noise and emission constraints;
- Focus on enabling technologies: acoustics predictions, propulsion/combustion, system integration, high-lift concepts, lightweight and strong materials, GNC.

Subsonic Rotary Wing (SRW)

- Improve civil potential of rotary wing vehicles (vs. fixed wing) while maintaining their unique benefits;
- Key advances in multiple areas through innovation in materials, aeromechanics, flow control, propulsion.

Each project addresses specific discipline, multi-discipline, sub-system and system level technology issues relevant to that flight regime. A key aspect of the Fundamental Aeronautics Program is that many technical issues are common across multiple flight regimes and may be best resolved in an integrated coordinated manner. As such, the FAP subtopics are organized by discipline, not by flight regime, with a special subtopic for rotary-wing issues.

Additional information: http://www.aeronautics.nasa.gov/fap/index.html

A2.01 Materials and Structures for Future Aircraft
Lead Center: GRC
Participating Center(s): ARC, DFRC, LaRC

Advanced materials and structures technologies are needed in all four of the NASA Fundamental Aeronautics Program research thrusts (Subsonics Fixed Wing, Subsonics Rotary Wing, Supersonics, and Hypersonics) to enable the design and development of advanced future aircraft. Proposals are sought that address specific design and development challenges associated with airframe and propulsion systems. These proposals should be linked to improvements in aircraft performance indicators such as vehicle weight, noise, lift, drag, durability, and emissions. This subtopic is also a subtopic for the “Low-Cost and Reliable Access to Space (LCRATS)” topic. Proposals to this subtopic may gain additional consideration to the extent that they effectively address the LCRATS topic (See topic O5 under the Space Operations Mission Directorate). In general, the technologies of interest cover four research themes:

- **Fundamental materials development, processing and characterization** – new approaches to enhance the durability, processability, and reliability of advanced materials (metals, ceramics, polymers, composites, hybrids and coatings) with an emphasis on multifunctional and adaptive materials and structural concepts. In particular, proposals are sought in:
    - Textile ceramic matrix composite materials and structures and environmental barrier coatings capable of multi-use at 2700°F or greater for air vehicle propulsion and airframe applications.
    - Nondestructive evaluation (NDE) methods for the detection of as-fabricated flaws and in-service damage for textile polymeric, ceramic and metal matrix composites, nanostructured materials and hybrids. NDE methods that provide quantitative information on residual structural performance are preferred.
    - Development of joining and integration technologies including fasteners and/or chemical joining methods for ceramic-to-ceramic, metal-to-metal, and metal-to-ceramic materials.
    - Development of variable stiffness materials to support adaptive, multifunctional structures concepts.
- **Structural analysis tools and procedures** – robust and efficient design methods and tools for advanced materials and structural concepts (in particular multifunctional and/or adaptive components) including variable fidelity methods, uncertainty based design and optimization methods, multi-scale computational modeling, and multi-physics modeling and simulation tools. In particular, proposals are sought in:
    - Multiscale design tools for aircraft structures that integrate novel materials, mechanism design, and structural subcomponent design into systems level designs.
    - Life prediction tools for textile ceramic composites including fiber architecture modeling methods that enable the development of physics-based hierarchical analysis methods. Fiber architecture models that address yarn-to-yarn and ply-to-ply interactions covering a wide range of textile preform structures in either a relaxed or compressed deformation state are of particular interest.

- **Computational materials development tools** – methods to predict properties of both airframe and propulsion materials based upon chemistry and process for conventional as well as nanostructured, multifunctional and adaptive materials.
    - Ab-initio methods that enable the development of refractory composite coating for multi-use at temperatures greater than 3000°F in an air environments.
    - Quantum chemistry, molecular dynamics, and mesoscale models for the design, characterization and optimization of ablation materials for radiation heating, thermal re-radiation, and catalytic effects.
- **Advanced structural concepts** – new concepts for airframe and propulsion components incorporating new light weight concepts as well as "smart" structural concepts such as those incorporating self-diagnostics with adaptive materials, multifunctional component concepts to reduce mass and improve durability and performance, lightweight, efficient drive systems and electric motors for use in advanced turboelectric propulsion systems for aircraft, and new concepts for robust thermal protection systems for high-mass planetary entry, descent and landing. In particular, proposals are sought in:
    - Microadaptive flow control for use in robust, efficient, low mass actuators with broad bandwidths. The identification and development of actuators that can operate in harsh environments (600-800°F) experienced in gas turbine engine compressors with the following features: (1) operational frequencies of 1000 to 10,000 Hz, (2) stroke or displacement >100μm, (3)capable of exerting forces >200 lbs.
    - Piezoelectric devices with the ability to convert strain energy into useable electric energy that can be integrated into aircraft designs for energy harvesting and or vibration damping including application to aircraft engine fan and compressor rotor blades. Requirement for these devices are power densities greater than or equal to 0.1 mW/cm^2. Novel approaches are sought to enable piezoelectric devices to operate in engine environment including typical stresses of fan/compressor blades and to have the durability for engine application.
    - Miniature thermoelectric devices for powering RF sensors for use in turbine engine compressors. Devices must be capable of operating at temperatures up to 600°C in oxidizing environments and capable of achieving power densities greater than or equal to 0.1 mW/cm^2. Prototype device demonstration is required showing functionality at 600° in air for 100 hours and delivering power output in excess of 10$\mu W/cm^2$.
    - Materials to support wireless sensing and actuating multifunctional structures.
    - Manufacturing and fabrication technologies leading to the development of lightweight structurally integrated thermal protection systems for space access and planetary entry, including high temperature honeycombs, hat-stiffeners, rigid fibrous and foam insulators.
    - Advanced material and component technologies to enable the development of mechanical and electrical drive system to distribute power from a single engine core to drive multiple propulsive fans, in particular, AC-tolerant, low loss (< 10 W/kA-m) conductors or superconductors for the stators of synchronous motors or generators operating at > 1.5 T field and 500 Hz electrical frequency; and high efficiency (≥ 30% of Carnot), low mass (<6kg/kW input) cryo-refrigerators for 20 to 65°K (lower efficiencies and mass-per-input-power that give the same or better refrigeration and mass are acceptable). Input power between 10 and 100 kW is envisioned in applications, but scalable small demonstrations are acceptable. In addition, fuel cell and energy harvesting for aircraft applications are of interest.
    - Novel structural design strategies for integrated fan cases that combine hardwall composite cases for blade containment with acoustic treatments. Concepts are also sought that also integrate the case with the fan inlet to maximize structural, acoustic attenuation and weight benefits.

A2.02 Combustion for Aerospace Vehicles
Lead Center: GRC
Participating Center(s): LaRC

Combustion research is critical for the development of future aerospace vehicles. Vehicles for subsonic and supersonic flight regimes will be required to emit extremely low amounts of gaseous and particulate emissions to satisfy increasingly stringent emissions regulations. Hypersonic vehicles require combustion systems capable of sustaining stable and efficient combustion in very high speed flow fields where fuel/air mixing must be accomplished very rapidly and residence times for combustion are extremely limited. Fundamental combustion research coupled with associated physics based model development of combustion processes will provide the foundation for technology development critical for aerospace vehicles. Combustion for aerospace vehicles typically involves multi-phase, multi-component fuel, turbulent, unsteady, 3D, reacting flows where much of the physics of the processes are not completely understood. CFD codes used for combustion do not currently have the predictive capability that is typically found for non reacting flows. Practical aerospace combustion concepts typically require very rapid mixing of the fuel and air with a minimum pressure loss to achieve complete combustion in the smallest volume. Reducing emissions may require combustor operation where combustion instability can be an issue and active control may be required. Areas of specific interest where research is solicited include:

- Development of laser-based diagnostics and novel experimental techniques for measurements in reacting flows;
- Two-phase flow simulation models and validation data under supercritical conditions;
- Development of ultra-sensitive instruments for determining the size-dependent mass of gas-turbine engine particle emissions;
- High frequency actuators (bandwidth ~1000 Hz) that can be used to modulate fuel flow at multiple fuel injection locations (with individual Flow Numbers of 3 to 5) with minimal fuel pressure drop for active combustion control;
- Combustion instability modeling and validation;
- Novel combustion simulation methodologies;
- Combustor and/or combustion physics and mechanisms, enhanced mixing concepts, ignition and flame holding, turbulent flame propagation, vitiated-test media and facility-contamination effects, hydrogen/hydrocarbon-air kinetic mechanisms, multi-phase combustion processes, and engine/propulsion component characterizations;
- Novel combustor concepts that advance/enhance the state-of-the-art in hypersonic propulsion to improve system performance, operability, reliability and reduce cost. Both analytic and/or experimental efforts are encouraged, as well as collaborative efforts that leverage technology from on-going research activities;
- Computational and experimental technologies for the accurate prediction of combined cycle phenomena such as shock trains in isolators, inlet unstart, and thermal choke.

A2.03 Aero-Acoustics
Lead Center: LaRC
Participating Center(s): ARC, GRC

Innovative technologies and methods are necessary for the design and development of efficient, environmentally acceptable airplanes, and advanced aerospace vehicles. In support of the Fundamental Aeronautics Program, improvements in noise prediction, measurement methods and control are needed for subsonic and supersonic vehicles, including fan, jet, turbomachinery, engine core, propfan, propeller and airframe noise sources. In addition, improvements in prediction and control of noise transmitted through aerospace vehicle structures are needed to reduce noise impact on passengers, crew and launch vehicle payloads. 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 engine and airframe and sources which arise from significant interactions between airframe and propulsion systems;
- Prediction of sound propagation (including sonic booms) from the aircraft through a complex atmosphere to the ground. This should include interaction between noise sources and the airframe and its flowfield;
- Computational and analytical structural acoustics prediction techniques for aircraft and advanced aerospace vehicle interior noise, particularly for use early in the airframe design process;
- Prediction and control of high-amplitude aeroacoustic loads on advanced aerospace structures and the resulting dynamic response and fatigue;
- Innovative source identification techniques for engine (e.g., fan, jet, combustor, or turbine noise) and for airframe (e.g., landing gear, high lift systems) noise sources, including turbulence details related to flow-induced noise typical of jets, 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, smart structures for nozzles and inlets, and noise control technology and methods that are enabled by advanced aircraft configurations, including integrated airframe-propulsion control methodologies;
- Technologies and techniques for active and passive interior noise control for aircraft and advanced aerospace vehicle structures;
- Development of synthesis and auditory display technologies for subjective assessments of aircraft community and interior noise, including sonic boom.

A2.04 Aeroelasticity
Lead Center: LaRC
Participating Center(s): ARC, DFRC, GRC

The NASA Fundamental Aeronautics program has the goal to develop system-level capabilities that will enable the civilian and military designers to create revolutionary systems, in particular by integrating methods and technologies that incorporate multi-disciplinary solutions. Aeroelastic behavior of flight vehicles is a particularly challenging facet of that goal.

The program's work on aeroelasticity includes conduct of broad-based research and technology development to obtain a fundamental understanding of aeroelastic and unsteady-aerodynamic phenomena experienced by aerospace vehicles, in subsonic, transonic, supersonic, and hypersonic speed regimes. The program content includes theoretical aeroelasticity, experimental aeroelasticity, and advanced aeroservoelastic concepts. Of interest are aeroelastic, aeroservoelastic, and unsteady aerodynamic analyses at the appropriate level of fidelity for the problem at hand; aeroelastic, aeroservoelastic, and unsteady aerodynamic experiments, to validate methodologies and to gain valuable insights available only through testing; development of computational-fluid-dynamic, computational-aeroelastic, and computational-aeroservoelastic analysis tools that advance the state of the art in aeroelasticity through novel and creative application of aeroelastic knowledge.

The technical discipline of aeroelasticity is a critical ingredient necessary in the design process of a flight vehicle for assuring freedom from catastrophic aeroelastic and aeroservoelastic instabilities. This discipline requires a thorough understanding of the complex interactions between a flexible structure and the unsteady aerodynamic forces acting on the structure, and at times, active systems controlling the flight vehicle. Complex unsteady aerodynamic flow phenomena, particularly at transonic Mach numbers, are also very important because this is the speed regime most critical to encountering aeroelastic instabilities. In addition, aeroelasticity is presently being exploited as a means for improving the capabilities of high performance aircraft through the use of innovative active control systems using both aerodynamic and smart material concepts. Work to develop analytical and experimental methodologies for reliably predicting the effects of aeroelasticity and their impact on aircraft performance, flight dynamics, and safety of flight are valuable. Subjects to be considered include:

- Development of design methodologies that include CFD steady and unsteady aerodynamics, flexible structures, and active control systems.
- Development of methods to predict aeroelastic phenomena and complex steady and unsteady aerodynamic flow phenomena, especially in the transonic speed range. Aeroelastic phenomena of interest include flutter, buffet, buzz, limit cycle oscillations, and gust response; flow phenomena of interest include viscous effects, vortex flows, separated flows, transonic nonlinearities, and unsteady shock motions.
- Development of efficient methods to generate mathematical models of wind-tunnel models and flight vehicles for performing vibration, aeroelastic, and aeroservoelastic studies. Examples include (a) CFD-based methods (reduced-order models) for aeroservoelasticity models that can be used to predict and alleviate gust loads, ride quality issues, and flutter issues and (b) integrated tool sets for fully coupled modeling and simulation of aeroservothermoelasticity / flight dynamic (ASTE/FD) and propulsion effects.
- Development of physics-based models for turbomachinery aeroelasticity related to highly separated flows, shedding, rotating stall, and non-synchronous vibrations (NSV). This includes robust, fast-running, accelerated convergence, reduced-order CFD approaches to turbomachinery aeroelasticity for propulsion applications. Development of blade vibration measurement systems (including closely spaced modes, blade-to-blade variations (mistuning), and system identification) and blade damping systems for metallic and composite blades (including passive and active damping methods) are of interest.
- Development of aeroservoelasticity concepts and models, including unique control concepts and architectures that employ smart materials embedded in the structure and/or aerodynamic control surfaces for suppressing aeroelastic instabilities or for improving performance.
- Development of techniques that support simulations, ground testing, wind-tunnel tests, and flight experiments of aeroelastic phenomena.
- Investigation and development of techniques that incorporate structure-induced noise, stiffness and strength tailoring, propulsion-specific structures, data processing and interpretation methods, non-linear and time-varying methods development, unstructured grid methods, additional propulsion systems-specific methods, dampers, multistage effects, non-synchronous vibrations, coupling effects on blade vibration, probabilistic aerodynamics and aeroelastics, actively controlled propulsion system core components (e.g. fan and turbine blades, vanes), and advanced turbomachinery active damping concepts.
- Investigation and development of techniques that incorporate lightweight structures and flexible structures under aerodynamic loads, with emphasis on aeroelastic phenomena in the hypersonic domain. Investigation of high temperatures associated with high heating rates, resulting in additional complexities associated with varying thermal expansion and temperature dependent structural coefficients. Acquisition of data to verify analysis tools with these complexities.

A2.05 Aerodynamics
Lead Center: LaRC
Participating Center(s): ARC, DFRC, GRC

The challenge of flight has at its foundation the understanding, prediction, and control of fluid flow around complex geometries - aerodynamics. Aerodynamic prediction is critical throughout the flight envelope for subsonic, supersonic, and hypersonic vehicles - driving outer mold line definition, providing loads to other disciplines, and enabling environmental impact assessments in areas such as emissions, noise, and aircraft spacing.

In turn, high confidence prediction enables high confidence development and assessment of innovative aerodynamic concepts. This subtopic seeks innovative physics-based models and novel aerodynamic concepts, with an emphasis on flow control, applicable in part or over the entire speed regime from subsonic through hypersonic flight.

All vehicle classes will experience subsonic flight conditions. The most fundamental issue is the prediction of flow separation onset and progression on smooth, curved surfaces, and the control of separation. Supersonic and hypersonic vehicles will experience supersonic flight conditions. Fundamental to this flight regime is the sonic boom, which to date has been a barrier issue for a viable civil vehicle. Addressing boom alone is not a sufficient mission enabler however, as low drag is a prerequisite for an economically viable vehicle, whether only passing through the supersonic regime, or cruising there. Atmospheric entry vehicles and space access vehicles will experience hypersonic flight conditions. Reentry capsules such as the new Crew Exploration Vehicle deploy multiple parachutes during descent and landing. Predicting the physics of unsteady flows in supersonic and subsonic speeds is important for the design of these deceleration systems. The gas-dynamic performance of decelerators for vehicles entering the atmospheres of planets in the solar system is not well understood. Reusable hypersonic vehicles will be designed such that the lower body can be used as an integrated propulsion system in cruise condition. Their performance is likely to suffer in off-design conditions, particularly acutely at transonic speeds. Advanced flow control technologies are needed to alleviate the problem.

This solicitation seeks proposals to develop and validate:

- Turbulence models capturing the physics of separation onset at Reynolds numbers relevant to flight, where relevant to flight is dependent on a targeted vehicle class and mission profile;
- Boundary-layer transition models suitable for direct integration with state-of-the-art flow solvers;
- Active flow control concepts targeted at separation control, shock wave manipulation, and/or viscous drag reduction with an emphasis on the development of novel, practical, lightweight, low-energy actuators;
- Innovative aerodynamic concepts targeted at vehicle efficiency or control;
- Physics-based models for simultaneous low boom/low drag prediction and design;
- Aerodynamic concepts enabling simultaneous low boom and low drag objectives;
- Innovative methods to validate both flow models and aerodynamic concepts with an emphasis on aft-shock effects which are hindered by conventional wind tunnel model mounting approaches;
- Uncertainty quantification methods suitable for use with state-of-the-art flow solvers;
- Accurate aerodynamic analysis and multidisciplinary design tools for multi-body flexible structures in the atmospheres of planets and moons including the Earth, Mars, and Titan;
- Advanced flow control technologies to alleviate off-design performance penalties for reusable hypersonic vehicles.

A2.06 Aerothermodynamics
Lead Center: LaRC
Participating Center(s): ARC, DFRC, GRC

Development of accurate tools to predict aerothermal environments and their effects on space vehicles is critically important to achieving the goals of current NASA missions. These tools will also enable the development of advanced spacecraft for future missions by reducing uncertainties during design and development.

The large size and high re-entry velocity of the Crew Exploration Vehicle and the conditions encountered in proposed aerocapture missions to Titan, Neptune, and Venus require study of shock layer radiation phenomena, radiative heat transfer, and non-equilibrium thermodynamic and transport properties; these in turn require understanding of the internal structure and dynamics of the constituent gases.

Transition and turbulence effects are particularly complex in hypersonic flows, where unique problems are posed by shocks, real gas effects, body surfaces with complex and possibly time-dependent roughness, nose bluntness, ablation, surface catalyticity, separation, and an unknown free-stream disturbance environment.

At the heating rates encountered during hypersonic re-entry, surface ablation products blowing into the boundary layer introduce new interactions including chemical reactions and radiation absorption, that strongly affect surface heating rates and integrated heat loads.

Proposals suggesting innovative approaches to any of these problems are encouraged; specific research areas of interest include:

- Computational analysis methods for radiation and radiation transport in the shock layer surrounding planetary entry vehicles;
- Advanced physics-based thermal and chemical non-equilibrium models for thermodynamics, transport, and radiation;
- Studies of the interactions of gases in the shock layer with ablating materials from the vehicle thermal protection system;
- Experimental methods and diagnostics to measure the characteristics of hypersonic flow fields, either in flight or in ground-based facilities;
- Software tools coupling radiation, non-equilibrium chemistry, Reynolds-averaged Navier-Stokes, and large eddy simulation codes to enable the design and validation of mission configurations for entry into planetary atmospheres.

A2.07 Flight and Propulsion Control and Dynamics
Lead Center: ARC
Participating Center(s): DFRC, GRC, LaRC

Enabling advanced aircraft configurations for subsonic, supersonic and hypersonic flight, and high performance engines will require advancement in the state-of-the art dynamic modeling and flight/propulsion control. Control methods need to be developed and validated for "optimal" and reliable performance of complex, unsteady, and nonlinear systems with significant modeling uncertainties while ensuring operational flexibility. New dynamic modeling and simulation techniques need to be developed to investigate dynamic performance issues and support development of control strategies for innovative aircraft configurations and propulsion systems. Technology needs specific to different flight regimes are summarized in the following:

Subsonic Fixed Wing Aircraft
Technologies of interest include: flying qualities design guidelines for civil transport aircraft and methods for evaluating the flying qualities of concept transport aircraft, including blended-wing-body and cruise efficient short takeoff and landing aircraft; active control techniques for subsystems within current and advanced engines that lead to improvements in propulsion system efficiency; definition of actuation requirements and characterization of transient behavior of flow control for active aerodynamic shaping; development of a modular, distributed control system architecture for unified propulsion/airframe control; toolset capable of assessing the controllability for a given control effector layout and determining the sizes of conventional control surfaces, horizontal tail and vertical tail necessary to meet control power requirements; novel control techniques for reducing system noise, emissions and fuel burn.

Supersonic Flight
Technologies of interest include: methods for developing integrated aeroservoelastic (ASE) models, including propulsion effects, suitable for simulation and control design; novel control design methods for integrated aero-propulsion-servo-elastic control leading to acceptable flying qualities over the operating flight envelope; novel, and feasible, takeoff and approach to landing procedures to accommodate the visibility challenges due to long forebodies; integrated inlet/engine control to ensure safe (no inlet unstart or compressor surge/stall) and efficient operation.

Hypersonic Flight
Technologies of interest include: system dynamic models pertaining to a dual-mode combustor based propulsion system (RAM/SCRAM) incorporating the essential coupled dynamic elements with varying fidelity for control design, analysis, and evaluation; methods for characterizing uncertainty in the dynamic models to enable control robustness evaluation; methods for dynamic modeling of hypersonic flow fields, both for external aerodynamics and internal flowpaths, and of heat release in scramjet flowpaths with appropriate fidelity for use in dynamic analysis and control design; hierarchical GNC (Guidance, Navigation and Control) architectures and energy management techniques to enable trajectory shaping and control over a wide operating envelope with integrated flight/propulsion control.

Proposals on other flight and propulsion control and dynamic technologies will also be considered as resources and priorities allow, but the primary emphasis of the solicitation will be on the technical areas identified above.

A2.08 Aircraft Systems Analysis, Design and Optimization
Lead Center: GRC
Participating Center(s): ARC, LaRC

One of the approaches to achieve the NASA Fundamental Aeronautics Program goals is to solve the aeronautics challenges for a broad range of air vehicles with system-level optimization, assessment and technology integration. The needs to meet this approach can be defined by four general themes:

(1) Design Environment Development;
(2) Variable Fidelity, Physics-Based Design/Analysis Tools;
(3) Technology Assessment and Integration; and
(4) Evaluation of Advanced Concepts.

Current interdisciplinary design/analysis involves a multitude of tools not necessarily developed to work together, hindering their application to complete system design/analysis studies. Multi-fidelity, multi-disciplinary optimization frameworks, such as Numerical Propulsion System Simulation (NPSS), have been developed by NASA but have limited capabilities to simulate complete vehicle systems. Solicited topics are aligned with these four themes that will support this NASA research area.

(1) Design Environment Development
Technology development is needed to provide complex simulation and modeling capabilities where the computer science details are transparent to the engineer. A framework environment is needed to provide a seamless integration environment where the engineer need not be concerned with where or how particular codes within the system level simulation will be run. Interfaces and utilities to define, setup, verify, determine the appropriate resources, and launch the system simulation are also needed.
Research challenges include the engineering details needed to numerically zoom (i.e., numerical analysis at various levels of detail) between multi-fidelity components of the same discipline, as well as, multi-discipline components of the same fidelity. A major computer science challenge is developing boundary objects that will be reused in a wide variety of simulations.

Proposals will be considered that enable coupling differing disciplines, numerical zooming within a single discipline, deploying large simulations, and assembling and controlling secure or non-secure simulations.

(2) Variable Fidelity, Physics-Based Design/Analysis Tools
An integrated design process combines high-fidelity computational analyses from several disciplines with advanced numerical design procedures to simultaneously perform detailed Outer Mold Line (OML) shape optimization, structural sizing, active load alleviation control, multi-speed performance (e.g., low takeoff and landing speeds, but efficient transonic cruise), and/or other detailed-design tasks. Current practice still widely uses sequential, single-discipline optimization, at best coupling low-fidelity modeling of other relevant disciplines during the detailed design phase. Substantial performance improvements will be realized by developing closely integrated design procedures coupled with highest-fidelity analyses for use during detailed-design. Design procedures must enable rapid determination of sensitivities (gradients) of a design objective with respect to all design variables and constraints, choose search directions through design space without violating constraints, and make appropriate changes to the vehicle shape (ideally both external OML shape and internal structural element size). Solicitations are for integrated design optimization tools that find combinations of design variables from more than one discipline and can vary synergistically to produce superior performance compared to the results of sequential, single-discipline optimization or repeated cut-and-try analysis.

(3) Technology Assessment and Integration
Improved analysis capability of integrated airframe and propulsion systems would allow more efficient designs to be created that would maximize efficiency and performance while minimizing both noise and emissions. Improved integrated system modeling should allow designers to consider trade-offs between various design and operating parameters to determine the optimum design for various classes of subsonic fixed wing aircraft ranging from personal aircraft to large transports. The modeling would also be beneficial if it had enough fidelity to enable it to analyze both conventional and unconventional systems. Current analysis tools capable of analyzing integrated systems are based on simplified physical and semi-empirical models that are not fully capable of analyzing aircraft and propulsion system parameters that would be required for new or unconventional systems.

Analysis tools are solicited that are capable of analyzing new and unconventional aircraft and propulsion integrated systems. These include: (1) New combustor designs, alternate fuel operation, and the ability to estimate all emissions, and (2) Noise source models (e.g., fan, jet, turbine, core and airframe components). Analyses tools that are scalable, especially to small aircraft, are desired.

(4) Evaluation of Advanced Concepts
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. This capability will enable "virtual expeditions through the design space" for multi-mission trade studies and optimization. This will require an integrated variable fidelity concept design system. The aerospace flight vehicle conceptual design phase is, in contrast to the succeeding preliminary and detail design phases, 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. Currently, the important primary aerospace vehicle design decisions at the conceptual design level (e.g., overall configuration selection) are still made using extremely simple analyses and heuristics. An integrated, variable fidelity system would have large benefits. Higher fidelity tools enabling unconventional configurations to be addressed in the conceptual design process are solicited.

A2.09 Rotorcraft
Lead Center: ARC
Participating Center(s): GRC, LaRC

The challenge of the Subsonic Rotary Wing thrust of the NASA Fundamental Aeronautics Program is to develop validated physics-based multidisciplinary design-analysis-optimization tools for rotorcraft, integrated with technology development, enabling rotorcraft with advanced capabilities to fly as designed for any mission. Technologies of particular interest are as follows:

Propulsion-Variable Speed Drive Systems/Transmissions
Technologies, and predictive capability, related to enabling concepts and techniques for variable speed drive systems/transmissions suitable for large rotorcraft application are encouraged. Specifically this would include concepts for controlling and enabling variable speed drives as well as lightweight and reliable drive system components. Efficient drive-system speed-variability on the order of 30-50% should be the focus of the proposed technologies and analysis tools.

Experimental Capabilities: Instrumentation and Techniques for Rotor Blade Measurements
Instrumentation and measurement techniques are encouraged for assessing scale rotor blade boundary layer state (e.g., laminar, transition, turbulent flow) in simulated hover and forward flight conditions, measurement systems for large-field rotor wake assessment, fast-response pressure sensitive paints applicable to blade surfaces, and methods to measure the rotor tip path plane angle of attack, lateral and longitude flapping, and shaft angle in flight and in the wind tunnel. Very low airspeed measurement systems for flight vehicles.

Acoustics: Interior and Exterior Rotorcraft Noise Generation, Propagation and Control
Topics of interest include, but are not limited to, external noise prediction methods for manned and unmanned rotorcraft, improved acoustic propagation models, psychoacoustics analysis of rotorcraft noise, interior noise prediction methods and active/passive noise control applications for rotorcraft including engine and transmission noise reduction, advanced acoustic measurement systems for flight and wind tunnel applications, acoustic data acquisition/reduction/analysis, rotor noise reduction techniques, noise abatement flight operations. Methods, devices, concepts for rotorcraft, or specifically wing, airflow control for steep noise abatement approach operations and hover (low speed) download relief. Rotor noise including broadband, harmonic, blade-vortex interaction, and high-speed impulsive noise, as well as rotor/tail rotor and rotor/rotor interactional noise, are of interest. Frequency range includes not only audible range, but very low frequency rotational noise (blade-passage frequency below 20 Hz) as well. Optimized active/passive concepts and noise tailoring, including rotorcraft designs that are inherently designed for lower noise as a constraint.

Rotorcraft Diagnostics
Health management of rotorcraft power trains is critical. Predictive, condition-based maintenance improves safety, decreases maintenance costs, and increases system availability. Topics of interest include algorithm development and tools to detect and predict the health and usage of rotorcraft dynamic mechanical systems in the engine and drive system. Automatic rotor imbalance detection and rotor smoothing is also of interest. Additionally, rotorcraft health management technologies can include, but are not limited, tools to: increase fault detection coverage and decrease false alarm rates; detect onset of failure, isolate damage, and assess damage severity; predict remaining useful life and maintenance actions required; integration of health monitoring information with maintenance processes and procedures; data management and automated techniques to acquire/process diagnostic information; system models, material failure models and correlation of failure under bench fatigue, seeded fault test and fielded data; data collection/management for analysis of operational data; in-flight pilot cueing and warning of impending catastrophic events.

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 four identified technical areas.

A2.10 Propulsion Systems
Lead Center: GRC

This subtopic is divided into two parts. The first part is the Turbomachinery and Heat Transfer and the second part is Propulsion Integration.

Turbomachinery and Heat Transfer
There is a critical need for advanced turbomachinery and heat transfer concepts, methods and tools to enable NASA to reach its goals in the various Fundamental Aeronautics projects. These goals include drastic reductions in aircraft fuel burn, noise, and emissions, as well as an ability to achieve mission requirements for Subsonic Rotary Wing, Subsonic Fixed Wing, Supersonics, and Hypersonics Project flight regimes. In the compression system, advanced concepts and technologies are required to enable 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 design 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 turbo-machinery sensitivity to tip clearance leakage effects where clearance to chord ratios are on the order of 5% or above.

- Advanced flow analysis tools to enable design optimization of highly loaded compression systems that can accurately predict aerodynamic efficiency and operability. This includes computer codes with updated models for losses, turbulence, and other models that can simulate the flow through turbomachinery components with advanced design features such as swept and bowed blade shapes, flow range extension techniques, such as flow control and transition control to maintain acceptable operability and efficiency.
- 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.
- Methods are sought to enable more efficient use of coolant air in the turbine through coolant flow modulation. These methods could consist of open-loop or closed-loop coolant flow modulation. Modulations could be high-frequency with frequencies on the order of the turbine blade passing frequency or longer time scales on the order of engine thermal transients. Development of methods to measure turbine local and/or average surface temperatures to enable the closed-loop capability will be considered. Feedback control of the coolant flow rates and/or methods to produce modulation in actual turbine thermal environments are desired. Finally, a description of how the proposed technology will work in a vision modulated turbine cooling turbine system will be needed.

Propulsion Integration

Proposals for Propulsion Integration will address engine and engine integration topics as outlined in this section in support of the Fundamental Aeronautics Program.

One objective of the Subsonic Fixed Wing Project is to develop verified analysis capabilities for the key technical issues related to integrating embedded propulsion systems for "N+2" hybrid wing/body configurations. These key technical issues include: inlet technologies for distorted engine inflows related to embedded engines with boundary layer ingestion; fan-face flow distortion and its effects on fan efficiency and operability, noise, flutter stability and aeromechanical stress and life; wide operability of the fan and core with a variable area nozzle; issues related to the implementation of a thrust vectoring variable area nozzle; and duct losses related to long flow paths associated with embedded engines. Specifically, proposals are sought to provide advanced technology, prediction methods and tools.

The supersonics project would like proposals to develop tools and propulsion technologies that will enable the design of high performance fans; high-efficiency, low-boom, and stable inlets; high-performance, low-noise exhaust nozzles; and intelligent sensors and actuators for supersonic aircraft. The supersonics project is interested in both computational and experimental research, aimed at evaluating and analyzing promising technologies as well as understanding the fundamental flow physics that will enable improved prediction methods.

A mission class of interest to the Hypersonics Project is Highly Reliable Reusable Launch Systems (HRRLS). The HRRLS mission was chosen to build on work started in NASA's Next Generation Launch Technology (NGLT) Program to provide new vehicle architectures and technologies to dramatically increase the reliability of future launch vehicles. The design of reusable entry vehicles that provide low-cost access to space is challenging in several technology areas. The development of hypersonic-unique air breathing propulsion systems and the integration of the propulsion system with the airframe impact vehicle performance and controllability and drive the need for an integrated physics-based design methodology.

For Propulsion Integration, topics will be solicited for two areas:

- Design concepts, actuators and analysis tools that enable:
    - High performance supersonic inlets and nozzles that have minimal impact on an aircraftÂ's sonic boom signature;
    - The control of shock wave boundary layer interactions and reduction of dynamic distortion in supersonic inlets;
    - Stable highly integrated supersonic inlets;
    - High pressure recovery, low distortion and low-weight subsonic diffusers;
    - Low weight systems for nozzle area control;
    - Thrust vectoring;
    - Practical, validated CFD models for flow control devices such as micro ramps, vaned vortex generators, air jets, or synthetic jets.

- Unsteady coupled Inlet / Fan Analysis Tools to investigate:
    - Engine transient affect on inlet unstart;
    - Mode transition for a hypersonic dual Turbine engine/RAM-SCRAM flowpath;
    - Inlet and fan aero/mechanical loads;
    - Engine/inlet control system development;
    - Distortion Tolerance.

TOPIC: A3 Airspace Systems

NASA's Airspace Systems (AS) Program is investing in the development of innovative concepts and technologies to support the development of the Next Generation Air Transportation System (NGATS is also commonly known as NextGen). NASA is working to develop, validate and transfer advanced concepts, technologies, and procedures through partnership with the Federal Aviation Administration (FAA) and other government agencies represented in the Joint Planning and Development Office (JPDO), and in cooperation with the U.S. aeronautics industry and academia. As such, the AS Program will develop and demonstrate 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. The AS Program integrates the two projects, NextGen Airspace and NextGen Airportal, to directly address the fundamental research needs of NextGen vision in partnership with the member agencies of the JPDO. The NextGen Airspace Project develops and explores fundamental concepts and integrated solutions that address the optimal allocation of ground and air automation technologies necessary for NextGen. The project will focus NASA's technical expertise and world-class facilities to address the question of where, when, how and the extent to which automation can be applied to moving aircraft safely and efficiently through the NAS. The NextGen Airportal Project develops and validates algorithms, concepts, and technologies to increase throughput of the runway complex and achieve high efficiency in the use of airportal resources such as gates, taxiways, runways, and final approach airspace. NASA research in this project will lead to development of solutions that safely integrate surface and terminal area air traffic optimization tools and systems with 4-D trajectory operations. Ultimately, the roles and responsibilities of humans and automation influence in the ATM will be addressed by both projects. Key objectives of NASA's AS Program are to:

- Improve mobility, capacity, efficiency and access of the airspace system;
- Improve collaboration, predictability, and flexibility for the airspace users;
- Enable accurate modeling and simulation of air transportation systems;
- Accommodate operations of all classes of aircraft; and
- Maintain system safety and environmental protection.

Additional information is available at http://www.aeronautics.nasa.gov/programs_asp.htm.

A3.01 NextGen Airspace
Lead Center: ARC
Participating Center(s): DFRC, LaRC

The primary goal of the Airspace project is to develop integrated solutions for a safe, efficient, and high-capacity airspace system. Of particular interest is the development of core capabilities, including:

- Trajectory-based operations, which manages traffic using 4-dimensional trajectories to achieve increases in capacity and efficiency;
- Super-density operations, which maximizes the use of limited runways at the busiest airports;
- Weather assimilated into decision making, with emphasis on probabilistic weather;
- Equivalent visual operations, which will allow the system to maintain visual flight rule capacities in instrument flight rule conditions.

These core capabilities are required to enable key Airspace project functions such as Dynamic Airspace Configuration, Traffic Flow Management, Separation Assurance, and the overarching Evaluator that integrates these ATM functions over multiple planning intervals.

In order to meet these challenges, innovative and technically feasible approaches are sought to advance technologies in research areas relevant to NASA's NextGen Airspace effort. The general areas of primary interest are Dynamic Airspace Configuration, Traffic Flow Management, and Separation Assurance. Specific research topics for the Airspace project include:

- Four-dimensional trajectory modeling in the presence of uncertainty;
- Air/air and air/ground trajectory exchange interoperability;
- Trajectory uncertainty prediction and mitigation;
- Intent information requirements for separation assurance and super density operations;
- Airspace re-design techniques that improve capacity, including changing shape of current sectors and introducing new airspace classes;
- Pilot and controller procedures and decision support systems needed to facilitate dynamic airspace changes;
- Collaborative decision making techniques involving multiple agents;
- Integrated solutions of ATM functions over multiple planning intervals and across domains;
- Optimal allocation of separation assurance functions across humans and automation and air and ground systems;
- Optimization techniques to address demand/capacity imbalances;
- New safety assessment methods for safety-critical air and ground automation technologies;
- Scheduling optimization for integrated arrival/departure/surface operations;
- Displays and procedures for very closely-spaced parallel approaches;
- Traffic complexity monitoring and prediction;
- Trajectory design and conformance monitoring;
- Weather assimilated into ATM decision-making;
- Environmental metrics and assessments of new concepts and technologies;
- The effect of new vehicles (including UAVs) on air traffic management;
- Gate-to-Gate modeling for NextGen concepts;
- Integration of UAVs into the NAS, including examination of the anticipated mix of UAV classes and capabilities (equipment, size, mission) in the next 20 years;
- The effect of traffic congestion on integration of UAVs into the NAS;
- Separation assurance responsibilities with regard to UAVs;
- The requirements for, and the development of, a simulation environment to test UAV integration in the NAS.

A3.02 NextGen Airportal
Lead Center: LaRC
Participating Center(s): ARC, DFRC

Airportal research focuses on key capabilities that will increase throughput of the airport environment, and that achieve the highest possible efficiencies in the use of airport resources such as terminal airspace, runways, taxiways, and gates. Of particular interest is the development of the following core capabilities within Airportal:

- Optimization of surface aircraft traffic;
- Dynamic airport configuration management (including the optimal balancing of Airportal resources for arrival, departure, and surface aircraft operations);
- Predictive models to enable mitigation of wake vortex hazards;
- New procedures for performing safe, closely spaced, and converging approaches at closer distances than are currently allowed;
- Modeling, simulation, and experimental validation research focused on single and multiple regional airports (metroplex);
- Other innovative opportunities for transformational improvements in Airportal/metroplex throughput.

Inherent to the ASP approach is the integration of airborne solutions within the overall surface management optimization scheme.

In order to meet these challenges, innovative and technically feasible approaches are sought to advance technologies in research areas relevant to NASA's Next Gen/Airportal effort. The general areas of interest are surface movement optimization, converging and parallel runway operations, safety risk assessment methodologies, and wake vortex solutions inside Metroplex boundaries. Specific research topics for Next Gen/Airportal include:

- Human/automation interface concepts and standards for flight crews and air traffic control personnel specific to surface/airportal operations;
- Integration of decision-support tools across different airspace domains;
- Advanced technologies and approaches to achieving 2-3X improvement in the throughput of airports and metroplexes;
- Automatic taxi clearance and aircraft control technologies;
- Scheduling algorithm for aircraft deicing and integration with a surface traffic decision-support tool;
- Collaborative decision making between airlines and airport traffic control tower personnel for optimized surface operations, including push back scheduling and management of airport surface assets;
- Real-time assessment of the performance of surface operations;
- Computationally efficient solution methods for surface traffic planning optimization problems;
- Automation concepts and technologies for handling off-nominal situations and failure recovery mechanism;
- Design of computer-human interface (CHI) for ground-based automated surface traffic management;
- 4D taxi clearances and air-ground trajectory negotiation for landing aircraft;
- Innovative concepts, technologies, and procedures for safely increasing throughput of runways, especially combinations of parallel, converging, and intersecting runways;
- Innovative concepts, technologies, and procedures to maintain airport runway throughput under off-nominal conditions such as zero-zero ceiling and visibility;
- Innovative ideas for very closely spaced parallel runway operations, including airborne spacing algorithms and wake vortex avoidance procedures;
- Algorithms for determining wake vortex encounters from aircraft flight data recorders;
- Wake vortex hazard research, especially: establishment of wake vortex encounter hazard threshold, encounter assessment tools, development of a wake vortex hazard metric, flight crew awareness and response techniques;

- Fusion of data from weather sensors and models for automated input into atmospheric prediction models (e.g., Terminal Area Simulation SystemÂ—TASS) used for assessments of atmospheric hazards to aviation and for initializing wake vortex prediction software;
- Innovations in sensors for detection of wake vortices as well as with weather sensors in support of wake vortex predictions;
- Measurements of wind, temperature, and turbulence from departing and arriving aircraft;
- Radar simulation tools for wake vortices.

Note: The development of technologies for the airborne detection of wake vortices is covered in Subtopic A1.04.

TOPIC: A4 Aeronautics Test Technologies

NASA has implemented the Aeronautics Test Program (ATP) within its Aeronautics Research Mission Directorate (ARMD). The purpose of the ATP is to ensure the long term availability and health of NASA's major wind tunnels/ground test facilities and flight operations/test infrastructure that support NASA, DoD and U.S. industry research and development (R&D) and test and evaluation (T&E) needs. Furthermore, ATP provides rate stability to the aforementioned user community. The ATP facilities are located at the NASA Research Centers, including at Ames Research Center, Dryden Flight Research Center, Glenn Research Center and Langley Research Center. Classes of facilities within the ATP include low speed wind tunnels, transonic wind tunnels, supersonic wind tunnels, hypersonic wind tunnels, hypersonic propulsion integration test facilities, air-breathing engine test facilities, the Western Aeronautical Test Range (WATR), support aircraft, test bed aircraft, and the simulation and loads laboratories. A key component of ensuring a test facility's long term viability is to implement and continually improve on the efficiency and effectiveness of that facility's operations. To operate a facility in this manner requires the use of state-of-the-art test technologies and test techniques, creative facility performance capability enhancements, and novel means of acquiring test data. NASA is soliciting proposals in the areas of instrumentation, test measurement technology, test techniques and facility development that apply to the ATP facilities to help in achieving the ATP goals of sustaining and improving our test capabilities. Proposals that describe products or processes that are transportable across multiple facility classes are of special interest. The proposals will also be assessed for their ability to develop products that can be implemented across government-owned, industry and academic institution test facilities. Additional information: http://www.aeronautics.nasa.gov/atp/index.html.

A4.01 Ground Test Techniques and Measurement Technology
Lead Center: LaRC
Participating Center(s): ARC, GRC

NASA is strategically positioning its ground test facilities to meet the future testing needs for our nation. NASA's aeronautics and space research and development pushes the limits of technology, including the ground test facilities that are used to confirm theory and provide validation and verification of new technical concepts. By using state-of-the-art test measurement technologies, data acquisition, testing techniques and enhancing facility performance, NASA will be able to operate its facilities more efficiently and effectively and also be able to meet the challenges presented by NASA's cutting edge research and development programs. Therefore, NASA is seeking highly innovative and commercially viable test measurement technologies, test techniques, and facility performance technologies that would increase efficiency, capability, productivity for ground test facilities.

The emphasis for this subtopic is in the area of test measurement technology. Examples of the types of technology solutions sought, but not limited to, are: skin friction measurement techniques; improved flow transition and quality detection methodologies; non-intrusive measurement technologies for velocity, pressure, temperature, and strain measurements; force balance measurement technology development; and improvement of current cutting edge technologies, such as Partical Based Velocimetry (LDV, PIV), Pressure Sensitive Paint (PSP), and focusing acoustic measurements that can be used more reliably in a production wind tunnel environment. Instrumentation solutions used to characterize ground test facility performance are being sought in the area of aerodynamics performance characterization (flow quality, turbulence intensity, mach number measurement, etc.). Areas of interest are in the subsonic, transonic, supersonic, and hypersonic speed regimes. Specialized areas may include cryogenic conditions, icing conditions, and rotating turbo machinery.

Proposals that lead to products or processes that are applicable specifically to the ATP facilities (see http://www.aeronautics.nasa.gov/atp) and across multiple facility classes are especially important. The proposals will also be assessed for their ability to develop products that can be used in government-owned, industry and academic institution aerospace ground test facilities.

A4.02 Flight Test Techniques and Measurement Technology
Lead Center: DFRC
Participating Center(s): ARC, GRC

NASA's flight research is reliant on a combination of both ground and flight research facilities. By using state-of-the-art techniques, measurement and data acquisition technologies, NASA will be able to operate its flight research facilities more effectively and also meet the challenges presented by NASA's cutting edge research and development programs.

The scope of this subtopic is broad, with emphasis on emissions, noise, and performance. Research technologies applicable to this subtopic should address (but are not limited to) the following ground and flight facilities at Dryden: Western Aeronautical Test Range (WATR), Flight Loads Laboratory (FLL), Research Flight Simulation Hardware-in-the-Loop Simulation (HILS), Test bed and Support Aircraft (e.g. F-15, F-18, ER-2, Gulfstream-III, and Ikhana). In addition to the facilities, the following generic capabilities are desired that pertain to any of a variety of types of vehicles ranging from low-speed, to high-altitude long-endurance to supersonic, to hypersonic and access-to-space.

- Modeling, identification, simulation, and control of aerospace vehicles in flight research, flight sensors, sensor arrays and airborne instruments for flight research, and advanced aerospace flight concepts.
- Safer and more efficient design of advanced aerospace vehicles requires advancement in current predictive design and analysis tools. The goal is to develop more efficient software tools for predicting and understanding the response of an airframe under the simultaneous influences of structural dynamics, thermal dynamics, steady and unsteady aerodynamics, and the control system. The benefit of this effort will ultimately be an increased understanding of the complex interactions between the vehicle dynamics subsystems with an emphasis on flight research validation methods for control-oriented applications.
- Proposals for novel multidisciplinary nonlinear dynamic systems modeling, identification, and simulation for control objectives are encouraged. Control objectives include feasible and realistic boundary layer and laminar flow control, aeroelastic maneuver performance and load control (including smart actuation and active aerostructural concepts), autonomous health monitoring for stability and performance, and drag minimization for high efficiency and range performance.
- Real-time measurement techniques are needed to acquire aerodynamic, structural, control, and propulsion system performance characteristics in-flight and to safely expand the flight envelope of aerospace vehicles. This subtopic encompasses the development of sensors, sensor systems, sensor arrays, or instrumentation systems for improving the state-of-the-art in aircraft ground or flight research. This includes the development of sensors to enhance aircraft safety by determining atmospheric conditions. The goals are to improve the effectiveness of flight research by simplifying and minimizing sensor installation, measuring new parameters, improving the quality of measurements, minimizing the disturbance to the measured parameter from the sensor presence, deriving new information from conventional techniques, or combining sensor suites with embedded processing to add value to output information. These sensors and systems are required to have fast response, low volume, minimal intrusion, and high accuracy and reliability.
- This subtopic further solicits innovative flight research experiments that demonstrate breakthrough vehicle or system concepts, methodologies, technologies, and operations in the real flight environment and that are particularly related to separation and flow quality characterization in subsonic flight, shockwave propaga-

tion in supersonic flight, and small scale technology development in hypersonic flight. It further seeks advanced flight techniques, operations, and experiments that promise significant leaps in vehicle performance, operation, safety, cost, and capability; and that require a demonstration in an actual-flight environment to fully characterize or validate advances.

NASA is seeking highly innovative and viable research technologies that would increase efficiency or overcome limitations for flight research. Other areas of interest include: Verification & Validation techniques for non-deterministic and complex redundant systems; Design Tools integrated into the simulation environment for early research and validation; Flight Measurements & Data Acquisition; Skin Friction; Flight Hardened Systems & Miniaturization; Signal Processing & Reconfigurable Systems; Wireless technologies.

9.1.2 EXPLORATION SYSTEMS

The Exploration Systems Mission Directorate (ESMD) is developing a constellation of new capabilities and supporting technologies and conducting foundational research to enable sustained and affordable human and robotic exploration. In order to support this complex mission, program offices have been established at the NASA Centers to manage the development of the next generation of space vehicles and systems. The Constellation Program (CxP), which is developing and building the Orion crew exploration vehicle and the Ares launch vehicles, is located at the Johnson Space Center (JSC). CxP also develops and builds the lunar lander, Earth departure stage, EVA, and lunar surface systems.

The Human Research Program (HRP), which performs research and technology development that addresses the highest risks to the human system in support of exploration, is also located at JSC. Advanced technologies will be developed for Orion, Ares, and other space vehicles and systems by the Exploration Technology Development Program (ETDP) at the Langley Research Center (LaRC). These three major ESMD Programs will maximize the use of SBIR Phase 1 through 3 technology research projects to minimize technology development costs and expedite the activation of explorations systems as soon as possible.

http://www.nasa.gov/exploration/home/index.html

TOPIC: X1 Avionics and Software

The Exploration Technology Development Program (ETDP) leads the Agency in the development of advanced avionics, software and information technology capabilities and research for the Exploration Systems Mission Directorate. The Avionics and Software elements perform mission-driven research and development to enable new system functionality, reduce risk, and enhance the capability for NASA's exploration missions. NASA’s focus has clarified around Exploration, and the agency's expertise and capabilities are being called upon to support these missions. The Ares Launch Vehicle, the Orion Crew Exploration Vehicle (CEV), the Altair Lunar Lander, and future lunar surface systems will each require unique advances in avionic and software technologies such as integrated systems health management, autonomous systems for the crew and mission operations, radiation hardened processing, and reliable, dependable software. Exploration requires the best of the nation's technical community to step up to providing the technologies, engineering, and systems to regain the frontiers of the Moon, to extend our reach to Mars, and to explore the beyond.

X1.01 Automation for Vehicle and Habitat Operations
Lead Center: ARC
Participating Center(s): JPL, JSC

Automation will be instrumental for decreasing workload, reducing dependence on Earth-based support staff, enhancing response time, and releasing crew and operators from routine tasks to focus on those requiring human judgment, leading to increased efficiency and reduced mission risk. To enable the application of intelligent automation and autonomy techniques, the technologies need to address two significant challenges: adaptability and software validation. Proposals are solicited in the areas of:

- **Automation Support Tools**: Support tools are needed to facilitate the authoring and validation of plans and execution scripts. Tools that are not tied specifically to one executive would provide NASA the most flexibility. Examples include: Graphical tool for monitoring and debugging plan execution and for creating and editing execution scripts; Tools for authoring and validating execution plans; User friendly abstraction of low-level execution languages by adding syntactic enhancements.
- **Decision Support**: Systems Decision support systems amplify the efficiency of operators by providing the information they need when and where they need it. Examples: Command and supervise complex tasks while projecting the outcome and identify potential problems; Understand system state, including visualization and summarization; Allow the system to interact with a user when generating the plan and allow evaluation of alternate courses of action; Integration of a planning and scheduling system as part of an on-board, closed loop controller.
- **Trustable Systems**: Systems that support or interact with crew require a very high level of reliability. Tools are needed that improve the reliability and trustworthiness of autonomous systems. These include: Ability to predict what the system will do; Guarantees of behavioral properties; Other properties that increase the operator's trust; Verifiability (e.g., restricted executive languages that facilitate model-based verification).

X1.02 Reliable Software for Exploration Systems
Lead Center: ARC
Participating Center(s): JPL, LaRC

This subtopic seeks to develop software engineering technologies that enable engineers to cost-effectively develop and maintain NASA mission-critical software systems. Particular emphasis will be on software engineering technologies applicable to the high levels of reliability needed for human-rated space vehicles. A key requirement is that proposals address the usability of software engineering technologies by NASA (including contractors) and not specialists. In addition to traditional capabilities, such as GNC (guidance, navigation, and control) or C&DH (command and data handling), new capabilities are under development: integrated vehicle health management, autonomous vehicle-centered operations, automated mission operations, and further out – mixed human-robotic teams to accomplish mission objectives. Mission phases that can be addressed include not only the software life-cycle (requirement engineering through verification and validation) but also upstream activities (e.g., mission planning that incorporates trade-space for software-based capabilities) and post-deployment (e.g., new approaches for computing fault tolerance, rapid reconfiguration, and certification of mission-critical software systems). Specific software engineering tools and methods are sought in the following areas:

- Automated software generation methods from engineering models that are highly reliable;
- Scalable verification technology for complex mission software, e.g., model-checking technology that addresses the 'state explosion' problem and static-analysis technology that addresses mission-critical properties at the system level;
- Automated testing that ensures coverage targeted both at the system level and software level, such as model-based testing where test-case generation and test monitoring are done automatically from system-level models;
- Technology for calibrating software-based simulators against high-fidelity hardware-in-the-loop test-beds to achieve dependable test coverage;
- Technology for verifying and validating autonomy capabilities including intelligent execution systems, model-based diagnosis, and Integrated Systems Health Management (ISHM);
- Methods and tools for development and validation of autonomic software systems (systems that are self protecting and self healing).

X1.03 Radiation Hardened/Tolerant and Low Temperature Electronics and Processors
Lead Center: LaRC
Participating Center(s): GSFC, JPL, MSFC

Constellation projects that are designed to leave low-earth orbit (Orion, Ares V Earth Departure Stage, Altair, Lunar Surface Systems, EVA suits, etc.) require avionic systems, components, and controllers that are capable of operating in 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 100 krads (Si) or more and providing single-event latchup immunity (SEL) of 100 MeV cm^2/mg or more.

Considering the extreme environment performance parameters for thermal and radiation extremes, proposals are sought in the following specific areas:

- Low power, high efficiency, radiation-hardened processor technologies;
- Field Programmable Gate Array (FPGA) technologies;
- 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;
- 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 improved radiation hardness and low-temperature (-230°C) analog and mixed-signal circuit performance;

- Packaging capable of surviving numerous thermal cycles and tolerant of the extreme temperatures on the Moon and Mars, which includes the use of appropriate materials including substrates, die-attach, encapsulants, thermal compounds, etc.

X1.04 Integrated System Health Management for Ground Operations
Lead Center: ARC
Participating Center(s): JPL, JSC, KSC, MSFC, SSC

Innovative health management technologies are needed throughout NASA's Constellation architecture in order to increase the safety and mission-effectiveness of future spacecraft and launch vehicles. In human space flight, a significant concern for NASA is the safety of ground and flight crews under off-nominal or failure conditions. The new Ares Crew Launch Vehicle will provide the means to abort the crew using a launch abort system in case of a catastrophic failure during launch or ascent within a very brief timeframe and with high certainty. Health management is essential for dormant periods between human habitation, and for transition of assets (such as lunar habitats) to crewed operations. In addition, the long-duration health of software systems themselves are also critical. Projects may focus on one or more relevant subsystems such as solid rocket motors, liquid propulsion systems, structures and mechanisms, thermal protection systems, power, avionics, life support, communications, and software. Proposals that involve the use of existing testbeds or facilities at NASA are strongly encouraged. Specific technical areas of interest are methods and tools for:

- Early-stage design of health management functionality during the development of space systems, including failure detection methods, sensor types and locations that enable fault detection to line replaceable units.
- Sensor validation and robust state estimation in the presence of inherently unreliable sensors. Focus on data analysis and interpretation using legacy sensors.
- Model-based fault detection and isolation in rocket propulsion systems based on existing sensor suites during pre-launch and flight mission operations that enables fault detection within time ranges to allow mission abort.
- Automatic construction of models used in model-based diagnostic strategies, limiting model construction times to 60% of the time required using manual methods.
- Advanced built-in-tests for spacecraft avionics that provide 95% functional coverage and reduce or eliminate the need for extensive functional verification and to predict remaining life of avionics systems.
- Prognostic techniques able to anticipate system degradation before loss of critical functions and enable further improvements in mission success probability, operational effectiveness, and automated recovery of function.
- Approaches for effective utilization of 100% of the health information on critical functions from spacecraft and launch vehicles with integration to ground based systems using commercial health information from programmable logic controller and RAS system.
- Techniques that address the particular constraints of maintaining long-duration systems health of structures, mechanical parts, electronics, and software systems on lunar surfaces are of special interest.

TOPIC: X2 Environmental Control and Life Support

Environmental Control and Life Support (ECLS) encompasses the process technologies and equipment necessary to provide and maintain a livable environment within the pressurized cabin of crewed spacecraft and to support associated human systems such as Extra Vehicular Activity (EVA). Functional areas of interest to this Solicitation include thermal control and ventilation, atmosphere resource management and particulate control, water recovery systems, solid waste management, habitation systems, environmental monitoring and fire protection systems. Technologies must be directed at Lunar transit and surface missions, including such vehicles as Lunar landers, surface habitats and pressurized rovers.

Requirements include operation in Lunar gravity and/or microgravity and compatibility with cabin atmospheres of up to 34% O_2 by volume and pressures ranging from 1 atmosphere to as low as 7.6 psia, or for EVA, as low as 3.2 psia and 100% O_2. Systems external to the spacecraft will be at vacuum. 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 dual application to Lunar and Mars missions. Results of a Phase 1 contract should show feasibility of the technology and approach. A resulting Phase 2 contract should lead to development, evaluation and delivery of prototype hardware. Specific technologies of interest to this Solicitation are addressed in each subtopic.

Additional information may be found at the following websites: http://els.jsc.nasa.gov and http://aemc.jpl.nasa.gov.

X2.01 Spacecraft Cabin Atmosphere Revitalization and Particulate Management
Lead Center: MSFC
Participating Center(s): ARC, GRC, JSC, KSC

Cabin Atmosphere Revitalization
Atmosphere revitalization developmental activities target process technologies and equipment to condition and supply gaseous oxygen at pressures at or above 3,600 psia and achieve mass closure by recycling resources. As well, portable means for atmosphere revitalization that have synergy with extravehicular activity (EVA) equipment pertaining to trace contaminant control, carbon dioxide removal, humidity control are target technology areas. Durable, dust-tolerant fluid connections support the EVA and life support system infrastructure. Details on areas of emphasis are the following:

<u>High Pressure Oxygen Gas Supply and Conditioning</u>: Process technologies leading to an on-demand, in-flight renewable 3,600-psia oxygen supply are of interest. Process technologies and techniques must be capable of conditioning oxygen for temperature, pressure, and water content using oxygen from several sources. Source oxygen may originate directly from the cabin atmosphere or from gaseous storage, cryogenic storage, and/or on-demand production from water electrolysis or in-situ resource utilization processes.

There is specific interest in process technologies to remove water from saturated oxygen to provide a product having a dewpoint below -62°C.

<u>Atmospheric Resource Recycling Techniques</u>: Process technologies suitable for conditioning and converting gaseous products produced by the Sabatier CO_2 reduction reaction to useful products are of interest. Of particular interest are process technologies to recover moisture from a saturated stream of methane that contains residual CO_2 and hydrogen reactants, to convert methane to products such as low molecular weight alcohols or other compounds suitable for use in power co-generation via fuel cells or other means, and to produce a solid carbon product via a regenerative process based on the Bosch reaction or a variant of the Bosch reaction.

Particulate Matter Management
Particulate matter suspended in the habitable cabin atmosphere is a challenge for all phases of crewed lunar surface exploration missions. Removing and disposing of particulate matter originating from sources internal to the habitable cabin and from lunar surface dust intrusion into the cabin environment is of interest. Staged techniques employing combinations of course media filtration (>50 micron size), inertial separation (<50 and >2.5 micron size), and fine media filtration (<2.5 micron size, including ultrafines <0.1 micron size) that are amenable to in-situ regeneration are of interest. Process technologies and equipment that efficiently remove the range of particulate matter sizes and morphologies encountered in a crewed spacecraft cabin from the atmosphere are sought. Candidate technology solutions should provide high efficiency and long-lived removal capacity. Successful process technologies must be tolerant of the abrasive properties of lunar surface dust. Performance should be demonstrated with appropriate lunar dust analogs or simulants. Process technologies sought must be highly efficient and promote safe disposal of accumulated particulate matter.

Atmosphere Revitalization for EVA
Synergy exists between cabin atmosphere revitalization and EVA suits. Common functions include trace contaminant control, CO_2 partial pressure control, and humidity control.

Trace Contaminant Control for EVA Suits: EVA suits designed for long durations with minimal maintenance will require new methods of trace contaminant control to maintain spacesuit environments below Spacecraft Maximum Allowable Concentrations for toxic or irritating chemicals. Historically this has used activated charcoal. In the case of ISS EVA, the charcoal is regenerable with heat. A need exists for a reduced power solution, such as vacuum regeneration of a sorbent, or another, innovative, low consumable solution. Consideration of on-back, real-time EVA regeneration as well as post EVA regeneration is acceptable.

Mars EVA CO_2 and Humidity Control: ISS EVA suits utilize heat regenerable CO_2 removal systems. These systems are heavy and require significant power for regeneration. Lunar EVA suits are planned to use a lightweight, vacuum regenerable amine system to remove CO_2 and humidity from the suit. It is envisioned this concept could be extensible to Mars suits with the addition of sweep gas to prevent intrusion of the Martian atmosphere. An innovative CO_2 and humidity removal system that could remove CO_2 and humidity while eliminating gas losses to the Martian atmosphere, remain lightweight, and utilize minimal power is desired. Consideration of on-back, real-time EVA regeneration as well as post EVA regeneration is acceptable.

Dust Tolerant Quick Disconnects for High and Low Pressure Fluids
Connections will need to be made between the EVA suits and lunar and Martian vehicles in environments where dust will be present. A lightweight QD that excludes dust during connections and disconnections is required.

X2.02 Spacecraft Habitation Systems, Water Recovery and Waste Management
Lead Center: ARC
Participating Center(s): GRC, JSC, KSC, MSFC

Habitation, water recovery and waste management systems supporting critical needs for lunar mission architectures are requested. Improved technologies are needed for clothing/laundry, recovery of water, recovery of other resources, stabilization of wastes and safe long term storage of waste residuals. Proposals should explicitly describe the weight, power, and volume advantages of the proposed technology and be compatible with the lunar and microgravity environments described in the overall X2 topic description.

Clothing/Laundry Systems
Clothing and towels are a major consumable and trash source. Advanced durable fabrics to enable multiple crew wear cycles before cleaning/disposal are required. The laundry system should remove/stabilize combined perspiration salt/organic/dander and lunar dust contaminants, preserve flame resistance properties and use cleaning agents compatible with biological water recovery technologies. Proposals using water for cleaning should use significantly less than 10 kg of water per kg of clothing cleaned.

Waste Management
Wastes (trash, food scraps, feces, water brines, clothing) must be managed to protect crew health, safety and quality of life, to avoid harm of planetary surfaces, and to recover useful resources. Areas of emphasis include: stabilization (particularly water removal and recovery) and solid waste storage and odor control (e.g., catalytic and adsorptive systems). Preferred stabilization methods will dry solids to less than 60% water activity and sterilize and/or prevent microbial growth. Waste compactors must reduce trash to less than 10% of hand compacted volume after any spring-back. Odor control technologies should reduce gaseous contaminants in air to below NASA's Space Maximum Allowable Concentration levels and below the human odor threshold. Lunar-Martian storage containers are desired that are lightweight, low in resupply stowage volume, easily deployable and capable of containing space mission wastes and residuals on Lunar or Martian surfaces without rupture for 400 years.

Water Recovery
Efficient technologies are desired for treatment to potability of wastewater including urine, brines, humidity condensate, hygiene water, and in situ lunar water. Areas of emphasis include: primary treatment reducing 1000 mg/L TOC to less than 100mg/L, post-treatment reducing 100 mg/L TOC to < 0.25 mg/L, control of solids precipitation in treatment hardware, and disinfection of stored potable water.

X2.03 Spacecraft Environmental Monitoring and Control
Lead Center: JPL
Participating Center(s): ARC, GRC, JSC, KSC, MSFC

Monitoring technologies are employed to assure that the chemical and microbial content of the air and water environment of the astronaut crew habitat falls within acceptable limits, and that the life support system is functioning properly. The sensors may also provide data to automated control systems. All proposed technologies should have a 2 year shelf-life, including any calibration materials (liquid or gas). The technologies will need to function in low pressure environments (~8 psi) and may see unpressurized storage. Significant improvements are sought in miniaturization, accuracy, precision, and operational reliability, as well as long life, in-line operation, self-calibration, reduction of expendables, low energy consumption, and minimal operator time/maintenance for monitoring and controlling the life-support processes.

- Microbial monitoring in water
  - 2 year shelf-life; this requirement precludes the usual antibody techniques which have lifetime limitations. Sufficient precision to resolve the following: 50 CFU/ml bacteria; coliform and fungi are required to be zero per 100 ml; zero counts of parasitic protozoa
- Microbial control of surfaces, typically done by chemically treated wipes or ultraviolet
  - Microbial Controls should be recyclable w/reduced consumables
- Improved Oxygen Monitor for breathing air
  - +/- 0.05%, must operate in variable pressure 8-14.7 psia and survive exposure to vacuum
- Broad spectrum Trace Contaminant Monitor, for air, with 2 year shelf life

X2.04 Spacecraft Fire Protection
Lead Center: GRC
Participating Center(s): JPL, JSC, KSC, MSFC

NASA's fire protection strategy consists of strict control of ignition sources and flammable materials, early detection and annunciation of fires, and effective fire suppression and response procedures. Providing effective and efficient means for conducting and monitoring post-fire cleanup and restoration of the cabin atmosphere to a habitable environment are also major concerns. While proposals for novel technologies in all of these areas are applicable, they are particularly sought in the areas of nonflammable crew clothing and advanced carbon monoxide sensors for fire detection and monitoring the progress of post-fire cleanup.

The requirements for crew clothing are balanced between appearance, comfort, wear, flammability and toxicity. Ideally, crew clothing should have durable flame resistance in a 34% O_2 (by volume) enriched environment through all end-use conditions including cleaning methods and frequency.

Fire detection strategies are being developed that combine advanced particulate detection technology with sensors that detect gaseous combustion products. Monitoring of carbon monoxide is being targeted both for fire detection and to monitor the progress of post-fire cleanup. A robust optical method is desired that has the dynamic range required to detect and monitor CO from approximately 1 to 500 ppm with resolution to 1 ppm CO. In addition to being sufficiently rugged, this sensor must have minimal mass, power, and volume requirements and exhibit high degrees of reliability, minimal maintenance, and self-calibration under varying humidity and ambient pressures.

X2.05 Spacecraft Thermal Control Systems
Lead Center: JSC
Participating Center(s): GRC, GSFC, JPL, LaRC, MSFC

Future spacecraft will require more sophisticated thermal control systems that can dissipate or reject greater heat loads at higher input heat fluxes while using fewer of the limited spacecraft mass, volume and power resources. The thermal control system designs also must accommodate the harsh thermal environments associated with these missions. Modular, reconfigurable designs could limit the number of required spares.

The lunar environment presents several challenges to the design and operation of active thermal control systems. During the approximately 2 hour lunar orbit, the environment can range from extremely cold to near room temperature. Polar lunar bases will see unrelenting cold thermal environments, as will the radiators for Martian transit spacecraft. In both cases the effective sink temperature will approach absolute zero.

Innovative thermal management components and systems are needed to accomplish the rejection of waste heat during these future missions. Advances are sought in the general areas of radiators, thermal control loops, thermal system equipment, and EVA thermal control.

Systems with enhanced thermal mass may be required to deal with the lunar orbital environment. Variable emissivity coatings (near unity emissivity with the ability to reduce emissivity by at least a factor of ten), clever working fluid selection (a freezing point approaching 150K), or robust design could be used to prevent radiator damage from freezing in cold environments at times of low heat load.

Part of the thermal control system in a habitable volume is likely to be a condensing heat exchanger, which should be designed to preclude microbial growth. Small, highly reliable, heat pumps could be used to provide 278 K cold fluid to the heat exchanger, allowing the loop temperatures to approach 300 K, thus reducing the size of the radiators.

Future space systems may generate waste heat in excess of 10 kW which could either be rejected or redirected to areas which require it. Novel thermal bus systems which can collect, transport (over a distance of ~30 meters), and provide heat for components are sought. The system should be highly flexible and adaptable to changes in equipment locations. Possible systems include single and two-phase pumped fluid loops, capillary-based loops, and heat pumps. Innovative design of the loops and components is needed.

Historically spacesuits have used water sublimators to provide heat rejection. Development of a low-venting or non-venting regenerable individual life support subsystem(s) concept for crewmember cooling and heat rejection is desired. Systems that integrate spacesuit thermal control systems with other life support tasks, such as removal of expired water vapor and CO_2 are highly desirable. Interests include low cost lightweight spacesuit compatible freezable radiators for thermal control and variable conductance flexible EVA spacesuit garments that can function as a radiator or as an insulator as required. Sensible heat loads average 300 W and peak at 800 W. Spacesuit cooling garments have water flow rates of approximately 100 kg/hr.

TOPIC: X3 Lunar In-Situ Resource Utilization

The purpose of In Situ Resource Utilization (ISRU) is to harness and utilize resources 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. In particular, the ability to make propellants, life support consumables, fuel cell reagents, and radiation shielding can significantly reduce the cost, mass, and risk of sustained human activities beyond Earth. To perform these tasks on the lunar surface, detailed knowledge of the terrain, local minerals and potential resources, and the behavior and characteristics of lunar regolith is extremely important. Lastly, since ISRU systems and operations have never been demonstrated before in missions, it is important that ISRU concepts and technologies be evaluated under relevant conditions (1/6 g and vacuum) as well as anchored through modeling to lunar soil and environmental conditions. With this in mind, the ISRU Project within the Exploration Technology Development Program (ETDP) has initiated development and testing of hardware and systems in two main focus areas: (1) Oxygen Extraction from Regolith, including regolith feed/removal; and (2) ISRU Development & Precursor Activities to evaluate alternative resource processing and product concepts.

The purpose of the following subtopics is to develop and demonstrate hardware and software technologies that can be added to on-going analysis and ISRU capability development and demonstration activities in ETDP to meet Outpost architecture and surface manipulation objectives for near and long term human exploration of the Moon.

X3.01 Oxygen Production from Lunar Regolith
Lead Center: JSC
Participating Center(s): GRC, KSC, MSFC

Oxygen (O_2) production from lunar regolith processing consists of receiving regolith from the excavation subsystem into a hopper, transferring that regolith into a chemical or an electrochemical reactor, intermediate reactions to produce O_2 and regenerate reactants if required, purification of the O_2 produced, and removal of processed regolith from the reactor to an outlet hopper. Three O_2 production from lunar regolith reaction concepts are currently under development: Hydrogen reduction, Carbothermal reduction, and Molten Oxide Electrolysis at initial lunar Outpost production scale of 1 to 2 MT per year (70% per year operations). This subtopic is seeking hardware, subsystem, and system components and technologies for insertion and integration into on-going oxygen extraction from regolith development and demonstration efforts. Items of particular interest are:

- Move feedstock material from hopper on ground to 2 m height for reactor inlet hopper; 40 kg/hr; material size <0.5 cm diameter.
- Inlet/outlet regolith hopper design and valve/seal concepts with no gas leakage, 1000's of operating cycles with abrasive lunar material, and minimum heat loss.
- Removal of 5 to 10 kg of molten material from molten electrolysis cell with metal slag processing and purification into individual metals.
- Water condensers that use the space environment for water condensation/separation with minimal energy usage.
- Gas Separators that provide low pressure drop separation of the system and product gas streams from impurities (e.g., HCl, HF, H_2S, SO_2); the process should be regenerable and the output contaminant concentration should be less than 50ppb.
- Removal of dissolved ions in water by methods other than de-ionization resins to meet water electrolysis purity requirements (minimum resistivity of 1M-Ohms-cm). Ions of interested are dissolved metal ions (Fe, Cr, Co, Ni, Zn) at concentration of 0.01% and dissolved anions (Cl, F, S) at concentrations of 0.01%-2%. The process should be regenerable, minimize consumables, and minimize water loss.
- Contaminant resistant, high temperature water electrolysis concepts.
- Advanced reactor concepts for carbothermal reduction or molten oxide electrolysis.

Phase 1 proposals should demonstrate technical feasibility of the technology or hardware concept through laboratory validation of critical aspects of the innovation proposed, as well as the design and path toward delivering hardware/subsystems in Phase 2 for incorporation into existing development activities. Interface requirements for on-going development efforts will be provided after selection. Proposers are encouraged to use the Lunar Sourcebook at a minimum for understanding lunar regolith material parameters in the design and testing of hardware proposed. It is also recommended that JSC-1a simulants be used during testing unless a more appropriate simulant can be obtained or manufactured.

X3.02 Lunar ISRU Development and Precursor Activities
Lead Center: JSC
Participating Center(s): GRC, KSC, MSFC

The incorporation of ISRU concepts is an on-going effort which requires an evaluation of the benefits and risks through computer modeling and testing under laboratory, analog field, and simulated lunar environmental conditions (1/6 g and vacuum). While excavation and oxygen extraction from regolith are included in lunar architecture plans, it is recognized that evaluating the feasibility and benefits of other technologies and concepts not ready for insertion into these efforts should be pursued. This subtopic is aimed at providing development support capabilities and hardware to advanced potentially beneficial ISRU concepts not yet ready for incorporation into current ISRU system laboratory and field test activities. Proposals aimed at the following are of particular interest:

- Mineral beneficiation concepts to separate iron oxide-bearing material from bulk regolith; up to 20 kg/hr based on hydrogen reduction. Hardware/concepts need to be designed for compatibility with both 1/6 g flight experiments and ground vacuum experiments.
- Lunar regolith storage and granular flow computer models, devices, and instruments to evaluate regolith flow and manipulation under 1/6 g flight and ground vacuum experimental conditions.
- Granular materials mixing and separation for reactor feedstock conditioning: remove material > 0.5 cm diameter before dumping into storage bin during excavation operation for oxygen extraction from regolith.
- Processing concepts for production of carbon monoxide, carbon dioxide, and/or water from plastic trash and dried crew solid waste using solar thermal or electrical/heat energy. In-situ produced oxygen or other reagents/consumables must be identified and quantified; recycling schemes for reagents to minimize consumables should be evaluated.
- Thermal energy storage and utilization using bulk or processed regolith.

Phase 1 proposals should demonstrate technical feasibility of the technology and/or subsystem through laboratory validation of critical aspects of the innovation proposed, as well as the design and path toward delivering hardware/subsystems in Phase 2.

TOPIC: X4 Structures, Materials and Mechanisms

The SBIR topic area of Structures, Materials and Mechanisms centers on developing lightweight structures, advanced materials technologies, and low-temperature mechanisms for enabling Exploration Vehicles and Lunar Surface Systems.

Lightweight structures and advanced materials have been identified as a critical need since the reduction of structural mass translates directly to additional up and down mass capability that would facilitate additional logistics capacity and increased science return for all mission phases. The major technology drivers of the lightweight structure technology development are to significantly enhance structural systems by 1) lowering mass and/or improving efficient volume for reduced launch costs, 2) improving performance to reduce risk and extend life, and 3) improving manufacturing and processing to reduce costs. The targeted applications of the lightweight structures and materials technologies are Orion Crew Module, the Ares launch vehicles, Lunar Lander, and Lunar Surface Systems. For this Solicitation, the desired area of focus is Lunar Surface Systems, particularly for Lunar habitats.

Low-temperature mechanism technology is being developed for reliable and efficient operation of mechanisms in lunar temperatures including operations in lunar shadows at -230°C and sustained surface operations thru varying lunar temperatures of -230°C to +120°C for lunar surface rovers, robotics, and mechanized operations. The technology drivers of the low temperature mechanism technology development are to significantly enhance operation of mechanized parts by 1) lowering the operating temperature for life of the component and 2) improving mechanism performance (torque output, actuation performance, lubrication state) at the lunar environment conditions of cold and vacuum over the required life of the mechanism. The targeted application of the technology is to provide for operation of motors and drive systems, lubricated mechanisms, and actuators of lunar rovers and mobility systems, ISRU machinery, robotic systems mechanisms, and surface operations machinery (i.e., cranes, deployment systems, airlocks) for lunar surface operations.

This topic area is to enhance and fill gaps in technology development programs in the Exploration Technology Exploration Program's Structures, Materials, and Mechanisms (SMM) Project. Areas of development included in the SMM project include: low temperature drive system, motor, and gearbox system, personal kit radiation shielding materials, low density parachute material systems, expandable structural systems, and friction stir welded spun-domes. This topic area is responsible for mid-level technology research, development, and testing through experimental and/or analytical validation.

X4.01 Advanced Radiation Shielding Materials and Structures
Lead Center: LaRC
Participating Center(s): ARC, MSFC

Advances in radiation shielding materials and structures technologies are needed to protect humans from the hazards of space radiation during NASA missions. The primary area of interest for this 2009 solicitation is radiation shielding materials systems for long-duration lunar surface galactic cosmic radiation (GCR) protection. The innovative materials systems should have radiation shielding effectiveness approaching that of polyethylene, for an equivalent areal density (grams per square centimeter). This can be determined either by radiation transport calculations or by radiation exposure measurements. Research should be conducted to demonstrate technical feasibility during Phase 1 and to show a path toward a Phase 2 technology demonstration. Specific areas in which SBIR-developed technologies can contribute to NASA's overall mission requirements include the following:

- Innovative lightweight radiation shielding materials and structures to shield humans in crew exploration vehicles, landers, habitats, and rovers;
- Physical, mechanical, structural, and other relevant characterization data to validate and qualify multifunctional radiation shielding materials and structures;
- Innovative processing methods to produce quality-controlled advanced radiation shielding materials of all forms.

X4.02 Expandable Structures
Lead Center: LaRC
Participating Center(s): JSC, MSFC

This subtopic solicits innovative structural concepts that support the development of lightweight structures technologies that could be applicable to lunar surface system habitats. The targeted innovative lightweight structures are for primary pressurized volumes and secondary structures that must be deployed during or after expansion of the primary volume such as the floor and work surfaces. Innovations in technology are needed to minimize launch mass, size and costs, while increasing operational volume and maintaining the required structural performance for loads and environments.

Of particular interest are inflatable structures which are considered to be viable solutions for increasing the volume in habitats, airlocks, and potentially other crewed vessels. However, areas of risk need to be mitigated to build confidence in the use of these structures, in particular: consistent and reproducible mechanical behavior, durability in the presence of micrometeoroid impact, crew-induced and ground handling damage, and repair techniques for long term survivability. Other interests include preintegration solutions, launching pressurized volume in an expandable, and addressing lunar surface deployment concerns.

Also of interest are innovative deployable secondary structures that have minimal mass and high packaging efficiency. These secondary multi-functional structures provide highly robust, stiff and mass efficient surfaces that enable the useful outfitting and pre-integration of subsystems within the primary structural volume.

Development of concepts can include structural components, methods of validation, and/or predictive analysis capabilities. Technological improvements that focus on risk reduction/mitigation, and development of reliable yet robust designs are also being sought under this announcement. Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

X4.03 Low Temperature Mechanisms
Lead Center: GSFC
Participating Center(s): GRC, JPL, JSC, LaRC

This subtopic focuses on the development of high power and high specific torque density actuators (e.g., motors and gear boxes) that will operate on the lunar surface exposed to the day/night cycle. They will need to operate over a temperature range of approximately 40 K to 403 K. A five year lifetime is desired. The component technologies developed in this effort will be utilized for rovers, cranes, instruments, drills, crushers, and other such facilities. The nearer term focus for this effort is for lunar missions, but these technologies should ideally be translatable to applications on Mars. These components must operate in a hard vacuum with partial gravity, abrasive dust, and full solar and cosmic radiation exposure. Additional requirements include high reliability, ease of maintenance, low-system volume, low mass, and minimal power requirements. Low out-gassing is desirable, as are modular design characteristics, fail-safe operation, and reliability for handling fluids, slurries, biomass, particulates, and solids. While dust mitigation is not specifically included in this subtopic, proposed concepts should be cognizant of the need for such technologies.

Specific areas of interest include innovative long life, light weight, wide temperature range motors (in the range of one to five kWatts), gear boxes, lubricants, and closely related components that are suitable for the environments discussed above.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

TOPIC: X5 Advanced Composite Technology

The SBIR Topic area of Advanced Composites Technologies (ACT) focuses on technologies to mature the use of composite structures and materials for launch vehicles and/or the lunar lander.

Organic matrix composite materials have the potential for a significant mass reduction compared to metallic materials by optimizing the structural architecture of applications including the Ares V Core Stage intertank, the Ares V Core-Stage-to-Earth-Departure-Stage interstage, the Ares V Payload Shroud, and the Altair lunar lander support struts. The major technology drivers for these applications of advanced composites technologies include large scale composites manufacturing, composite damage tolerance and detection, and primary structure durability in a lunar environment. Successful composites technologies will demonstrate concepts with reduced weight and cost with no loss in performance when compared to technologies for metallic concepts.

This Topic is to enhance and fill gaps in technology development activities in the Exploration Technology Development Program Advanced Composites Technologies Project. Areas of development in the ACT project include: materials; manufacturing; nondestructive evaluation/structural health monitoring; and structural concepts. This Topic is responsible for mid-level technology research, development, and testing through experimental and/or analytical validation.

X5.01 Composite Structures - Practical Monitoring and NDE for Composite Structures
Lead Center: JSC
Participating Center(s): ARC, LaRC

Orion backshell, Aries Payload fairing, and Lander struts and composite pressure vessel option, COPV and composite tankage and Habitat modules are only a few of the many weight-reducing applications for composites that need efficient and modular systems to accomplish monitoring and NDE for them to be practical.

This subtopic seeks the development of technologies to detect, locate and characterize indications of a failure far enough ahead that routine actions can be taken to rectify the situation. Perform monitoring such that models can be built of event behaviors and structural response condition can be determined. Monitoring and/or NDE changes can be made with minimum cost/operations.

Performance Goals/Metrics:

- Provide impending system failure indications with sufficient time to take action to reduce the risk of catastrophic failure;
- Increase the number of sensor locations per pound of monitoring weight by 50%;
- Decrease the system monitoring electronics weight by 50%;
- Decrease total wiring required for monitoring by 50%;
- Decrease the time to plan and install monitoring by 50%;
- Decrease the overall life-cycle cost per sensor by 50%;
- Decrease total data rate required from the sensor data acquisition location by 50%;
- Decrease time to perform NDE inspections by 50%;
- Decrease the expected cost of instrumentation changes/upgrades by 50%.

Technologies sought include: smart sensors, wireless passive sensors, flexible sensors for highly curved surfaces, direct-write film sensors, real-time compact NDE imagers for damage inspection, highly accurate defect and tool position determination.

Applications include: Advanced composite structures such as cryo-tanks, large area composites such as launch vehicle fairings, habitable volumes, hard to access/inspect composite members, as well as metallic pressurized structures of all kinds. Interior as well as exterior measurements of the pressure vessel are needed.

This subtopic is also a subtopic for the “Low-Cost and Reliable Access to Space (LCRATS)” topic. Proposals to this subtopic may gain additional consideration to the extent that they effectively address the LCRATS topic (See topic O5 under the Space Operations Mission Directorate).

X5.02 Composite Structures - Cryotanks
Lead Center: LaRC
Participating Center(s): GRC, GSFC, JSC, MSFC

The use of composite materials for smaller cryotanks offers the potential of significant weight savings. Composite cryotank technology would be applicable to EDS propellant tanks, Altair propellant tanks, lunar cryogenic storage tanks and Ares V tanks. A material system (resin+fiber) which displays high resistance to microcracking at cryogenic temperatures is necessary for linerless cryotanks, which provide the most weight-saving potential.

This subtopic will focus on development of toughened, high strength composite materials, because the literature indicates that they have the highest microcrack resistance at cryogenic temperatures. Greatest interest is in novel approaches to increase resin strength and/or reduce resin CTE, thereby increasing resistance to microcracking at cryogenic temperature.

Performance would be evaluated by a characterization program, which would ideally generate temperature-dependent material properties including strength, modulus, and CTE as functions of temperature. Additionally, notch sensitivity, plain strain fracture toughness, and microcracking fracture toughness as functions of temperature are desirable. Tests will need to be performed at temperatures between -273°C and 180°C to fully characterize any nonlinearity in material properties with changes in temperature.

Initial property characterization would be done at the coupon level in Phase 1. Generation of design allowables, characterization of long-term material durability, and fabrication of larger panels would be part of follow-on efforts.

X5.03 Composite Structures - Manufacturing
Lead Center: MSFC
Participating Center(s): GRC, LaRC

The SBIR subtopic area of Composites Materials and Manufacturing centers on developing lightweight structures using advanced materials technologies, and new manufacturing processes. The objective of the subtopic is to advance technology readiness levels of composite materials and manufacturing for Ares launch vehicle applications resulting in structures having consistent, predictable response.

Areas of interest include: polymer matrix composites (PMCs), large-scale manufacturing; innovative automated processes (e.g., fiber placement); advanced non-autoclave curing; bonding of composite joints; and damage-tolerant/repairable structures.

Performance metrics include: achieving adequate structural and weight performance; analysis supported by test approach; manufacturing and life-cycle affordability; ability to demonstrate capabilities at the laboratory scale and confidence for scale-up; validation of confidence in design, materials performance, and manufacturing processes; quantitative risk reduction capability; minimum sensitivity and maximum robustness for operability.

Lightweight structures and advanced materials have been identified as a critical need since the reduction of structural mass translates directly to vehicle additional performance, reduced cost, and increased up and down mass capability.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 prototype demonstration. Demonstrate manufacturing technology that can be scaled up for very large structures.

This subtopic is also a subtopic for the "Low-Cost and Reliable Access to Space (LCRATS)" topic. Proposals to this subtopic may gain additional consideration to the extent that they effectively address the LCRATS topic (See topic O5 under the Space Operations Mission Directorate).

TOPIC: X6 Lunar Operations

This call for technology development is in direct support of the Exploration Systems Mission Directorate's (ESMD) Exploration Technology Development Program (ETDP). The purpose of this research is to develop component and subsystem level technologies to support the Constellation Program's (CxP) human lunar return missions. The initial missions will be heavily engaged in construction methods, regolith excavation, establishing self-sustaining power generation, and producing life support consumables in-situ in order to establish continuous operational capability via earth based and lunar based human and robotic assets.

The objective is to produce new technology that will reduce lunar operations workloads associated with crew extra-vehicular activities (EVA) and intra-vehicular activities (IVA), and reduce the total mass-volume-power of equipment and materials required to support both short and long duration Lunar stays as well as maximizing crew and outpost safety during landing, launch and lunar operations. The proposals must focus on component and subsystem level technologies in order to maximize the return from current SBIR funding levels. Doing so increases the likelihood of successfully producing a technology that can be readily infused into the Constellation Program.

Lunar operations are a stepping-stone toward achieving long-term space exploration goals. This research focuses on technology development for the critical functions that will secure an extended human presence on the lunar surface and 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 lunar surface. Reducing risk and ensuring mission success depends on the coordinated interaction of many functional surface systems including life support, power, communications infrastructure, and transportation. This topic addresses technology needs associated with lunar surface systems infrastructure, interaction of humans and machines, mobility systems, payload and resource handling, regolith excavation and mitigation of environmental contaminations. For more information, see the following websites:

http://www.nasa.gov/exploration/home/LER.html
http://www.nasa.gov/multimedia/podcasting/Haughton_Mars_project.html
http://robonaut.jsc.nasa.gov/index.asp
http://www.nasa.gov/centers/ames/multimedia/images/2008/K_10_38.html
http://www.lpi.usra.edu/meetings/leagilewg2008/pdf/4001.pdf
http://www.nasa.gov/home/hqnews/2008/jun/HQ_08149_Moses_Lake.html

X6.01 Robotic Systems for Human Exploration
Lead Center: JSC
Participating Center(s): ARC, KSC

The objective of this subtopic is to provide advanced capabilities for lunar surface system assets that deliver, handle, transfer, construct, and prepare site infrastructure for lunar operations. This includes robust dexterous manipulation capabilities; large and small cargo transporters for delivery and deployment of construction materials, power generation systems, and habitable enclosures.

This subtopic seeks to develop technologies that reduce the risk of Extra-Vehicular Activity (EVA), facilitates remote robotic operations by both flight crew and ground control, and enables autonomous robotic operations. Automation and robotics capabilities include the ability to use robots for site setup and operations, both at an outpost and at remote lunar surface locations. Site operations support focuses on two types of activities: (1) tedious, highly repetitive, long-duration tasks that cannot be performed by EVA crew and (2) rapid response for addressing emergency, time-critical situations. Candidate tasks include: systematic site survey (engineering and/or science), inspection, emergency response, site preparation (clearing, leveling, excavation, etc.), instrument deployment, payload offloading, dexterous manipulation, and regolith handling for In-situ Resource Utilization.

Maximizing the useful life of surface assets is essential to a successful lunar program. Material components must be robust and tolerate extreme temperature swings and endure harsh environmental effects due to solar events, micrometeorite bombardment, and abrasive lunar dust.

Proposals are sought for the following technology needs:

- Low-mass, high-strength, long-life, non-pneumatic wheel assembly capable of spreading the supported load over a large contact patch area and moving over surface terrain similar to loose beach sand. Range, Life, Mass, Mean-time-to-repair, and Mean-time-between-failure are key performance parameters being sought. Low psi contact patch. Minimal deformation of wheel under varying terrain makeup. Minimal rolling resistance. High performance in 4-sigma soil. 10,000 km expected life. 40K to 400K operating temperature range. Supports 100x its own mass.

- Active and passive damping materials for suspension components that provide extended range of motion (45 degrees in pitch), extreme temperature tolerance (40K to 400K), reactive rates of 1-3 msec, and withstand torsional forces of 3000 N-m.
- Active suspension components that reclaim and store energy absorbed through the suspension system.
- Fluid and electrical connectors that can be repeatedly mated and de-mated (5000+ cycles) without failure in a contaminating environment consisting of regolith (abrasive dust) grains ranging in size from 100um down to 10um. Capable of carrying up to 10kw of power transmission or withstanding up to 3000psi pressures.
- Low power sensors for inspection and surface navigation and obstacle avoidance that are not adversely affected by the accumulation of lunar dust on the sensor. Developing robust sensor technologies will enable mobility assets to execute automated path planning, automated driving, and obstacle avoidance.
- Robot user interfaces enabling more efficient interaction with robots, facilitating situational awareness and telepresence, and reducing the amount of interaction effort required to operate robots. Appropriate user interfaces will support humans and robots operating in a shared space, close but separated, line-of-sight remote, and ground control remote. Particular interest is given to systems that robustly support robot operations with up to 10 seconds of communications delay.
- Modular implements for digging, collecting, transporting and dumping lunar soil. The excavation rates are in the order of 50 kg/hr for regolith mining for O_2 production and 300 kg/hr for Site preparation tasks. Total amounts of regolith required are 100 tons for O_2 production and over 2,000 tons for a full outpost deployment. Excavation capabilities involve excavation and collection of both unconsolidated and consolidated surface regolith. Regolith Excavation includes tasks such as clearing and leveling landing areas and pathways, buildup of berms (2.5 m high) and burying of reactors or habitats for radiation protection (2 m deep), and regolith transportation for oxygen production (500 m distance) . Robotic excavation hardware must be able to operate over broad temperature ranges (40 K to 400 K) and in the presence of abrasive lunar regolith and partial-gravity environments. Expectations for maintenance by crew must be minimal and affordable (annual cycle). Therefore, general attributes desired for all proposed hardware include the following: lightweight, abrasion resistant, vacuum and large temperature variation compatible materials, low power, robust/low maintenance, and minimize dust generation/saltation during operation.
- Large surface area, i.e., 100 m X 100 m, soil stabilization/solidification techniques to prevent dust and regolith disturbances/ejecta from vehicular or suited EVA traffic (7 - 70 kilopascal bearing pressure).

X6.02 Surface System Dust Mitigation
Lead Center: GRC
Participating Center(s): ARC, GSFC, JPL, JSC, KSC, LaRC, MSFC

The general objective of the subtopic is to provide knowledge and technologies (to Technology Readiness Level (TRL) 6 development level) required to address adverse dust effects to exploration surface systems and equipment, which will reduce life cycle cost and risk, and will increase the probability of sustainable and successful lunar missions. The subtopic will help to develop a balance of near- and long-term knowledge and technology development, driven by Exploration Systems Mission Directorate needs and schedule requirements, aligned with existing technology investments where possible. The technical scope of the subtopic includes the evaluation of lunar dust effects and development of mitigation strategies and technologies related to Exploration Surface Systems, such as: Rovers and Robotic Systems, In Situ Resource Utilization (ISRU) Systems, Power Systems, Communication Systems, Airlock Systems and Seals, Habitats, and Science Experiments.

Lunar lander and surface systems will likely employ common hatch and airlock systems for docking, mating, and integration of spacecraft, habitat, EVA, and mobility elements. The large number of EVAs will require hatches that are safe if non-pressure assisted, and do not have to be serviced or replaced regularly. Lunar lander and surface systems will require materials and mechanisms that do not collect dust and do not abrade when in contact with lunar regolith. Technologies are also needed to remove lunar regolith, including dust, from materials and mechanisms. Lunar Surface systems will require EVA compatible connectors for fluid, power, and other umbilicals for transfer of consumables, power, data, etc. between architecture elements that will maintain functionality in the presence of lunar regolith, including dust. Lunar surface systems (power, mobility, communications, etc.) will require gimbals, drives, actuators, motors, and other mechanisms with required operational life when exposed to lunar regolith, including dust. Radiators and other thermal control surfaces for lander and surface systems must maintain performance and/or mitigate the effects of contamination from lunar regolith, including dust.

Also included in the technical scope is the development of lunar regolith simulants. Simulants that are properly designed, analyzed, and produced are critical to understanding the effects of dust on humans and mission critical subsystems and how to handle and utilize regolith on the lunar surface. Proposals are requested in technology areas that improve simulant fidelities, reduce simulant manufacturing costs and schedules, and improve on simulant development processes and characterization techniques and methods.

Lunar Regolith Simulants

- Should cost <\$15,000/ton for low fidelity applications (excavation, mobility testing, etc.), and <\$60,000/ton for high fidelity (ISRU process evaluation, regolith mitigation, surface stabilization, etc.);
- Should cost <\$5,000/kg with particle size distribution representative of lunar regolith below 10 ƒÝm in diameter;
- Be producible in quantities up to 30 tons/year;
- Have reproducible production processes;
- Have particle size distributions representative of lunar regolith from 0.5 to 1000ƒÝm in size.

The subtopic specifically requests technologies addressing dynamic mechanical systems used for lunar surface missions with potential to mitigate effects of lunar dust. For lubricated mechanisms, such as drives and pointing mechanisms, the sealing element must be durable enough to maintain a hermetic seal to prevent lubricant out gassing and dust contamination for at least 5 years. Also, the bearings, gears, etc of the mechanism must be robust enough to survive and provide nominal operation with lunar dust contamination and possible lubrication starvation.

Mechanical Systems

- Should achieve <10% increase transmission positional error when contaminated by lunar fines over a 5 year life;
- Should achieve dynamic seal wear life of 20 million cycles;
- Should achieve 300% improvement in bearing life (frictional torque vs. time) relative to lubricated SOA bearings contaminated with lunar fines.

The subtopic also requests proposals for advanced materials, coatings, and related technologies with the proper combination of physical, mechanical, and electrical properties, and lunar environmental durability, suitable for use in dust mitigation applications on the lunar surface.

Materials and Coatings

- Should demonstrate reduced initial contamination (>90%) compared to conventional materials;
- Should demonstrate improved efficiency of cleaning processes (>99% removal of initial contamination) without damage.

Another area of interest encompassed by this subtopic is alternative technologies for lunar dust removal that may be used in a variety of lunar surface applications. Both manual and automated cleaning systems are sought and may be derived from any or a combination of particle removal forces appropriate for use on the lunar surface.

Cleaning Systems

- Should demonstrate >99% removal of dust contamination. Tolerable contamination levels will be application specific.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path to hardware or production demonstration in Phase 2. When possible, a demonstration unit or material quantity should be delivered for functional and environmental testing and characterization and evaluation at the end of Phase 2.

TOPIC: X7 Energy Generation and Storage

This topic includes technology development for batteries, fuel cells, regenerative fuel cells, and fission and isotopic power systems for the Altair lunar lander and surface operations on the Moon and Mars. Technologies developed must be infused into these Constellation program elements: primary fuel cells for the Altair lunar lander descent stage, secondary batteries for the Altair ascent stage, secondary batteries for extravehicular activities (EVA) suits, and regenerative fuel cells, fission and isotopic power systems on the Moon and Mars to power habitats, in situ resource production, and mobility systems. Specific technology goals and component needs are given in the sub-topics. General mission priorities for energy storage and generation include:

- EVA suits require secondary batteries sufficient to power all portable life support, communications, and electronics for an 8-hour mission with minimal volume. Battery operation required for six months and 100 recharge cycles with a shelf life of at least two years. Mission priorities include human-safe operation; 8-hr duration; high specific energy; and high energy-density.
- Secondary batteries for the Altair ascent stage require nominally 10 recharge cycles with 1.7 kW nominal power and 2 kW peak power, operating for 7 hours continuously. Mission priorities include human-safe, reliable operation and high energy-density in a 0 - 30°C and 0 - 1/6 gravity environment.
- The Altair descent stage requires a fuel cell with a nominal power level of 3 kW with 5.5 kW peak, operating for 220 hours continuously. Mission priorities include human-safe reliable operation; the ability to scavenge available fuel; and high energy-density.
- Regenerative fuel cells, which combine a fuel cell with a water electrolyzer, have been baselined for lunar surface system operations. Mission priorities include reliable, long-duration maintenance-free operation; human-safe operation; high specific-energy; and high system efficiency in a 0 - 100°C, 1/6 gravity environment.
- Architecture studies have identified nuclear power technology to effectively satisfy high power requirements for extended duration lunar surface missions. Nuclear power generation is especially attractive for missions with significant solar eclipse periods, including non-polar locations and inside lunar craters, as well as Mars outposts.
- Power systems for lunar rovers require human-safe operation; reliable, maintenance-free operation; and high specific-energy.

X7.01 Advanced Space Rated Batteries
Lead Center: GRC
Participating Center(s): JPL, JSC

Advanced battery systems are sought for use in Exploration mission applications including power for landers, rovers, and extravehicular activities. Areas of emphasis include advanced cell chemistries with the aggressive mass and volume performance improvements and safety advancements in human-rated systems over state-of the-art lithium-based systems. Rechargeable cell chemistries with advanced non-toxic anode and cathode materials and nonflammable electrolytes are of particular interest.

The focus of this solicitation is on advanced cell components and materials to provide mass and volume improvements and safety advancements that contribute to the following goals:

- Specific energy (cell level)>300 Wh/kg at C/2 and 0°C;
- Energy density (cell level)>600 Wh/l at C/2 and 0°C;
- Operating Temperature Range from 0°C to 30°C;
- Tolerance to abuse such as overcharge and over temperature conditions;
- Calendar life >5 years; cycle life 250 cycles at 100% depth of discharge.

Systems that combine all of the above characteristics and demonstrate a high degree of safety are desired. Cell safety devices such as shutdown separators, current limiting devices that inhibit or prevent thermal runaway, cell venting, and flame or fire; autonomous safety features that result in safe, non-flammable, non-hazardous operation especially for human-rated applications are of particular interest. Safety features that enhance the performance of high-power/high-rate cells that operate at >30°C discharge rates are also of interest.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

X7.02 Surface Nuclear Power Systems
Lead Center: GRC
Participating Center(s): MSFC

NASA is interested in the development of highly advanced systems, subsystems and components for use with fission and isotopic systems to power habitats, resource production, and mobility systems on the Moon and Mars. Nuclear systems are anticipated to enable the long duration stay over the lunar night and for "global access" Mars missions. Initial planetary outpost power levels are anticipated to be between 30-50 kWe with anticipated growth to 100's kWe. Isotopic technologies that improve the utilization of a limited fuel supply and have extensibility to fission systems are sought. Performance goals include reducing overall system mass, volume and cost, and increasing safety and reliability.

Specific technology topics of interest are:

- High efficiency (>20%) power conversion at 900 K;
- Electrical power management, control and distribution (1-5 kV);
- High temperature, low mass (< 6 kg/m^2) radiators, liquid metal/liquid metal and liquid metal/gas heat exchangers (>90% effectiveness) and electromagnetic pumps (>20% efficiency);
- Deployment systems/mechanisms for large radiators (~3m x 15m);
- High temperature (>900 K) materials or coatings compatible with local soil and atmospheric environments;
- Systems/technologies to mitigate planetary surface environments including dust accumulation, wind, planetary atmospheres, corrosive soils, etc.;
- System designs to provide autonomous control for 10-year operation, including sensor and control technologies;
- Radiation tolerant systems and materials enabling robust, long life operation.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

X7.03 Fuel Cells for Surface Systems
Lead Center: GRC
Participating Center(s): JPL, JSC

Advanced primary fuel cell and regenerative fuel cell energy storage systems are baselined to provide descent power for the Altair lander and stationary power for lunar bases. Technology advances that reduce the weight and volume, improve the efficiency, life, safety, system simplicity and reliability of PEM fuel cell, electrolysis, and regenerative fuel cell systems are desired. Proposals are sought which address the following areas:

Advanced Conductive Fuel Cell Water Separator
Research directed towards improving the water separating capability of a planar separator internal to each fuel cell in a fuel cell stack. Proposals directed at developing such advanced separator materials must meet the following criteria to be considered relevant.

The separator:

- Must be wettable with water, and have a contact angle less than 30 degrees;
- Must allow water to penetrate and be transferred through the plane of the separator at a rate of at least 0.33 grams of water per hour per square centimeter of separator planar area;
- Must not permit gas vapor to penetrate through the separator up to at least 30 psid (i.e., a bubble pressure point of at least 30 psid);
- Must be electrically conductive, and have a resistivity of no more than 7.0×10^{-3} Ohm-cm;
- Ideally should be compatible with a fuel cell fabrication process step that occurs at 1000°C with a compressing force of at least 600 psi. (The separator will not need to operate at these conditions, but could be subjected to these conditions during fuel cell fabrication). This bullet is not a requirement but a desirable characteristic.

Hydrogen/Oxygen Dual Gas Pressure Regulator
Research directed towards improving the regulators that regulate hydrogen and oxygen gases down to a usable pressure for the fuel cell. The regulated pressure needs to be controlled so that the pressure differential between the gases is within a few psi. NASA is interested in developing a single mechanical component which functions as a dual gas regulator that can reliably regulate these gases from high pressure source (>500psi) down to <50 psi and maintain the pressure differential between these gases to <2 psid.

Advanced Electrocatalyst Materials for Fuel Cells and Electrolyzers
Research directed towards improving the kinetics of oxygen reduction and oxygen evolution. Nano-phase, high-surface area unsupported platinum-alloys, incorporating cobalt, nickel and iron are potential candidates for improving the kinetics of oxygen reduction. Oxides of ruthenium and iridium are particularly promising electrocatalysts for the oxygen evolution reaction. In addition to performance, the new materials must exhibit durability for over 10,000 hours of operation with no more than 20% loss in performance. Proposals directed at developing such advanced nano-phase materials, understanding composition/property relationships, and demonstrating their characteristics in operating fuel cells will be considered directly relevant to achieving the long-term goals of the Explorations Missions.

- Fuel cell MEA efficiency >75% (>0.92volts) @ 200 mA/cm^2;
- Electrolysis MEA efficiency >85% (<1.44 volts/cell) @ 200 mA/cm^2.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

TOPIC: X8 Cryogenic Systems

The Exploration Systems architecture presents cryogenic storage, distribution, and fluid handling challenges that require new technologies to be developed. Reliable knowledge of low-gravity cryogenic fluid management behavior is lacking and yet is critical for Altair and Ares in the areas of storage, distribution, and low-gravity propellant management. Additionally, Earth-based and lunar surface missions will require success in storing and transferring liquid and gas commodities. Some of the technology challenges are for long-term cryogenic propellant storage and distribution; cryogenic fluid ground processing and fluid conditioning; liquid hydrogen and liquid oxygen liquefaction processes on the lunar surface. Furthermore, specific technologies are required in valves, regulators, instrumentation, modeling, mass gauging, cryocoolers, and passive and active thermal control techniques. The technical focus for component technologies is for accuracy, reduced mass, minimal heat leak, minimal leakage, and minimal power consumption. The anticipated technologies proposed are expected to increase reliability, increase cryogenic system performance, and are capable of being made flight qualified and/or certified for the flight systems and dates to meet Exploration Systems mission requirements.

X8.01 Cryogenic Fluid Transfer and Handling
Lead Center: KSC
Participating Center(s): ARC, GRC, GSFC, JSC, MSFC, SSC

This subtopic solicits cryogenic storage and transfer technologies to enable NASA Exploration goals. This includes a wide range of applications, scales, and environments on ground, in orbit, and on the Lunar or Martian surface. Specifically:

- Passive thermal control for ZBO (zero boil-off) storage of cryogens for both long term (>200 days for LOX/LH_2) on the lunar surface and short term (14 days for LH_2, LOX) on orbit. Insulation for both ground and flight.
- Active thermal control for long term ZBO storage for lunar surface and space applications. Technologies include 20 K cryocoolers for Mars missions, cryocooler integration techniques, heat exchangers, distributed cooling, and circulators. Scavenging of residual propellants.
- Zero gravity cryogenic control devices including thermodynamic vent systems, spray bars and mixers, and liquid acquisition devices.
- Advanced spacecraft valve actuators using piezoelectric ceramics. Actuators that can reduce the size and power while minimizing heat leak and increasing reliability.
- Propellant conditioning and densification technologies for Earth based applications, scaled for Altair or EDS tanks. Destratification technologies and recirculation systems for homogeneous tank loads. Reliability and operability upgrades over past densification systems.
- High capacity liquid oxygen pump systems capable of delivering high quality of liquid over a wide flow range between 500 GPM to 2000 GPM are sought. Special emphasis on variable control pumping, parallel pumping, system reliability and robustness, and advanced pump sealing technology is needed.
- Liquefaction of oxygen on the Lunar surface, including passive cooling with radiators, cryocooler liquefaction, or open cycle systems that work with HP electrolysis. Efficiency, mass savings, and reliability upgrades are needed. Heat pumps, switches, and heat pipes to control energy flow at low temperatures. Deployable radiators and radiation shields.

X8.02 Cryogenic Instrumentation for Ground and Flight Systems
Lead Center: GRC
Participating Center(s): JPL, KSC, MSFC, SSC

This subtopic includes technologies for reliable, accurate cryogenic propellant instrumentation needs in-space, on the lunar surface, and on the Earth. Innovative concepts are requested to enable accurate measurement of cryogenic liquid mass in low-gravity storage tanks, to enable the ability to detect in-space and on-pad leaks from the storage system, and to address other cryogenic instrumentation needs. Cryogenic propellants such as hydrogen, methane, and oxygen are required for many current and future space missions. Proposed technologies should offer enhanced safety, reliability, or economic efficiency over current state-of-the-art, or should feature enabling technologies to allow NASA to meet future space exploration goals.

Propellant mass gauging provides accurate measurement of cryogenic liquid mass (LH_2, LO_2, and LCH_4) in low gravity storage tanks, and is critical to allowance of smaller propellant tank residuals and assuring mission success. Both low-gravity gauging (measurement uncertainty <1%) and low-thrust level settled gauging (measurement uncertainty <0.5%) technologies are being solicited for these applications.

Leak detection technologies impact cryogenic systems for space transportation orbit transfer vehicles, lunar surface, and launch site ground operations. These systems will be operational both in atmospheric conditions and in vacuum with multiple sensor systems distributed across the vehicle or a region of interest to isolate leak location. Methane and hydrogen leak detection sensors with milli-second response times and 1 ppm detection sensitivity in air are desired for ground and launch operations.

Other cryogenic instrumentation needs include:

- Miniature cryogenic pressure sensors (0 - 1 atm) for use under MLI blankets.
- Zero dead-volume in-line pressure sensors for use in liquid hydrogen flow streams.
- Real-time in-situ measurements of ppm levels of N_2, O_2, and H_20 in gaseous helium purge streams. Sensors that can survive the temperature range 20 K - 300 K and the vibration loads on a launch platform are especially desired.
- Minimally intrusive in-situ measurements of liquid hydrogen and liquid oxygen purity levels in real time. The goal is to accurately measure cryogenic propellant liquid purity levels (99% - 100% purity) in ground test stands during test operations. Helium and nitrogen impurity levels are of specific interest, but the sensors must be able to measure overall purity level of the cryogenic liquid.
- Minimally invasive cryogenic liquid flow measurement sensors for rocket engine feed lines, and sensors to detect and quantify two-phase flow (bubbles) within the feed lines.
- Non-intrusive flowmeters for high-pressure (up to 6,000 psi) gaseous helium distribution lines are sought for flow rates ranging from a trickle flow up to 1500 SCFM. Ultrasonic clamp-on flowmeters are especially desired, but must be able to sense the flow through 2" Schedule-XX pipe (0.436" wall thickness).
- Position indicators and long life application of the instrumentation for deep space missions.

TOPIC: X9 Thermal Protection Systems

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 CEV missions, e.g., Mars Landing with 8 km/s entry and Mars Sample Return with 12-15 km/s Earth entry. 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.

X9.01 Ablative Thermal Protection Systems
Lead Center: ARC
Participating Center(s): GRC, JPL, JSC, LaRC

The technologies described below support the goal of developing higher performance ablative TPS materials for higher performance CEV as well as 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, including: development of acreage materials, adhesives, joints, penetrations, and seals. Two classes of materials will be required.
    - One class of materials, for Mars aerocapture and entry, will need to survive heat fluxes of 200-400 W/cm^2 (primarily convective) and integrated heat loads of up to 25 kJ/cm^2. 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/cm^2 and pressures of 0.3 atm and improve on the state-of-the-art areal mass of 1.0 g/cm^2 required to maintain a bondline temperature below 250°C.
    - The second class of materials, for Mars return, will need to survive heat fluxes of 1500-2500 W/cm^2, with radiation contributing up to 75% of that flux, and integrated heat loads from 75-150 kJ/cm^2. 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/cm^2 and pressures of 0.3 atm and improve on the state-of-the-art areal mass of 4.0 g/cm^2 required to maintain a bondline temperature below 250°C.
- 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 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 6-mm, and bondline defect detection requirements are on the order of 25.4-mm by 25.4-mm times the thickness of the adhesive.
- Advances are sought in ablation modeling, including radiation, convection, gas surface interactions, pyrolysis, coking, and charring. 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 4 or higher are sought.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

This subtopic is also a subtopic for the “Low-Cost and Reliable Access to Space (LCRATS)” topic. Proposals to this subtopic may gain additional consideration to the extent that they effectively address the LCRATS topic (See topic O5 under the Space Operations Mission Directorate).

X9.02 Advanced Integrated Hypersonic Entry Systems
Lead Center: ARC
Participating Center(s): GRC, JPL, JSC, LaRC

The technologies below support the goal of developing advanced integrated hypersonic entry systems that meet the longer term goals of realizing larger payload masses for future Exploration missions.

- Advanced integrated thermal protection systems are sought that address: (1) thermal performance efficiency (i.e., ablation vs. conduction), (2) in-depth thermal insulation performance (i.e., material thermal conductivity and heat capacity vs. areal density), (3) systems thermal-structural performance, and (4) system integration and integrity. Such integrated systems would not necessarily separate the ablative TPS material system from the underlying sub-structure, as is the case for most current NASA heat shield solutions. Instead, such integrated solutions may show benefits of technologies such as hot structures and/or multi-layer systems to improve the overall robustness of the integrated heat shield while reducing its overall mass. The primary performance metrics for concepts in this class are increased reliability, reduced areal mass, and/or reduced life cycle costs over the current state of the art.
- Advanced multi-purpose TPS solutions are sought that not only serve to protect the entry vehicle during primary planetary entry, but also show significant added benefits to protect from other natural or induced environments including: MMOD, solar radiation, cosmic radiation, passive thermal insulation, dual pulse heating (e.g., aero capture followed by entry). Such multi-purpose materials or systems must show significant additional secondary benefits relative to current TPS materials and systems while maintaining the primary thermal protection efficiencies of current materials/systems. The primary performance metrics for concepts in this class are reduced areal mass for the combined functions over the current state of the art.
- Integrated entry vehicle conceptual development is sought that allow for very high mass (> 20 mT) payloads for Earth and Mars entry applications. Such concepts will require an integrated solution approach that considers: TPS, structures, aerodynamic performance (e.g., L/D), controllability, deployment, packaging efficiency, system robustness / reliability, and practical constraints (e.g. launch shroud limits, ballistic coefficients, EDL sequence requirements, mass efficiency). Such novel system designs may include slender or winged bodies, deployable or inflatable entry systems as well as dual use strategies (e.g., combined launch shroud and entry vehicle). New concepts are enabling for this class of vehicle. Key performance metrics for the overall design are system mass, reliability, complexity, and life cycle cost.
- Advances in Multidisciplinary Design Optimization (MDO) are sought specifically in application to address combined aerothermal environments, material response, vehicle thermal-structural performance, vehicle shape, vehicle size, aerodynamic stability, mass, vehicle entry trajectory / GN&C, and cross-range, characterizing the entry vehicle design problem.

Technology Readiness Levels (TRL) of 4 or higher are sought.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

This subtopic is also a subtopic for the “Low-Cost and Reliable Access to Space (LCRATS)” topic. Proposals to this subtopic may gain additional consideration to the extent that they effectively address the LCRATS topic (See topic O5 under the Space Operations Mission Directorate).

TOPIC: X10 Cryogenic and Non-Toxic Storable Propellant Space Engines

The Exploration Systems architecture presents propulsion challenges that require new technologies to be developed. Non-toxic engine technologies are being explored for use in lieu of the currently operational nitrogen tetroxide (NTO) and monomethylhydrazine (MMH) systems. Safety concerns with toxic propellants drive mission planners to the use of more costly propulsion modules that are fueled and sealed on the ground and can limit operational flexibility on the launch pad. There are also concerns with exhaust residue from toxic systems, which may be carried into habitats for lunar and Mars systems. To address these challenges, the focus will be on the development of cryogenic and non-toxic propulsion technologies to support informed decisions on implementation in the Exploration architecture. The major components of this effort will focus on reaction control systems, main engine, and deep throttling descent engines. A summary of some of the current activities is located at:

http://spaceflightsystems.grc.nasa.gov/Advanced/Capabilities/PCAD/

The anticipated technologies to be proposed are expected to increase reliability, increase system performance, and to be capable of being made flight qualified and certified for the flight systems to meet Exploration Systems mission requirements.

X10.01 Cryogenic and Non-Toxic Storable Propellant Space Engines
Lead Center: GRC
Participating Center(s): JSC, MSFC

This subtopic intends to examine a range of key technology options associated with cryogenic and non-toxic storable propellant space engines. The primary mission for the engines will be to support lunar ascent/descent reaction control engines and lunar ascent engines. These engines can be compatible with the future use of in situ propellants such as oxygen, methane, methanol, monopropellants, or other non-toxic fuel blends. Key performance parameters:

- Reaction control thruster development is in the 25-500-lbf thrust class with a target vacuum specific impulse of 325-sec. These RCS engines would operate cryogenic liquid-liquid for applications requiring integration with main engine propellants; or would operate gas-gas or gas-storable liquid for small total impulse type applications.
- Ascent engine development is projected to be in the 3,500-8,000-lbf thrust class with a target vacuum specific impulse of 355-sec. The engine shall achieve 90% rated thrust within 0.5 second of the issuance of the Engine ON Command.

Specific technologies of interest to meet proposed engine requirements include:

- Non-toxic fuel blends or monopropellants that meet performance targets while improving safety and reducing handling operations as compared to current state-of-the-art storable propellants.
- Low-mass propellant injectors that provide stable, uniform combustion over a wide range of propellant inlet conditions.
- High temperature materials, coatings and/or ablatives for injectors, combustion chambers, nozzles and nozzle extensions.
- Combustion chamber thermal control technologies such as regenerative, transpiration, swirl or other cooling methods which offer improved performance and adequate chamber life.
- Highly-reliable, long-life, fast-acting propellant valves that tolerate space and lunar environments with reduced volume, size, and weight is also desirable.
- Cryogenic instrumentation such as pressure and temperature sensors that will operate for months/years instead of hours.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

TOPIC: X11 Exploration Crew Health Capabilities

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. Although aerobic capacity has not been formally measured in returning ISS crew, short duration Space Shuttle crewmembers have been shown to undergo a 22% reduction in VO2max in response to space flight. During future exploration missions such physiological 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. The ability to estimate the physical cost of exploration tasks, monitor crew health and fitness, and to provide effective hardware for exercise countermeasures use will be valuable in supporting safe and successful space exploration. Exercise Systems is seeking technologies or devices to provide resistive and aerobic exercise in flight or simulate an Extra Vehicular Activity (EVA) suit on the ground. Visit the following for additional information:

http://hacd.jsc.nasa.gov/projects/ecp.cfm
http://hacd.jsc.nasa.gov/projects/eva.cfm

X11.01 Crew Exercise System
Lead Center: GRC
Participating Center(s): JSC

Human space flight is associated with losses in muscle strength, bone mineral density and aerobic capacity. The ability to estimate the physical cost of exploration tasks, monitor crew health and fitness, and to provide effective hardware for exercise countermeasures use will be valuable in supporting safe and successful space exploration.

Exercise Systems is seeking technologies or devices to provide resistive and aerobic exercise in flight.

- Compact, reliable, multi-function exercise devices/systems are required to protect bone, muscle, and cardiovascular health during lunar outpost missions (missions with total duration less than 6 months). This device should be easily configured and stowed, require minimal power to operate, include instrumentation to document exercise session parameters including portable electronic media, and require minimum periodic calibration (no more than 2 times per year). The device must be capable of providing whole body axial loading and individual joint resistive loading that ideally simulates free weights. If unable to match the inertial properties of free weights, then the device must achieve an eccentric to concentric load ratio greater than 90%. The load must be adjustable in increments no greater than 2.5 kgs and provide adequate loading to protect muscle strength and bone health such that post-mission muscle strength is maintained at or above 80% of baseline values. The same device must be capable of providing whole-body aerobic exercise levels necessary to maintain aerobic capacity at or above 75% of baseline VO2max. Finally, the ideal device should also stimulate the sensory-motor system which controls balance and coordination.
- Identify compact, multi-function exercise devices to protect muscle and cardiovascular health during lunar sortie missions (missions with a total duration of less than 30 days). This device must be 20 lbs or less including all accessories (or demonstrated to be within this allotment for a flight unit if the ground prototype exceeds 20 lbs), require no vehicle power to operate, include materials/components that can be flight certified and do not pose risk to the crew vehicle/habitat, and can be stowed within 1 cubic foot of space aboard the Orion vehicle. The device must require no crew calibration or maintenance (for missions less than 30 days), require minimal deployment/setup time (easily portable between vehicles), and ideally include in-

strumentation to document exercise session parameters using portable electronic media. The device must be capable of providing whole body and individual joint resistive loading that ideally simulates free weights.

Phase 1 Requirements: a fully developed concept, complete with feasibility analyses and top-level drawings. A breadboard or prototype is highly desired.

X11.02 EVA Suit Simulator
Lead Center: GRC
Participating Center(s): JSC

Human space flight is associated with losses in muscle strength, bone mineral density and aerobic capacity. The ability to estimate the physical cost of exploration tasks, monitor crew health and fitness, and to provide effective hardware for exercise countermeasures use will be valuable in supporting safe and successful space exploration.
Exercise Systems is seeking technologies or devices to simulate an Extra Vehicular Activity (EVA) suit on the ground.

A wearable system that simulates the mechanical properties of the current extravehicular activity (EVA) space suit is sought. System should be lightweight (less than 30 pounds), easy to don/doff (especially in the supine position), replicate the mechanical properties of a space suit (in terms of resistance to motion and mass and inertia), and able to be worn during conduct of simulated lunar tasks that last up to 4 hours. Suit system must be adjustable to accommodate individuals of different height and weight. Joints of primary interest to simulate in this system are the shoulder, elbow, trunk, hip, and knee.

Phase 1 Requirements: a fully developed concept, complete with feasibility analyses and top-level drawings. A breadboard or prototype is highly desired.

TOPIC: X12 Behavioral Health and Performance

The Behavioral Health and Performance topic is interested in developing strategies, tools, and technologies to mitigate Behavioral Health and Performance risks. The Behavioral Health and Performance topic is seeking tools and technologies to prevent performance degradation, human errors, or failures during critical operations resulting from: fatigue or work overload; deterioration of morale and motivation; interpersonal conflicts or lack of team cohesion, coordination, and communication; team and individual decision-making; performance readiness factors (fatigue, cognition, and emotional readiness); and behavioral health disorders.

For 2009, the Behavioral Health and Performance topic is interested in the following technologies: Crew autonomy assessment tools and unobtrusive behavioral health monitoring tools. Proposals may respond to one or more of these areas.

http://humanresearch.jsc.nasa.gov/elements/smo/nra.asp
http://www.nsbri.org/Research/Psycho.html

X12.01 Crew Autonomy Assessment for Exploration
Lead Center: JSC

The NASA Behavioral Health and Performance Program Element (BHP) identifies and characterizes the behavioral health and performance risks associated with training, living and working in Space, and return to Earth. BHP develops strategies, tools, and technologies to mitigate these risks. Currently, BHP has the need for behavioral health and assessment tools relevant to autonomy during Exploration Missions.

The aim of the current task is to identify the optimal level of autonomy by providing a tool that will objectively and unobtrusively measure both crew autonomy and its relevant outcomes (performance, empowerment, satisfaction, cohesion, etc.). The technologies will be able to provide data for BHP to interpret how changes in crew autonomy during a mission influence the relevant team outcomes that are measured.

Objectives:

- Determine optimal level of autonomy needed for different spaceflight missions or mission phases;
- Design and/or enhance unobtrusive tools that measure crew autonomy and its relevant team outcomes:
- Establish how autonomy levels change within and across missions;
- Interpret how these changes in autonomy influence important team outcomes.

Requirements: The Crew Autonomy Assessment shall:

- Be unobtrusive
- Require minimal crew time or effort
- Detect changes in team (ground and flight crew) autonomy and team outcomes (those that are chosen)

Phase 1 Requirements: Develop Requirements for Crew Autonomy Assessment

- An assessment of current methods through which to monitor/measure autonomy and relevant team outcomes within the DOD and other agencies will be provided;
- An assessment of current technologies that unobtrusively monitor crew autonomy and relevant team outcomes (if any) will also be conducted;
- Recommendations regarding enhancements to current technologies or the development of new technologies will be presented;
- The spaceflight environment (current and future) and models related to autonomy and its relevant team outcomes will be assessed in order to determine the optimal requirements for developing a Crew Autonomy Assessment suitable for NASA human space exploration.

Phase 2 Requirements: Crew Autonomy Assessment Prototype developed based on accurate models and Phase 1 findings.

- Develop prototype hardware;
- Develop manual and troubleshooting guide;
- Evaluate and test the functionality of the prototype device.

X12.02 Behavioral Health Monitoring Tools
Lead Center: JSC

The NASA Behavioral Health and Performance Program Element (BHP) identifies and characterizes the behavioral health and performance risks associated with training, living and working in Space, and return to Earth. BHP develops strategies, tools, and technologies to mitigate these risks. Currently, BHP has the need for behavioral health monitoring tools specific to the long duration Exploration Mission environment.

The aim of the current task is to provide requirements for a tool that will unobtrusively monitor behavioral health of the individual crew member while on a mission. The objective of this technology would be to monitor changes in behavioral health and automatically generate meaningful feedback for astronauts and flight surgeons, regarding their individual behavioral health status.

The technologies will unobtrusively monitor markers of behavioral health such as body language and voice acoustics (not including facial recognition software).

The technologies will provide meaningful feedback to the astronaut and flight surgeon regarding behavioral health status; if decrements in behavioral health are detected, the technologies should provide feedback regarding potential causes of decrements.

Requirements: The Behavioral Health Assessment Tool shall:

- Be unobtrusive and function autonomously;
- Require minimal crew time or effort to train and utilize;
- Monitor objective indications of behavioral health;
- Provide meaningful feedback to astronauts and flight surgeons regarding individual behavioral health status;
- If decrements are detected, the technologies shall provide meaningful feedback to astronauts and flight surgeons regarding potential causes of decrements and recommendations for potential countermeasures.

Phase 1 Requirements: Develop Requirements for Behavioral Health Monitoring Technology

- An assessment of current methods through which to monitor behavioral health during autonomous missions within DOD and other agencies will be provided;
- An assessment of current technologies that unobtrusively monitor behavioral health (not including facial recognition software) will also be conducted;
- Recommendations regarding enhancements to current technology or the development of a new technology will be presented;
- The spaceflight environment (current and future) and models related to behavioral health will be considered in order to develop requirements for a Behavioral Health Monitoring Technology suitable for NASA human space exploration missions.

Phase 2 Requirements: Behavioral Health Monitoring Technology Prototype developed based on accurate models and Phase 1 findings.

- Develop prototype hardware/software;
- Develop manual and troubleshooting guide;
- Evaluate and test the functionality of the prototype device.

TOPIC: X13 Space Human Factors and Food Systems

The new Vision for Space Exploration encompasses needs for innovative technologies in the areas of Space Human Factors and Food Systems. Operations in confined, isolated, and foreign environments can lead to impairments of human performance. Research and development activities in the Space Human Factors and Food Systems topic address challenges that are fundamental to design and development of the next generation crewed space vehicles. These challenges include: (1) understanding the requirements for information feedback to the crew and developing technologies to ensure these requirements are met, (2) building tasks and tools that are compatible with humans and that enable human performance consistent with mission success, and (3) providing extended shelf life foods with improved nutritional content, quality and reduced packaging mass. This Topic seeks methods for monitoring, modeling, and predicting human performance in the spaceflight environment. The Space Human Factors and Food Systems is seeking new Space Human Factors Assessment Tools and Advanced Food Technologies that utilize non-foil barriers and allow food processing or preparation in a reduced gravity and pressure environment.

http://humanresearch.jsc.nasa.gov/elements/smo/docs/shfh_evidence_report_summary.pdf
http://hefd.jsc.nasa.gov/aft.htm

X13.01 Automated Tool for Human Factors Evaluations
Lead Center: JSC
Participating Center(s): ARC

This subtopic calls for a Small Business Innovative Research project to develop an automated tool to assist non-human factors engineers to conduct human factors evaluations. Human factors evaluations are essential in gathering human performance data and analyzing the usability of new design concepts. These evaluations are generally carried out by human factors experts due to the level of expertise required. However, in some cases, it would both save time and cost if a tool is available for non-human factors engineers to carry out a standardized evaluation procedure to obtain the needed data and with comparable quality.

The tool therefore shall provide a comprehensive set of measurement methods and guide non-human factors engineer to carry out human factors evaluations. The tool development shall include defining a comprehensive set of commonly used human factors evaluation methods that allow engineers to gather relevant human factors data. Through a user-friendly interface, the tool shall recommend evaluation metrics, provide step-by-step guidance for setting up the evaluation, and summarize/store evaluation data. The ability for the tool provide interfaces for human factors data acquisition systems is highly desirable.

An algorithm for the tool is expected as the deliverable for Phase 1 and a prototype is expected should the project continue on to Phase 2.

X13.02 Situational Awareness for Multi-agent Operations
Lead Center: JSC
Participating Center(s): ARC

This subtopic calls for a Small Business Innovative Research project to develop a situation awareness and conflict resolution tool for a wide-area multi-agent operation environment with substantial time delays. Humans and robots in future Lunar or Mars surface operations would be operating both on the Lunar (Mars) surface and on Earth remotely to carry out a common task. Consequently, substantial communication delay would make tasks planning and execution difficult. The goal of this SBIR is to develop a tool so multiple agents can work harmoniously regardless of geographical locations.

The tool therefore shall overcome the hurdle of communication delays and (1) enable situation awareness by providing timely information of tasks conducted by other agents, (2) ensure that newly generated procedures mesh well with the originally scheduled activities, (3) allow operators to poll state data from all agents at any moment, and (4) provide recommendations for best task planning and procedures.

An algorithm for the tool is expected as the deliverable for Phase 1 and a prototype is expected should the project continue on to Phase 2.

X13.03 Advanced Food Technologies
Lead Center: JSC

The purpose of the Advanced Food Technology Project is to develop, evaluate and deliver food technologies for human centered spacecraft that will support crews on missions to the Moon, Mars, and beyond. Safe, nutritious, acceptable, and varied shelf-stable foods with a shelf life of 3 - 5 years will be required to support the crew during future exploration missions to the Moon or Mars. Concurrently, the food system must efficiently balance appropriate vehicle resources such as mass, volume, water, air, waste, power, and crew time. One of the objectives during the lunar outpost missions is to test technologies that can be used during the Mars missions.

It will require approximately 10,000 kg of packaged food for a 6-crew, 1000 day mission to Mars. The packaged food will require that the safety, nutrition, and acceptability are maintained at reasonable levels for the entire 5-year shelf life. Therefore, this subtopic request will concentrate on technologies that use a systems approach to provide food in remote locations with limited mass, volume, power, and waste is required.

It has been proposed to use a food system which incorporates processing of raw ingredients into edible ingredients and uses these edible ingredients in recipes in the galley to produce meals. This type of food system will require technologies that will allow these raw ingredients to maintain their functionality and nutrition for 5-years. This food system would also require food processing and food preparation equipment. The equipment should be miniaturized, multipurpose and efficiently use vehicle resources such as mass, volume, water, and power.

There are some unique parameters that need to be considered when developing the technologies. The Moon's gravity is 1/6 of Earth's gravity. In addition, it is being proposed that the habitat will have a reduced atmospheric pressure of 8 psia which is equivalent to a 16,000 foot mountain top. These two factors will affect the heat and mass transfer during food processing and food preparation of the food. In addition, there also will not be any significant refrigerator or freezer available.

The response to this subtopic should include a plan to develop a technology that will enable safe and timely food processing and food preparation in reduced cabin pressure and reduced gravity.

Phase 1 Requirements: Phase 1 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 and top-level drawings.

TOPIC: X14 Space Radiation

The goal of the NASA Space Radiation Research Program is to assure that we can safely live and work in the space radiation environment, anywhere, any time. Space radiation is different from forms of radiation encountered on Earth. Radiation in space consists of high-energy protons, heavy ions and secondary products created when the protons and heavy ions pass through spacecraft shielding and human tissue. The Space Radiation Program Element, within the Human Research Program uses the NASA Research Announcement as a primary means of soliciting research to understand the health risks and reduce the uncertainties in risk projection; however, there are areas where the SBIR program contributes. Specific areas where SBIR technologies can contribute to NASA’s overall goal include: reliable radiation monitoring for manned and unmanned spaceflight; and radiation damage imaging.

http://hacd.jsc.nasa.gov/projects/space_radiation_overview.cfm
http://spaceradiation.usra.edu/
http://www.nsbri.org/Research/Radiation.html

X14.01 Active Charged Particle and Neutron Radiation Measurement Technologies
Lead Center: ARC
Participating Center(s): JSC

For exploration class missions, there is extraordinary premium on compact and reliable active detection systems to meet very stringent size and power requirements. NASA requires compact, low power, active monitors that can measure charged particle spectrum and flux separately from neutrons and other radiations. Also, NASA requires compact active neutron spectrometers that can measure the neutron component of the dose separate from the charged particles. Advanced technologies up to technology readiness level (TRL) 4 are requested in the following areas:

Charged Particle Spectrometer
Measure charge and energy spectra of protons and other ions (Z = 2 to 26) and be sensitive to charged particles with LET of 0.2 to 1000 keV/m. For Z less than 3, the spectrometer should detect energies in the range 30 MeV/n to 400

MeV/n. For Z = 3 to 26, the spectrometer should detect energies in the range 50 MeV/n to 1 GeV/n. Design goals for mass should be 2 kg and for volume, 3000 cc. The spectrometer should be able to measure charged particles at both ambient conditions in space (0.01 mGy/hr) and during a large solar particle event (100 mGy/hr). The time resolution should be less than or equal to 1 minute. The spectrometer shall be able to perform data reduction internally and provide processed data.

Neutron Spectrometer
Measure neutron energy spectra in the range of 0.5 MeV to 150 MeV. Measure neutrons at ambient conditions such that proton/ion veto capability should be approaching 100% at solar minimum GCR rates; measure ambient dose equivalent of 0.02 mSv in a 1 hour measurement period, using ICRP 74 (1997) conversion factors; store all necessary science data for post measurement data evaluation. Design goals for mass and volume should be 5 kg and 6000 cc, respectively.

X14.02 Miniature Radiation Pulse Processing Electronics
Lead Center: ARC
Participating Center(s): JSC

For Exploration class missions, there is extraordinary premium on compact and reliable active detection systems to meet very stringent size and power requirements. Miniaturized electronics for radiation pulse processing would be important to help reduce size/power needs. Very small technologies (chips) are developed by the computer industry that may be adaptable to process radiation induced pulses from detectors to provide multi-channel analysis (MCA) and other analysis functions with very low power and size requirements. This is a need for NASA as power and size requirements are severely tightened on future missions to the Moon and beyond. Advanced technologies up to technology readiness level (TRL) 4 are requested in this area.

The miniature processor must not exceed 0.2 W of power and have a volume not to exceed 20 cc. A communication interface, such as USB or other serial interface, is required. A fast clock rate is required, not less than 100 MHz. An analog-to-digital converter, minimum sample rate of 10 M samples per second. Could be part of chip or on the same board with chip. Requires adequate pulse height measurement to perform MCA, e.g., peak hold, digital waveform processing, or other approach. MCA should cover the input pulse height range of .002 to 10 volts (or equivalent) in either 100 channels on log scale or in two linear spectra of not less than 250 channels each with different gains.

TOPIC: X15 Inflight Biological Sample Preservation and Analysis

Flight resources such as the International Space Station and the Lunar outpost are essential assets for the Human Research Program goals of quantifying the human health and performance risks for crews during exploration missions. However, the resources for carrying supplies and returning biological samples to/from these assets are limited. Thus, the Human Research Program must identify the means for inflight sample analysis or unique sample processing techniques that minimize the need to return conditioned human samples for analysis. The Inflight Biological Sample Preservation and Analysis topic is seeking innovative technologies or techniques to: provide On Orbit Ambient Biological Sample Preservation Techniques and On Orbit Biologic Sample Analysis capabilities.

X15.01 Alternative Methods for Ambient Preservation of Human Biological Samples during Spaceflight and Lunar Operations
Lead Center: JSC

Measurement of blood and urine analytes is a common clinical medicine practice used for differential disease diagnosis and determination of the therapeutic response to treatment. Accurate biochemical results depend on maintaining the integrity of blood and urine samples until analyses can be completed. Improper sample collection, handling, or preservation may lead to critical errors in diagnostic interpretation of analytical results. Traditional methods have been developed that include the use of sample component separation by means of centrifugation, refrigeration, freezing or the addition of preservatives to maintain the integrity of biological samples. While such techniques are easily achieved in a routine clinical setting, the spaceflight environment presents unique challenges to sample processing and stowage. Thus, novel on-orbit methods for the ambient preservation of biological samples are critical for scientific research, monitoring of crew health and evaluation of countermeasure efficacy. The development of alternative innovative techniques with advantages over currently used methods for processing and preserving biological samples at ambient temperatures during spaceflight that provide a high level of reliability in maintaining a wide array of both blood and urine analytes over a long period of ambient stowage is highly desirable.

9.1.3 SCIENCE

NASA's Science Mission Directorate (SMD) conducts scientific exploration that is enabled by access to space. We project humankind's vantage point into space with observatories in Earth orbit and deep space, spacecraft visiting the Moon and other planetary bodies, and robotic landers, rovers, and sample return missions. From space, in space, and about space, NASA's science vision encompasses questions as practical as hurricane formation, as enticing as the prospect of lunar resources, and as profound as the origin of the Universe.

From space we can view the Earth as a planet, seeing the interconnectedness of the oceans, atmosphere, continents, ice sheets, and life itself. At NASA we study planet Earth as a dynamic system of diverse components interacting in complex ways—a challenge on a par with any in science. We observe and track global-scale changes, and we study regional changes in their global context. We observe the role that human civilization increasingly plays as a force of change. We trace effect to cause, connect variability and forcing with response, and vastly improve national capabilities to predict climate, weather, and natural hazards. NASA research is an essential part of national and international efforts to employ Earth observations and scientific understanding in service to society.
We extend humankind's virtual presence throughout the solar system via robotic visitors to other planets and their moons, to asteroids and comets, and to icy bodies in the outer reaches known as the Kuiper Belt. We are completing our first survey of the solar system with one mission that will fly by Pluto and another that will visit two protoplanets, Ceres and Vesta. We are in the midst of a large-scale investigation of Mars, with one or more robotic missions launching every 26 months when the positions of Mars and Earth are optimal. We are directing our attention to certain moons of the giant planets where we see intriguing signs of surface dynamism and of water within, knowing that on Earth, where there is water and energy there is also life. We are progressing from observers to rovers to sample return missions, each step bringing us closer to our principal goals: to understand our origins, to learn whether life does or did exist elsewhere in the solar system, and to prepare for human expeditions to the Moon, Mars and beyond. For more information on SMD, visit http://nasascience.nasa.gov

The following topics and subtopics seek to develop technology to enable science missions in support of these strategic objectives.

TOPIC: S1 Sensors, Detectors, and Instruments

NASA's Science Mission Directorate (SMD) (http://nasascience.nasa.gov/) encompasses research in the areas of Astrophysics (http://nasascience.nasa.gov/astrophysics), Earth Science (http://nasascience.nasa.gov/earth-science), Heliophysics (http://nasascience.nasa.gov/heliophysics), and Planetary Science (http://nasascience.nasa.gov/ planetary-science). 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 2009 program year, we are actively encouraging proposal submissions for subtopic S1.10 that solicits technology for geodetic instruments and instruments to enable global navigation and very long baseline interferometry. 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 components that can be used in planned missions or a current technology program. Research should be conducted to demonstrate feasibility during Phase 1 and show a path towards a Phase 2 prototype demonstration. The following subtopics are concomitant with these objectives and are organized by technology.

S1.01 Lidar and Laser System Components
Lead Center: LaRC
Participating Center(s): GSFC

Accurate measurements of atmospheric parameters with high spatial resolution from ground, airborne, and space-based platforms require advances in the state-of-the-art lidar technology with emphasis on compactness, efficiency, reliability, lifetime, and high performance. Innovative lidar component technologies 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. Frequency-stabilized lasers for a number of lidar applications as well as for highly accurate measurements of the distance between spacecraft for gravitational wave astronomy and gravitational field planetary science are among technologies of interest. Innovative technologies that can expand current measurement capabilities to spaceborne or Unmanned Aerial Vehicle (UAV) platforms are particularly desirable. Development of components that can be used in planned missions or current technology programs is highly encouraged. Examples of planned missions and technology programs are: Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI), Laser Interferometer Space Antenna (LISA), Doppler Wind Lidar, Lidar for Surface Topography (LIST), or earth and planetary atmospheric composition (ASCENDS).

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 prototype demonstration. For the PY09 SBIR Program, we are soliciting only the specific component technologies described below.

- High speed fiber multiplexers for multimode fiber (200 micron core, 0.22 NA) operating at 1 micron wavelength. We require an N by M de-multiplexer (where M is 32 or greater and N is 2) capable of switching at speeds on the order of 10 microseconds with low insertion loss (<1 dB). Units must be small, lightweight, capable of long life, and have low power consumption. It would be desirable to have an option to have multiple input fibers, M, transmit to N simultaneously.

- Space-qualifiable high reliability frequency-stabilized CW laser source with 2 W output power at 1064 nm. A master oscillator power amplifier (MOPA) configuration is desirable since the source must be phase-modulated.
- Fiber-coupled pulse compressor device for 1064 nm and 532 nm for reducing 4-6 ns level pulses to sub-ns (0.4 - 0.6 ns) pulses, capable of input pulse energies > 2 mJ.
- Efficient and compact single frequency, near diffraction limited semiconductor lasers (interband cascade laser or quantum cascade lasers) operating in mid-infrared (3 - 4 µm). Requirements include room temperature operation, and pulsed lasers with repetition rates on the order of 10 KHz and pulse energies greater than 0.5 mJ. CW lasers in multiwatt regimes are applicable. Wavelength tunability over 10s of nanometers is desirable for certain applications.
- Efficient and compact single mode solid state or fiber lasers operating at 1.5 and 2.0 micron wavelength regimes suitable for coherent lidar applications. These lasers must meet the following general requirements: pulse energy 0.5 mJ to 50 mJ, repetition rate 10 Hz to 1 kHz, and pulse duration of approximately 200 nsec.
- Single frequency semiconductor or fiber laser generating CW power in 1.5 or 2.0 micron wavelength regions with less than 10 kHz linewidth. Frequency modulation with about 5 GHz bandwidth and wavelength tuning over several nanometers are desirable.
- Development of efficient, compact, and space qualifiable laser absorption spectrometry-related technologies for measuring atmospheric pressure and density. Remote sensing of oxygen in the 1.26 micron or 760 nm spectral region for measuring atmospheric pressure is of particular interest.
- Photon counting detectors (single element and/or multi-element detector array) at near-IR (1 - 1.8 µm) and mid-IR (3 - 4 µm) with single photon sensitivity.

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.

S1.02 Active Microwave Technologies
Lead Center: JPL
Participating Center(s): GSFC, LaRC

NASA employs active sensors (radars) for a wide range of remote sensing applications (http://www.nap.edu/catalog/11820.html). These sensors include low frequency (less than 10 MHz) sounders to G-band (160 GHz) radars for measuring precipitation and clouds and for planetary landing. We are seeking proposals for the development of innovative technologies to support future radar missions. The areas of interest for this call are listed below:

High-density low-loss millimeter-wave packaging and interconnects for advanced cloud and precipitation radars or Mars landing radars. These packing and interconnect technologies are critical to achieving the density and RF signal performance required for scanning millimeter-wave array radars. Desired performance specifications include:

- Frequency: 35 - 160 GHz
- Performance at 35 GHz:
    - Interconnect loss: <0.05 dB
    - Line loss: <0.1 dB/cm

High-speed, low-power analog-to-digital converters (ADCs) and digital-to-analog converters (DACs) for advanced SAR, advanced interferometer for surface monitoring, ice topography or hydrology. Digital beam forming (DBF) systems require an array of ADCs. The power consumption of current ADC chips prohibits implementation of large DBF arrays. Furthermore, large arrays require true time delays, which are easily implemented using low-power, high speed ADCs and DACs. Desired performance specifications include:

- Analog Input Bandwidth: 1.3 GHz
- Sampling rate: 500 MS/s

- Resolution 12 bits
- Power consumption: 100 mW

High performance miniature bandpass filters for SMAP, Aquarius follow-on, DESDynI, or Advanced L-band SAR and interferometers. The size of current filters allows for implementation of near-term missions with (with volume and mass penalties) but filter size constrains RF system architectural choices. Desired performance specifications include:

- Center Frequencies: 1.2 - 36 GHz
- Bandwidth:1%
- Loss: <1dB
- Isolation: >30 dB
- Volume: < 10mm^3

High-performance mm-wave integrated circuits (MMICs) for Advanced SAR, advanced interferometer for surface monitoring, ice topography, hydrology, advanced cloud and precipitation radars or Mars landing radars. Besides packaging, performance of MMICS is the main road block to development of electronically scanned arrays at 94 GHz and higher. Desired specifications/technologies include:

- Frequencies: 94 - 350 GHz
- Device types: Lower Noise Amplifiers, Power Amplifiers, Mixers, Oscillators, Phase Shifters, Switches

Ultra-high efficiency L-band power amplifiers for Advanced SAR/Interferometers or geosynchronous SAR for earthquake monitoring. Using lower efficiency amplifiers in large arrays leads to much higher power system requirements and thermal management challenges. Desired performance specifications include:

- Frequency: 1.2 - 1.3 GHz
- Efficiency: >85%

P-band stretch processing imaging radar antennas and transceivers with bandwidth > 100 MHz for airborne SAR applications for Biomass/ecosystems. Wideband P-band radar systems require low power transmitters with high processing gain to avoid interference with other services. Furthermore, achieving fine range resolution will require novel wideband airborne antennas.

Small radar packaging concepts for Unmanned Aerial Systems (UAS) for Biomass (P), soil moisture and ocean salinity (L, and C), or snow water equivalent (X, Ku, and Ka). Miniaturization of radar and radiometer components while maintaining power and performance is a requirement for UAV science. Desired performance specifications include:

- Mass: 1.5 lb - 35 lb
- Frequency: P-band, L-band, C-band, X-band, Ku -band, and Ka-band
- High Efficiency SSPAs: > 70% efficiency (P, L and C), > 20% (ka)

High power/high efficiency Ka-band and W-band solid state and TWT amplifiers for Aerosol/ Cloud/Ecosystems (ACE) Mission. Spaceborne applications require higher power and efficiency than currently available. Desired performance specifications include:

- SSPA power: > 10 W (Ka-band) and > 2 W (W-band)
- TWT power: > 1kW (Ka-band) and > 200 W (W-band)
- Efficiency: > 20%.
- Phase Linearity: < 0.5 degrees

Simultaneous, multi-frequency U-band transceivers, frequency converters, and amplifiers for airborne/spaceborne applications for barometric pressure measurements in support of NASA/NOAA hurricane science, NWS/aviation weather or decadal survey missions. Currently available airborne and space-qualified U-band (50 - 60 GHz) transceiver and components do not support simultaneous operation at multiple frequencies within the band.

Wide bandwidth, U-band antennas for airborne/spaceborne applications for barometric pressure measurements in support of NASA/NOAA hurricane science, NWS/aviation weather, or decadal survey missions. Currently available antennas do not compensate for wide bandwidth (50 - 60 GHz) operation; consequently, main beam characteristics (e.g., beamwidth, gain, pointing angle, polarization, etc.) vary according to frequency. The need is for a light-weight, aviation/space-qualifiable antenna capable of operating over 50 - 60 GHz without significant variation in main beam characteristics.

Membrane materials for large inflatable membrane antennas for remote sensing applications for earth and planetary science missions. Reflectors manufactured from polymer films could enable greater packaging efficiencies due to their low mass, high packaging efficiencies, solar radiation resistance, and cryogenic flexibility. However, these polymer films must also exhibit near zero CTE and stability in the space environment, as well as be deployable wrinkle free. Innovative intrinsically electroactive polymer membrane actuation mechanisms that can reduce the bulk of traditional active control systems are also of interest. Proposals for remote sensing antenna membrane materials technology are being solicited and should be submitted to subtopic “O1.02 – Antenna Technologies” in the Space Operations portion of this solicitation. Such proposals should indicate that they are applicable to remote sensing antennas.

Composite materials for large deployable antenna reflector structures for remote sensing applications for earth and planetary science missions. These antennas will require high specific stiffness composite materials that can be packed compactly and deployed multiple times for ground evaluation of the antenna structure prior to launch and deployment in space. The deployment of these materials should require low energy. Proposals for remote sensing antenna composite materials technology are being solicited and should be submitted to subtopic “O1.02 – Antenna Technologies” in the Space Operations portion of this solicitation. Such proposals should indicate that they are applicable to remote sensing antennas.

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.

S1.03 Passive Microwave Technologies
Lead Center: GSFC
Participating Center(s): JPL

NASA employs passive microwave and millimeter-wave instruments for a wide range of remote sensing applications from measurements of the Earth's surface and atmosphere (http://www.nap.edu/catalog.php?record_id=11820) to cosmic background emission. Proposals are sought for the development of innovative technology to support future science and exploration missions employing 450 MHz to 5 THz sensors. Technology innovations should either enhance measurement capabilities (e.g., improve spatial, temporal, or spectral resolution, or improve calibration accuracy) or ease implementation in spaceborne missions (e.g., reduce size, weight, or power, improve reliability, or lower cost). While other concepts will be entertained, specific technology innovations of interest are listed below for missions including decadal survey missions (http://www.nap.edu/catalog/11820.html) such as PATH, SCLP, and GACM and the Beyond Einstein Inflation Probe (Inflation Probe (cosmic microwave background, http://universe.nasa.gov/program/probes/inflation.html).

- Low power >200 Mb/s 1-bit A/D converters and cross-correlators for microwave interferometers. Earth Science Decadal survey missions which apply: PATH, SCLP.
- Automated assembly of 180 GHz direct conversion I-Q receiver modules. This technology applies to both the Beyond Einstein Inflation probe and the Decadal Survey PATH concept.

- Low DC power spectrometer (channelizer) covering >500 MHz with 125 kHz resolution for planetary radiometer missions and covering 4 GHz with 1 MHz resolution for Earth observing missions. Also RFI mitigation approaches employing channelizers for broad band radiometers. Earth Science Decadal Survey mission which applies: GACM
- RF (GHz to THz) MEMS switches with low insertion loss (< 0.5 dB), high isolation (>18 dB), capable of switching with speeds of >100 Hz at cryogenic temperatures (below 10 K) for 10^8 or more cycles. Technology applies to Beyond Einstein Probe.
- High emissivity (>40 dB return loss) surfaces/structures for use as onboard calibration targets that will reduce the weight of aluminum core targets, while reliably improving the uniformity and knowledge of the calibration target temperature. Earth Science Decadal survey missions which apply: SCLP and PATH.
- MMIC Low Noise Amplifiers (LNA). Room temperature LNAs for 165 to 193 GHz with low 1/f noise, and a noise figure of 6.0 dB or better; and cryogenic LNAs for 180 to 270 GHz with noise temperatures of less than 150K. Earth Science Decadal Survey missions that apply: PATH and GACM.
- Low loss, low RF power waveguide SPDT diode switches and active noise sources for frequencies above 90 GHz to support calibration of SWOT and other atmospheric temperature and humidity measurements.
- Broad band 180 - 270 GHz radomes for aircraft borne submillimeter remote sensing instruments.

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.

S1.04 Sensor and Detector Technology for Visible, IR, Far IR and Submillimeter
Lead Center: JPL
Participating Center(s): ARC, GSFC, LaRC

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 specific technologies are of interest for instrument concepts such as Scanning Microwave Limb Sounder (http://mls.jpl.nasa.gov/index-cameo.php) on the Global Atmospheric Composition Mission, Climate Absolute Radiance and Refractivity Observatory (http://science.hq.nasa.gov/earth-sun/docs/Volz4_CLARREO.pdf), Methane Trace Gas Sounder, Single Aperture Far Infrared (SAFIR) Observatory (http://safir.jpl.nasa.gov/technologies.shtml), and Inflation Probe (cosmic microwave background, http://universe.nasa.gov/program/probes/inflation.html):

- New or improved technologies leading to measurement of trace atmospheric species (e.g., CO, CH_4, N_2O) from geostationary and low-Earth orbital platforms. Of particular interest are new techniques in gas filter correlation spectroscopy, Fabry-Perot spectroscopy, or improved component technologies.
- Uncooled or passively cooled detectors with specific detectivity (D*) >= 1010 cm Hz1/2/W in the operating wavelength ranges 6-14 µm and 10-100 µm.
- Efficient, flight qualifiable, spur free, local oscillators for SIS mixers operating in low earth orbit. Two bands: (1) tunable from 200 to 250 GHz, and (2) tunable from 600 to 660 GHz, phase-locked to or derived from an ultra-stable 5 MHz reference.
- Sideband separating SIS mixer with RF band from 580 to 680 GHz, IF band from 6 to 18 GHz, image rejection greater than 10 dB, and receiver noise temperature less than 300 Kelvin. Thermal load on 4 K and 15 K stage must be less than 4 and 30 mW respectively. Application: GACM.
- Quantum cascade laser-based local oscillators for astrophysics applications (2nd generation SOFIA instruments, SAFIR).
- Technologies for calibrating millimeter wave spectrometers for spaceborne missions, including low power, flight qualifiable comb generators and low noise diodes for the bands from 180 to 270 and 600 to 660 GHz;

very low return loss (70 dB or better) calibration targets and techniques for quantifying and calibrating out the impact of standing waves in broadband heterodyne submillimeter spectrometers.
- Low power, stable, linear, spectrometers capable of measuring the band from 6-18 GHz with ~120 100 MHz wide channels.
- Digital spectrometers with ~4 GHz bandwidth and 10 MHz resolution. Components for these digital spectrometers including high speed digitizers, efficient spectrometer firmware, and ASIC implementations.
- Spatial Filter Array (SFA) consisting of a monolithic array of up to 1200 coherent, polarization preserving, single mode fibers that operate over a large fraction of the spectral range from 0.4 - 1.0 microns and such that each input and output lenslet is mapped to a single fiber. Uniformity of output intensity and high throughput is desired and fiber-to-fiber placement accuracies of < 2.0 microns are required with < 1.0 microns desired. Applications include active and passive wavefront and amplitude control, and relevant missions include Terrestial Planet Finder (http://planetquest.jpl.nasa.gov/TPF/tpf_index.cfm) and Stellar Imager (http://hires.gsfc.nasa.gov/si/).
- High resolution wedged filters with resolving powers of 1,000 to 5,000 in the visible to short wave infrared spectral region. Of particular interest are filters in the 1 to 3.5 micron range.

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.

S1.05 Detector Technologies for UV, X-Ray, Gamma-Ray and Cosmic-Ray Instruments
Lead Center: GSFC
Participating Center(s): JPL, MSFC

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 Decadel 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:
EXIST: http://exist.gsfc.nasa.gov/
IXO: http://htxs.gsfc.nasa.gov/index.html
Future planetary programs: http://nasascience.nasa.gov/planetary-science/mission_list
Earth Science Decadel 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, individual detectors, and detector arrays for operation at room temperature or higher for missions such as EXIST, Geo-CAPE 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 Council Decadal Survey (NRC, 2007): Future Missions include EXIST, GEOCape, HyspIRI, GACM, future GOES and SOHO programs and planetary science composition measurements.

- Large formal UV and X-ray focal plane detector arrays: microchannel plates, CCDs, and active pixel sensors (>50% QE, 100 Megapixels, <0.1 W/Megapixel, 30 Hz). Improved microchannel plate detectors, including improvements to the plates themselves (smaller pores, greater lifetimes, 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 missions such as International X-ray Observatory, Advanced Technology Large Aperture Space Telescope (ATLAST) and Black Hole Imager.
- 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 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 Council Decadal Survey (NRC, 2007): Future missions include GEOCape, HyspIRI, 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 GOES missions post-GOES R and T.
- Visible-blind SiC 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 at near 135nm spectral wavelength. See needs of National Council Decadal Survey (NRC, 2007): Tropospheric ozone.
- Imaging from low-Earth orbit of air fluorescence, UV light generated by giant airshowers by ultra-high energy (E >1019 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 x 2 mm2 to 10 x 10 mm^2. Focal plane mass must be minimized (2 g/cm^2 goal). Individual pixel readout. The entire focal plane detector can be formed from smaller, individual sub-arrays.

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.

S1.06 Particles and Field Sensors and Instrument Enabling Technologies
Lead Center: GSFC
Participating Center(s): ARC, JPL, MSFC

Advanced sensors and instrument enabling technologies for the measurement of the physical properties of space plasmas and energetic charged particles, mesospheric – thermospheric neutral species, energetic neutral atoms created at high altitudes by charge exchange, and electric and magnetic fields in space are needed to achieve NASA's transformational science advancements in Heliophysics. The Heliophysics discipline (http://sec.gsfc.nasa.gov/) has as its primary strategic goal the understanding of the physical coupling between the sun's outer corona, the solar wind, the trapped radiation in Earth's and other planetary magnetic fields, and the upper atmospheres of the planets and their moons. This understanding is of national importance not only because of its intrinsic scientific worth, but also because it is the necessary first step toward developing the ability to measure and forecast the "space weather" that affects all human crewed and robotic space assets. Improvements in particles and fields sensors and associated instrument technologies will enable further scientific advancement for upcoming NASA missions such as Solar Probe (http://solarprobe.gsfc.nasa.gov/), Solar Sentinels (http://lws.gsfc.nasa.gov/

missions/sentinels/sentinels.htm), GEC (http://stp.gsfc.nasa.gov/missions/gec/gec.htm), Magnetospheric Constellation (http://stp.gsfc.nasa.gov/missions/mc/mc.htm), IT-SP and planetary exploration missions. Technology developments that result in expanded measurement capabilities and a reduction in size, mass, power, and cost are necessary in order for some of these missions to proceed. Of special interest are fast high voltage stepping power supplies for charged particle analyzers, electric field booms, self calibrating vector magnetometers, and other supporting sensor electronics.

Specific areas of interest include:

- Low cost, low power, low current, high voltage power supplies which allow ultra-fast stepping (t < 100-µs) over the full voltage range (0 < V < 5-15 kV).
- Strong, lightweight, thin, compactly-stowed electric field booms possibly using composite materials that deploy sensors to distances of 10m or more and/or long wire boom (> 50 m) deployment systems for the deployment of very lightweight tethers or antennae on spinning spacecraft.
- Self-calibrating scalar-vector magnetometer for future Earth and space science missions. Performance goals are dynamic range: +/-100,000 nT, accuracy with self-calibration: 1 nT, sensitivity: 5 pT / sqrtHz,Max, max sensor unit size: 6 x 6 x 12 cm, max sensor mass: 0.6 kg, max electronics unit size: 8 x 13 x 5 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".
- Low-power cathode for detection of neutral atoms and molecules ionosphere-thermosphere and planetary investigations. Performance goals are thermionic cathodes capable of emitting 1 mA electron current with heater power less than 0.1 W. The largest dimension of the electron emitter surface should not exceed 1 mm; the entire cathode assembly should be small enough so it may be mounted in a shallow channel shaped to match the largest cathode dimension. The assembly should include robust connection leads for heater and cathode surface. Uniformity across the electron beam is not critical.
- A compact electronics box to enable the operation of one Wind Temperature Spectrometer (WTS), one Ion-Drift Spectrometer (IDS), one Neutral Mass Spectrometer (NMS) and one Ion Mass Spectrometer (IMS), all based on the new generation charged-particle spectrometer SDEA. The electronics should be housed in a volume with dimensions not exceeding 3.2x3.2x3.2 inches with power requirement not exceeding 1.1 W. The EB must provide: (a) electronics for MCP detector pulse handling, (b) minimum of 64 detector pulse channels for WTS and IDS, (c) 2 channels devoted to TOF pulse processing with 2 ns time resolution or faster for NMS and IMS, (d) two ion source power supplies (1V/0.1A cathode supply floating at -100VDC) for WTS and NMS, (e) two energy scan supplies (0 to 5 V) for WTS and IMS, (f) two rectangular-wave supplies (0 to 1 V with 1 microsec rise time) for NMS and IMS, (g) ion accelerator optics voltage supplies (3 outputs @ 200 VDC max) for NMS and IMS, (h) MCP voltage supply (one lead/2700VDC max @ 50 microAmp max), and (i) micro-controller with buffer memory and telemetry link.

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.

S1.07 Cryogenic Systems for Sensors and Detectors
Lead Center: GSFC
Participating Center(s): ARC, JPL, MSFC

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 IXO (http://ixo.gsfc.nasa.gov/), Safir (http://safir.jpl.nasa.gov/), Spirit, Specs (http://geons.gsfc.nasa.gov/live/Home/SPECS.html) 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 50 K. Present state of the art capabilities display < 100 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/Power Cooling Systems
Cooling systems providing cooling capacities approximately 0.3W at 35 K with heat rejection capability to temperature sinks upwards of 150 K are of interest. Presently there are no cooling systems operating at this heat rejection temperature. Input powers should be limited to no greater than 10W. Study of passive cooler in tandem with low power, low mass cryocooler satisfying the above mentioned requirements is also of interest.

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.

S1.08 In Situ Airborne, Surface, and Submersible Instruments for Earth Science
Lead Center: GSFC
Participating Center(s): ARC, JPL, LaRC, MSFC, SSC

New, innovative, high risk/high payoff approaches to miniaturized and low cost instrument systems are needed to enhance Earth science research capabilities. Sensor systems for a variety of platforms are desired, including those designed for remotely operated robotic aircraft, surface craft, submersible vehicles, and balloon-based systems (tethered or free). Global deployment of numerous sensors is an important objective, therefore cost and platform adaptability are key factors.

Novel methods to minimize the operational labor requirements and improve reliability are desired. Long endurance (days/weeks/months) autonomous/unattended instruments with self/remote diagnostics, self/remote maintenance, capable of maintaining calibration for long periods, and remote control are important. Use of data systems that collect geospatial, inertial, temporal information, and synchronize multiple sensor platforms are also of interest.

Priorities include:

- Atmospheric measurements in the troposphere and lower stratosphere: Aerosols, Cloud Particles, Water, and chemical composition: Carbon Dioxide ($12CO_2$ and $13CO_2$), Carbon Monoxide, Methane, Reactive and Trace Gases, Radicals, Ozone, Three-dimensional Winds and Turbulence.
- Oceanic, coastal, and fresh water measurements including inherent and apparent optical properties, temperature, salinity, currents, chemical and particle composition, sediment, and biological components such as phytoplankton, harmful algal blooms, fish or aquatic plants.
- Instrument systems for hazardous environments such as volcanoes and severe storms.
- Instrument systems for difficult to access areas such as sub-glacial waters.

Instrument systems to support field studies of fundamental processes are of interest, as well as for satellite measurement calibration and validation. Applicability to NASA's Airborne Science, Atmospheric Composition and Radiation Sciences, Ocean Biology and Biogeochemistry, and Applied Sciences programs is a priority. Support of the Integrated Ocean Observing System (IOOS) and regional coastal research is also desired.

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.

S1.09 In Situ Sensors and Sensor Systems for Planetary Science
Lead Center: JPL
Participating Center(s): ARC, GSFC, JSC, LaRC, MSFC

This subtopic solicits development of advanced instruments and instrument components that are tailored to the demands of planetary instrument deployment on a variety of space platforms (orbiters, flyby spacecraft, landers, rovers, balloon or other aerial vehicles, subsurface penetrators or impactors, etc.) accessing the wide variety of bodies in our solar system (inner and outer planets and their moons, comets, asteroids, etc.). These instruments must be capable of withstanding operation in space and planetary environmental extremes, which include temperature, pressure, radiation, and impact stresses. For example missions see:
http://science.hq.nasa.gov/missions/solar_system.html

Specifically, this subtopic solicits instrument development that provides significant advances in the following areas:

- Improved science return and/or reduced mass, power, volume, data rates for instruments or instrument components (e.g., lasers and other light sources from UV to microwave, X-ray and ion sources, detectors, mixers, seismometers, etc.) or electronics (e.g., FPGA and ASIC implementations, advanced array readouts);
- Instrument technologies for detecting inorganic and organic biomarkers on future Mars missions;
- Improved robustness and g-force survivability for rough landings on planetary bodies;
- Radiation mitigation strategies, radiation tolerant detectors, and readout electronics components for candidate instruments for the Europa-Jupiter System Mission;
- Advanced sample acquisition and processing technologies, including fluid and gas storage, pumping, and manipulation, to support analytical instrumentation, sample return, or planetary protection.
- Sensors, mechanisms, and environmental chamber technologies for operation in Venus's high temperature, high pressure environment with its unique atmospheric composition. Venus test chambers that can support evaluation of 50 to 100 cm sensors, instruments, and related structures are particularly requested.

Proposers are strongly encouraged to relate their proposed development to (a) future planetary exploration goals of NASA; and (b) existing flight instrument capability to provide a comparison metric for assessing proposed improvements. Proposed instrument architectures should be as simple, robust, and reliable as possible while enabling compelling science.

Proposals should show an understanding of one or more relevant space science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S1.10 Space Geodetic Observatory Components
Lead Center: GSFC
Participating Center(s): JPL

NASA is working with the international community to develop the next generation of geodetic instruments and networks to determine the terrestrial reference frame with accuracy better than one part per billion. These instruments include Global Navigation Satellite System (GNSS) receivers, Very Long Baseline Interferometry (VLBI) systems, and Next Generation Satellite Laser Ranging (SLR) stations. The development of these instruments and the needed integrating technology will require contributions from a broad variety of optical, microwave, antenna and survey engineering suppliers. These needs include but are not limited to:

- Broadband feeds capable of receiving GNSS signals, Ka-band feeds integrated with broadband feeds, and matching antennas that meet or exceed the slewing and duty cycle requirements of the IVS VLBI2010 specifications.
- VLBI system components including > 4 Gbps recorders, phase/cable calibrators, and frequency standards / distribution systems that meet or exceed the requirements of the IVS VLBI2010 specifications.
- Cost-effective data transmission for e-VLBI from a global network of 30 VLBI stations operating up to 8 Gbps.
- Compact, low mass, space-qualified for MEO, SLR retroreflector arrays with greater than 100 million square meter lidar cross section, with a design that assures the ability to determine the array center to the center of mass of the spacecraft to a millimeter.
- A very high quantum efficiency (>50% at 532nm), low instrument noise, multi-pixilated detector for SLR use in the automated tracking.
- Wide band GNSS antenna and RF front-end technologies accommodating all expected GNSS signals in the next decade, and offering at least an order of magnitude improvements over COTS devices in terms of multipath rejection, and stability of output relative to temperature.
- Continuous, reliable co-location monitoring and control system for the relative 3-D displacement of geodetic instruments within a geodetic observatory to better than 1 mm.

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.

S1.11 Lunar Science Instruments and Technology
Lead Center: MSFC
Participating Center(s): ARC, GSFC, JPL, JSC

NASA lunar robotic science missions support the high-priority goals identified in the 2007 National Research Council report, The Scientific Context for Exploration of the Moon: Final Report (http://www.nap.edu/catalog.php?record_id=11954). Future missions will characterize the lunar exosphere and surface environment; field test new equipment, technologies, and approaches for performing lunar science; identify landing sites and emplace infrastructure to support robotic and human exploration; demonstrate and validate heritage systems for exploration missions; and provide operational experience in the harsh lunar environment.

Space-qualified instruments are required to perform remote and in situ lunar science investigations, to include measurements of lunar dust composition, reactivity and transport, searching for water ice, assessing the radiation environment, gathering long period measurements of the lunar exosphere, and conducting surface and subsurface geophysical measurements.

In support of these requirements, this subtopic seeks advancements in the following areas:

Geophysical Measurements
Systems, subsystems, and components 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 compared to the Apollo Lunar Surface Experiments Package (ALSEP) instruments (http://www.hq.nasa.gov/alsj/frame.html). Instrument deployment options include robotic deployment from soft Landers, as well as emplacement by hard landers or penetrators. Also of interest are portable surface ground penetrating radars with antenna frequencies of 250-MHz, 500-MHz, and 1000-MHz to characterize the thickness of the lunar regolith. Also of interest are accurate, low mass, thermally stable hollow cubes and retroreflector array assemblies for lunar surface laser ranging.

In Situ Lunar Surface Measurements
Light-weight and power efficient instruments that enable elemental and/or mineralogy analysis using techniques 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 (TDL) sensors for in situ isotopic and elemental analysis of evolved volatiles, calorimetry, and Laser Induced Breakdown Spectroscopy (LIBS). Instruments shall have the potential to provide isotope ratio measurements and/or hydrogen distributions to ±10 ppm locally. Characterizing the meteoroid and subsequent eject flux environment and measurements of surface and deep dielectric charging on the lunar surface should be considered. Also, self calibrating instruments to measure surface and deep dielectric charging on a variety of materials encompassing conductors, semi-conductors, and insulators are another area. Instrument deployment options include robotic deployment from soft Landers, as well as emplacement by hard Landers or penetrators.

Lunar Atmosphere and Dust Environment Measurements
Low-mass and low-power instruments that measure the local lunar surface environment which includes but is not limited to the characterization of: the plasma environment, surface electric field, and dust concentrations and its diurnal dynamics. Instrument deployment options include robotic deployment from soft Landers, as well as emplacement by hard Landers or penetrators.

Lunar Regolith Particle Analysis
A substantial portion of the particles in the Lunar Regolith are smaller than the integration volume of e-beam analytical equipment, making automated quantitative analysis extremely difficult using available approaches. Therefore, software development is sought 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 cathode luminescence and EDS X-ray. The said software would then use standard image processing tools to resample to common scales, perform appropriate discriminant analysis using the high resolution data, mixed pixel inversion, image segmentation to extract particles, and correlate chemistry with products of the discriminant analysis.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration, and when possible, deliver a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

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: 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 a 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 telescope for Earth science that have the potential to cost between $50 to $150M.

S2.01 Precision Spacecraft Formations for Telescope Systems
Lead Center: JPL
Participating Center(s): GSFC

This subtopic seeks hardware and software technologies necessary to establish, maintain, and operate precision spacecraft formations to a level that enables cost effective large aperture and separated spacecraft optical telescopes and interferometers (e.g., http://constellation.gsfc.nasa.gov/, http://lisa.gsfc.nasa.gov/). Also sought are technologies (analysis, algorithms, and testbeds) to enable detailed analysis, synthesis, modeling, and visualization of such distributed systems.

Formation flight can synthesize large effective telescope apertures through, multiple, collaborative, smaller telescopes in a precision formation. Large effective apertures can also be achieved by tiling curved segments to form an aperture larger than can be achieved in a single launch, for deep-space high resolution imaging of faint astrophysical sources. These formations require the capability for autonomous precision alignment and synchronized maneuvers, reconfigurations, and collision avoidance. The spacecraft also require onboard capability for optimal path planning and time optimal maneuver design and execution.

Innovations are solicited for: (a) sensor systems for inertial alignment of multiple vehicles with separations of 10,000 - 100,000 km to accuracy of 1 - 50 milli-arcseconds; (b) development of nanometer to sub-nanometer metrology for measuring inter-spacecraft range and/or bearing for space telescopes and interferometers; (c) control approaches to maintain line-of-sight between two vehicles in inertial space near Sun-Earth L2 to milli-arcsecond levels accuracy; (d) development of combined cm-to-nanometer-level precision formation flying control of numerous spacecraft and their optics to enable large baseline, sparse aperture UV/optical and X-ray telescopes and interferometers for ultra-high angular resolution imagery. Proposals addressing staged-control experiments which combine coarse formation control with fine-level wavefront sensing based control are encouraged.

Innovations are also solicited for distributed spacecraft systems in the following areas:

- Distributed, multi-timing, high fidelity simulations;
- Formation modeling techniques;
- Precision guidance and control architectures and design methodologies;
- Centralized and decentralized formation estimation;
- Distributed sensor fusion;
- RF and optical precision metrology systems;
- Formation sensors;
- Precision microthrusters/actuators;
- Autonomous reconfigurable formation techniques;
- Optimal, synchronized, maneuver design methodologies;
- Collision avoidance mechanisms;
- Formation management and station keeping.

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 Proximity Glare Suppression for Astronomical Coronagraphy
Lead Center: JPL
Participating Center(s): ARC, GSFC

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 and innovative advanced wavefront sensing and control for cost-effective space telescopes. 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 infrared wavelengths. The ultimate application of these instruments is to operate in space as part of a future observatory mission. Much of the scientific instrumentation used in future NASA observatories for the astrophysical sciences will require control of unwanted radiation (thermal and scattered) across a modest field of view. The performance and observing efficiency of astrophysics instruments, however, must be greatly enhanced. The instrument components are expected to offer much higher optical throughput, larger fields of view, and better detector performance. The wavelengths of primary interest extend from the visible to the thermal infrared. 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 starlight canceling coronagraphic instrument concepts;
- Advanced aperture apodization and aperture shaping techniques;
- Pupil plane masks for interferometry;
- Advanced apodization mask or occulting spot fabrication technology controlling smooth density gradients to 10^{-4} with spatial resolutions ~1 µm, low dispersion, and low dependence of phase on optical density;
- 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 in homogeneity, 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;
- Single mode fiber filtering from visible to 20 µm wavelength;
- Methods of polarization control and polarization apodization; and
- Components and methods to insure amplitude uniformity in both coronagraphs and interferometers, specifically materials, processes, and metrology to insure coating uniformity.

Wavefront Control Technologies

- Development of small stroke, high precision, deformable mirrors and associated driving electronics scalable to 10^4 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; and
- Highly reflecting broadband coatings.

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.

S2.03 Precision Deployable Optical Structures and Metrology
Lead Center: JPL
Participating Center(s): GSFC, LaRC

Planned future NASA Missions in astrophysics, such as the Single Aperture Far-IR (SAFIR) telescope, Terrestrial Planet Finder (TPF, http://planetquest.jpl.nasa.gov/TPF/tpf_index.cfm) missions: Coronagraph, External Occulter and Interferometer, ATLAST, Life Finder, and Submillimeter Probe of the Evolution of Cosmic Structure (SPECS), and the UV Optical Imager (UVOIR) 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. The desired areal density is 1 - 10 kg/m^2. 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 L2.

This topic solicits proposals to develop enabling, cost effective component and subsystem technology for these telescopes. Research areas of particular interest include precision deployable structures and metrology (i.e., innovative active or passive deployable primary or secondary support structures); innovative concepts for packaging fully integrated (i.e., including power distribution, sensing, and control components); distributed and localized actuation systems; deployment packaging and mechanisms; active opto-mechanical control distributed on or within the structure; actuator systems for alignment of reflector panels (order of cm stroke actuators, lightweight, nanometer stability); innovative architectures, materials, packaging and deployment of large sunshields and external occulters; mechanical, inflatable, or other deployable technologies; new thermally-stable materials (CTE < 1ppm) for deployables; innovative ground testing and verification methodologies; and new approaches for achieving packagable depth in primary mirror support structures.

Also of interest are innovative metrology systems for direct measurement of the optical elements or their supporting structure; requirements for micron level absolute and subnanometer relative metrology for multiple locations on the primary mirror; measurement of the metering truss; and innovative systems which minimize complexity, mass, power and cost. The goal for this effort is to mature technologies that can be used to fabricate 20 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. A successful proposal shows a path toward a Phase 2 delivery of demonstration hardware scalable to 3 m for characterization.

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.

S2.04 Advanced Optical Component Systems
Lead Center: MSFC
Participating Center(s): GSFC, JPL

Future launch systems (such as the planned Ares V) will enable extremely large and/or extremely massive 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-16 and ST-2020) 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 IXO and GenX) require 1 to 2 meter long grazing incidence segments with angular resolution < 5 arc-sec down to 0.1 arc-sec and surface micro-roughness < 0.5 nm rms. Additionally, missions such as EUSO and OWL need 2 to 9 meter diameter UV-transparent refractive, double-sided Fresnel or diffractive lens.

In view of the very large total mirror or lens collecting aperture required, affordability or areal cost (cost per square meter of collecting aperture) rather than areal density is probably the single most important system characteristic of an advanced optical system. For example, both x-ray and normal incidence space mirrors currently cost $3 million to $4 million per square meter of optical surface area. This research effort seeks a cost reduction for precision optical components by 20 to 100 times, to less than $\$100K/m^2$.

The primary purpose of this subtopic is to develop and demonstrate technologies to manufacture ultra-low-cost precision optical systems for very large x-ray, UV/optical or infrared telescopes. Potential solutions include but are not limited to direct precision machining, rapid optical fabrication, slumping or replication technologies to manufacture 1 to 2 meter (or larger) precision quality mirror or lens segments (either normal incidence for UV/optical/infrared or grazing incidence for x-ray).

An additional key enabling technology for UV/optical telescopes is a broadband (from 100 nm to 2500 nm) high-reflectivity mirror coating with extremely uniform amplitude and polarization properties which can be deposited on 1 to 3 meter class mirror.

Successful proposals will demonstrate prototype manufacturing of a precision mirror or lens system or precision replicating mandrel in the 0.25 to 0.5 meter class with a specific scale up roadmap to 1 to 2+ meter class space qualifiable flight optics systems. Material behavior, process control, optical performance, and mounting/deploying issues should be resolved and demonstrated. The potential for scale-up will need to be addressed from a processing and infrastructure point of view.

An ideal Phase 1 deliverable would be a near UV, visible or x-ray precision mirror, lens or replicating mandrel of at least 0.25 meters. The Phase 2 project would further advance the technology to produce a space-qualifiable precision mirror, lens or mandrel 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 2 would also include a mechanical and thermal stability analysis.

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.

S2.05 Optics Manufacturing and Metrology for Telescope Optical Surfaces
Lead Center: GSFC
Participating Center(s): JPL, MSFC

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:

JDEM concepts: http://universe.nasa.gov/program/probes/jdem.html,
IXO: http://ixo.gsfc.nasa.gov/,
LISA: http://lisa.gsfc.nasa.gov/,
ICESAT: http://icesat.gsfc.nasa.gov/, CLARREO, and ACE.

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.

Of particular interest is the area of x-ray optics metrology, including the evaluation of the optical quality of x-ray mirrors and substrates; the general characterization of x-ray mirrors; and the development of new metrology measurement techniques and instrumentation for x-ray mirrors.

By the end of a Phase 2 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:

- Interferometric nulling optics for very shallow conical optics used in x-ray telescopes.
- Segmented systems commonly span 60 degrees in azimuth and 200 mm axial length and cone angles vary from 0.1 to 1 degree.
- 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 (PIAA).

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 beyond. SMD's future direction will be moving from exploratory missions (orbiters and flybys) into more detailed/specific exploration missions that are at or near the surface of where we want to explore (landers, rovers, and sample returns), that would require new vantage points, or that would need to integrate or distribute capabilities across multiple assets. Future destinations will be more challenging to get to, have more extreme environmental conditions and challenges once you get there, and may be a challenge to get a spacecraft or data back from. A major objective of the NASA science spacecraft systems development programs is 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 subsystem capabilities while reducing the mass and cost, that would in turn enable increased scientific return for future NASA missions. Innovations are sought in the areas of: Command, Data Handling, and Electronics; Thermal Control Systems; Power Generation and Conversion; Propulsion Systems; Power Management and Storage; Guidance, Navigation and Control; Sensor and Platform Data Processing & Control; Planetary Ascent Vehicles; Unmanned Aerial Vehicles and Terrestrial Balloons.

S3.01 Command, Data Handling, and Electronics
Lead Center: GSFC
Participating Center(s): ARC, JPL, JSC, LaRC

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 guidance, navigation, command and data handling are sought to support NASA's goals and several missions and projects under development.

http://nasascience.nasa.gov/search?SearchableText=missions+under+development
http://www.nap.edu/catalog.php?record_id=10432

The subtopic goals are to: (1) develop high-performance processors and memory architectures and reliable electronic systems, and (2) develop an avionics architecture that is flexible, scalable, extensible, adaptable, and reusable. 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.

Successful proposal concepts should significantly advance the state-of-the-art. Proposals should clearly (1) state what the product is; (2) describe how it targets the technical priorities listed below; and (3) outline the feasibility of the technical and programmatic approach. If a Phase 2 proposal is awarded, the combined Phase 1 and Phase 2 developments should produce a prototype that can be characterized by NASA. The technology priorities sought are listed below.

Command and Data Handling

- Processors - General purpose (processor chips and radiation-hardened by design synthesizable IP cores) and special purpose single-chip components (DSPs) with sustainable processing performance and power efficiency (>500 MIPS at >100 MIPS/W for general purpose processing platforms, >5 GMACs at >5 GMACS/W for computationally-intensive processing platforms), and tolerance to total dose and single-event radiation effects. Concepts must include tools required to support an integrated hardware/software development flow.
- Radiation-hardened non-volatile low power memories.
- Radiation-hardened physical layer components for onboard data busses (e.g. Ethernet).
- Tunable, scalable, reconfigurable, adaptive fault-tolerant avionics.

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.

The Small Spacecraft Build effort highlighted in Topic S4 (Low-cost Small Spacecraft and Technologies) of the solicitation participates in this subtopic. Offerors are encouraged to take this in consideration as a possible flight opportunity when proposing work to this subtopic.

S3.02 Thermal Control Systems
Lead Center: GSFC
Participating Center(s): ARC, GRC, JPL, MSFC

Future Spacecraft and instruments for NASA's Science Mission Directorate will require increasingly sophisticated thermal control technology. Some of these requirements include:

(1) Optical systems, lasers and detectors require tight temperature control, often to better than +/- 1°C. Some new missions such as LISA require thermal gradients held to even tighter micro-degree levels.
(2) Exploration science missions beyond earth orbit present engineering challenges requiring systems which are more self-sufficient and reliable.
(3) The introduction of low-cost, small, rapidly configured spacecraft requires the development of new thermal technologies to reduce the time and costs typically required for analysis, design, integration, and testing of the spacecraft.

Innovative proposals for the cross-cutting thermal control discipline are sought in the following areas:

- Methods of precise temperature measurement and control to tight temperature levels.
- High conductivity, vacuum-compatible interface materials to minimize losses across make/break interfaces.
- High conductivity materials to minimize temperature gradients and provide high efficiency light-weight radiators, including interfaces to heat pipes and fluid loops that overcomes issues with CTE mismatch.
- Advanced more efficient thermoelectric coolers capable of providing cooling at ambient and cryogenic temperatures,
- Advanced thermal control coatings, particularly those with low absorptance, high emmittance, and good electrical conductivity. Also, variable emittance surfaces to modulate heat rejection are needed.
- Single and two-phase mechanically pumped fluid loop systems which accommodate multiple heat sources and sinks, and long life, lightweight pumps for these systems. Also includes advanced fluid system components such as accumulators, valves, pumps, flow rate sensors, etc. optimized for improved reliability, long life, and low resource needs.
- Phase change systems for Mars or Lunar applications. Reusable phase change systems are desired which can be employed to absorb transient heat dissipations during instrument operations. Technology is sought for phase change systems which can then either store this energy or provide an exothermic process which would provide heat for instrument power-on after the dormant phase.
- Ionic liquids, salts composed of separate cations and anions, have been known but not intensely studied. Because of their tunable and thus extremely favorable solvent and materials properties, ionic liquids are potentially useful for a wide range of space applications, e.g. liquid-mirror telescopes and heat transfer of fluids that could enhance lunar regolith geothermal potential many-fold.
- Efficient, lightweight, oil-less, high lift vapor compression systems or novel new technologies for high performance cooling up to 2 KW.
- Advanced thermal modeling techniques that can be easily integrated into existing codes, emphasizing inclusion of two-phase systems and mechanically pumped system models.
- Integration of standardized formats into existing analytical codes for the representation and exchange of thermal network models and thermal geometric models and results.
- Analytical codes to automate the generation of reduced thermal models from larger models, including routines to verify the accuracy of the reduced models.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration. Phase 2 should deliver a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

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.

S3.03 Power Generation and Conversion
Lead Center: GRC
Participating Center(s): GSFC, JPL, JSC, MSFC

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
Improvements are solicited in component and systems technology relevant to Sterling and thermophotovoltaic power conversion. For Stirling conversion, advances sought, but not limited to, include:

- Novel methods or approaches for radiation-tolerant, sensorless, autonomous control of Stirling converters with very low vibration and having low mass, size, and electromagnetic interference (EMI);
- High-temperature, high-performance regenerators and linear alternators;
- Advances applicable to Venus surface missions including high-temperature heater heads (> 850°C), joining techniques and regenerators (~1200°C), and combined electrical power generation and cooling systems applicable to Venus surface missions (~1200°C);
- Concepts for Stirling engine power from cold energy lunar regolith down to 2-3 meters below the surface, including Stirling Engines that will provide up to 100 watts with a mass less than 50kg for the surface lunar environment with the hot side operating at about 256 K and a cold side at about 100 degrees lower.

Thermophotovoltaic conversion is currently focused on follow-on technology for the International Lunar Network (ILN) and for the outer planets mission. Advances sought, but not limited to, include:

- Low-bandgap cells having high efficiency and high reliability;
- High temperature selective emitters;
- Low absorptance optical band-pass filters;
- Efficient multi-foil insulation.

Photovoltaic Energy Conversion
Photovoltaic cell, blanket, and array technologies that lead to significant improvements in overall solar array performance (i.e. conversion efficiency >30%, 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 150 volts and have a low stowed volume.

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.

S3.04 Propulsion Systems
Lead Center: GRC
Participating Center(s): JPL

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://www.nap.edu/catalog.php?record_id=10432). 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.

The focus of this solicitation is for next generation propulsion systems and components, including high-pressure chemical rocket technologies and low cost/low mass electric propulsion technologies. Specific sample return propulsion technologies of interest include higher pressure chemical propulsion system components, lightweight propulsion components, and Earth-return vehicle propulsion systems. Propulsion technologies related specifically to planetary ascent vehicles will be sought under S3.08 Planetary Ascent Vehicle.

Chemical systems for sample return missions should focus on component technologies for high-pressure (>700 psi) chemical systems such as:

- Lightweight tanks;
- Actuators and regulators;
- Self pressurizing propellants.

This subtopic also seeks proposals that explore uses of technologies that will provide superior performance in electric propulsion systems. These technologies include:

- Hall thruster power processing unit (PPU) capable of 3 ½ kW, 5A, and 700 V with a maximum mass of 5.25 kg;
- High specific impulse/low mass electric propulsion systems for sample return missions;
- Future low cost/low mass electric propulsion systems;
- Thrusters should provide thrust up to 20 mN with a specific impulse between 1600 to 3500 seconds;
- Corresponding power processing units capable up to 1 kW of input power;
- The total system mass should not exceed 3 kgs (roughly 1 kg for a thruster and 2 kg for a PPU).

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.

S3.05 Power Management and Storage
Lead Center: GRC
Participating Center(s): JPL

Future NASA science objectives will include missions such as Earth Orbiting, Venus, Europa, Titan and Lunar Quest. 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 long life, high reliability, low mass/volume, radiation tolerance, and wide temperature operation. Other subtopics which could potentially benefit from these technology developments include X1.03 Radiation Hardened/Tolerant and Low Temperature Electronics and Processors. Battery development could also be beneficial to X7.01 Advanced Space-rated Batteries which is investigating similar, but different technologies.

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°C to 500°C for Venus missions, and a span of -230°C to +120°C for Lunar Quest. In addition, 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 (>200 Wh/kg for secondary battery systems) and energy density, along with radiation tolerance are of interest.

Power Management and Distribution (PMAD)
Advanced electrical power technologies are required for the electrical components and systems on future platforms to address the size, mass, efficiency, capacity, durability, and reliability requirements. 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. Advancements are sought for power electronic devices, components and packaging for Venus type missions with power ranges of a few watts for minimum missions up to a few hundred watts for large missions. In addition, advancements in components or architectures for application to Radioisotope Electric Propulsion (REP) PMAD systems are considered beneficial. Technologies of interest include:

- High temperature devices and components (up to 450°C);
- Advanced electronic packaging for thermal control and electromagnetic shielding.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2, and when possible, deliver a demonstration unit for NASA testing at the completion of the Phase 2 contract. Phase 2 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.

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.

S3.06 Guidance, Navigation and Control
Lead Center: GSFC
Participating Center(s): ARC, JPL

Advances in the following areas of guidance, navigation and control are sought.

Navigation systems (including multiple sensors and algorithms/estimators, possibly based on existing component technologies) that work collectively on multiple vehicles to enable inertial alignment of the formation of vehicles (i.e., pointing of the line-of-sight defined by fixed points on the vehicles) on the level of milli-arcseconds relative to the background star field.

Light-weight sensors (gyroscopic or other approach) to enable milli-arcsecond class pointing measurement for individual large telescopes and low cost small spacecraft.

Isolated pointing and tracking platforms (pointing 0.5 arcseconds, jitter to 5 milli-arcsecond), targeted to placing a scientific instrument on GEO communication satellites that can track the sun for > 3 hours/day.

Working prototypes of GN&C actuators (e.g., reaction or momentum wheels) that advance mass and technology improvements for small spacecraft use. Such technologies may include such non-contact approaches such as magnetic or gas. Superconducting materials, driven by temperature conditioning may also be appropriate provided that the net power used to drive and condition the "frictionless" wheels is comparable to traditional approaches.

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.

S3.07 Sensor and Platform Data Processing and Control
Lead Center: GSFC
Participating Center(s): ARC, JPL

Future NASA's science missions will require high-performance onboard data processing capabilities that far exceed those of today. These capabilities will be leveraged to provide data reduction for missions where sensor bandwidths far exceed downlink bandwidth. Improved onboard data processing will also enable autonomous/collaborative systems, where science operations are autonomously controlled via features extracted from the sensor data. Advances in technologies relevant to sensor and platform data processing and control are sought to support NASA's goals and several missions and projects under development.

http://nasascience.nasa.gov/search?SearchableText=missions+under+development
http://www.nap.edu/catalog.php?record_id=10432

The subtopic goals are to: (1) develop device technologies and architectures that can yield a 10x to 100x improvement in on-board computing power is required to enable the next generation of Earth Science, Space Science and Exploration missions; and (2) develop tool technologies that can enable rapid development of high reliability, high performance onboard data processing applications for these missions.

Successful proposal concepts will significantly exceed the present state-of-the-art. Proposals will clearly (1) state what the product is; (2) describe how it targets the technical priorities listed below; and (3) outline the feasibility of the technical and programmatic approach. If a Phase 2 proposal is awarded, the combined Phase 1 and Phase 2 developments shall produce a prototype that is testable by NASA. The technology priorities sought are listed below.

Device Technologies and Architectures

- Highly reliable, radiation tolerant, special purpose data processing devices (FPGA, multi-core, DSP) that enable accelerated onboard data processing;
- Hybrid onboard processing architectures using multiple heterogeneous processing elements (CPU, FPGA, DSP, multi-core);
- Architectures providing software-based radiation mitigation strategies for commercial processing elements.

Development Tool Technologies

- Hybrid system design tools that (a) take full advantage of hybrid processing platforms, and (b) automate/accelerate the design and verification process.

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.

S3.08 Planetary Ascent Vehicles
Lead Center: GRC
Participating Center(s): DFRC, JPL, MSFC

NASA aims to design, build and test vehicles that will be launched from the surface of other planets and place a payload, Orbiting Sample (OS), into orbit. We are seeking proposals for the development of innovative technologies to support future planetary ascent vehicles. Immediate focus is the Mars ascent vehicle. Technology innovations should either enhance vehicle capabilities (e.g., launch success probability, mission success, improved performance or margins, and improved environmental robustness) or ease implementation in spaceborne missions (e.g., reduce size, mass, power, and thermal requirements, improve reliability and ability to withstand the ~20 g lateral g-loading, or lower cost). The areas of interest for this call are listed below.

Advanced solid propellant engine system technologies:

- Solid propellant technology with specific impulse performance potential higher than HTPB and CTPB;
- Propellant blend with high performance and low storage and operating capability down to 150 K;
- Low temperature seals and components;
- Light weight and reliable thrust vector control;
- Other light weight system and component technologies.

Alternate propellants, thrusters and propulsion system technologies for the planetary ascent vehicles:

- Higher performing monopropellants with specific impulse >240 secs;
- High chamber pressure thrusters > 500 psia;
- Pressurization component technologies to reduce system mass (filters, solenoid valves, latch valves, tanks, fill and drain and check valves);
- Small lightweight pump technologies to operate at >500 psi output pressure;
- Non-pyrotechnic isolation valves.

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.

S3.09 Technologies for Unmanned Atmospheric Platforms
Lead Center: DFRC
Participating Center(s): ARC, GRC, GSFC, JPL, LaRC

Unmanned Aerial Vehicles (UAVs) offer significant potential new capabilities for scientific earth exploration over a large range of mission durations, altitudes, and geographical locations. UAVs can carry earth resources remote sensing and atmospheric sampling instruments on scientific investigations including the Polar Regions. The potential for these robotic systems has just begun to be realized, and to date their earth observation and atmospheric sampling capabilities are in a state of infancy when compared to platform requirements needed to address national concern over global climate and environmental changes. Current UAV operations are restricted from operations in inclement weather particularly when airframe icing or freezing of fuel may become issues. Airframe icing limits both aircraft flight envelope and may affect scientific payload operations.

UAVs must adhere to regulatory requirements for flight operations within the national airspace. These regulatory issues pose challenges to the trade space of potential solutions. UAVs can be roughly categorized into 1) larger/high value assets and 2) smaller/lower value or expendable assets. Such categorization of UAVs may drive different technology solutions to meet the technology needs as described below.

- Precision flight path control for highly repeatable terrain monitoring over daily, seasonal or multi-year cycles;
- Highly accurate UAV platform attitude control with corresponding science payload instrument stability and pointing accuracy;
- Lower-cost over-the-horizon telemetry alternatives for real-time collaborative data sharing and decision-making involving multiple in-flight and ground-based instruments;
- Drop-sonde and surface sampling probes remote from the unmanned aircraft;
- Airframe icing detection and mitigation to enable UAV severe weather flight operations;
- UAV flight systems to enable long endurance inclement weather operations; systems such as fuel anti-freezing thermal management will be needed.

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.

S3.10 Terrestrial Balloon Technologies
Lead Center: GSFC

Currently, NASA is developing a Super Pressure terrestrial vehicle targeting 100 day duration missions in mid-latitude. This added capability will greatly enable new science investigations. The design of the current pumpkin shape vehicle utilizes light weight polyethylene film and high strength tendons made of twisted Zylon® yarn. The in-flight performance and health of the vehicle relies on accurate information on a number of environmental, design, and operational parameters. Therefore, NASA is seeking innovations in the following specific areas:

Balloon Instrumentation
Devices or methods to accurately and continuously measure ambient air, helium gas, balloon film temperatures, and film strain. These measurements are needed to accurately model the balloon performance during a typical flight at altitudes of approximately 120,000 feet. The measurements must compensate for the effects of direct solar radiation through shielding or calculation. Minimal mass and volume are highly desired. For film measurements, a non-invasive and non-contact approach is highly desired for the thin polyethylene film used as the balloon envelope, with film thickness ranging from 0.8 to 1.5 mil. The devices of interest must be compatible with existing NASA balloon packaging, inflation, and launch methods. These instruments must also be able to interface with existing NASA balloon flight support systems or alternatively, a definition of a telemetry solution be provided.

Device and method to recover a scientific balloon from Antarctica
Scientific balloons are recovered after flight from the interior of Antarctica. These balloons are either loaded onto aircraft used for remote field operation support, or are loaded upon passing overland traverse vehicles to carry back to McMurdo Station for later disposal. Better methods and/or equipment are needed to expedite the operation and reduce the burden on resources used for recovery of scientific balloons in Antarctica. Current methods to recover balloons are resource and time intensive. In these remote locations, resources and available time are limited. Balloons must be cut up into bundles of manageable size and weight in order to fit inside aircraft that are currently used in support of the United States Antarctic Program (USAP). Scientific balloons weigh up to approximately 2000 kg. The balloon is made up of layers of polyethylene film that are 0.8 to 1.5 mil thick. Each balloon is made up of approximately 200 gores that are heat-sealed together. Each gore seal incorporates load tendons that are made of either polyester load tapes or woven Zylon® fibers. Each balloon incorporates metal end-fittings that can be cut out by hand. Folds, twists and binding of material are characteristics of balloons being recovered. The Antarctic operating environment can be -50 degrees Celsius. Environmental sensitivity is also an issue in Antarctica. Existing aircraft recovery assets include ski-equipped Twin Otters and a DC-3 Basler.

Devices or methods to accurately and continuously measure individual axial loading on an array of ~50 or up to 300 separate tendons during a Super Pressure balloon mission

Tendons are the load carrying member in the pumpkin design. During a typical mission, loading on individual tendons should not exceed a critical design limit to ensure structural integrity and survival. Tendons are typically captured at the fitting via individual pins. Loading levels on the tendons can range from ~20 N to ~8,000 N and temperature can vary from room temperature to the troposphere temperatures of -90 degrees Celsius or colder. The devices of interest shall be easily integrated with the tendons or fittings during balloon fabrication and shall have minimal impact on the overall mass of the balloon system. Support telemetry and instrumentation is not part of the this initiative; however, data from any sensors (devices) that are selected from this initiative must be able to be stored on board and/or telemetered in-flight using single-channel (two-wire) interface into existing NASA balloon flight support systems.

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: S4 Low-Cost Small Spacecraft and Technologies

This subtopic is targeted at the development of technologies and systems, which can enable the realization of small spacecraft science and exploration missions. While small spacecraft have the benefit of reduced launch costs by virtue of their lower mass, they may be currently limited in performance and their capacity to provide on-orbit resources to payload and instrument systems. With the incorporation of smaller bus technologies, launch costs, as well as total life cycle costs, can continue to be reduced, while still achieving and expanding NASA's mission objectives.

The Low-Cost Small Spacecraft and Technologies category is focused on the identification and development of specific key spacecraft technologies in the areas of avionics, attitude determination and control, and spacecraft integration planning and management. The primary thrust of this topic is directed at reducing the footprint and resources that these bus subsystems require (power, mass, and volume), allowing more of these critical resources to be shifted to payload and instrument systems, and to further reduce the overall launch mass and volume requirements for small spacecraft.

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.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and/or software demonstration, and when possible, deliver a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

S4.01 Radiation Hardened High-Density Memory, High Speed Memory Controllers, Data Busses
Lead Center: ARC

There has been considerable progress in the development of low cost high-density memory in the consumer electronics industry. However, spacecraft memory capacities can be orders of magnitude smaller than a desktop computer hard drive. Therefore, NASA has an interest in the development of low cost, high-density memory suitable for spaceflight applications including operations in near and deep space radiation and temperature environments. High-density, radiation-tolerant memory can be beneficial for Astrophysics, Earth Sciences, Heliophysics and Planetary missions where instruments, such as large-scale imagers and spectrometers can quickly produce large amounts of data.

Proposals are sought for radiation-tolerant high-density memory systems that can address or consider the following performance parameters:

- Storage capabilities of up to 192 Gigabytes of data on single 3U card form factor, suitable for inclusion within integrated avionics units and 3U chassis;
- Units that utilize the Space Plug and Play Architecture (SPA) developed at AFRL (See http://www.dukeworks.org);
- Tolerate standard internal spacecraft bus operating temperatures of -25ºC to 40ºC;
- Tolerate space radiation with Total Ionizing Dose (TID) of 10-400kRad (Si) with an average goal of 100kRad (Si);
- Capable of surviving space launch environments.

Although these are baseline goals, proposals that are able to achieve near comparable values will also be considered.

The proposer to this subtopic is advised that the products proposed may be included in a future small satellite flight opportunity.

S4.02 Radiation Hardened Integrated Unit: GPS/IMU/Time/Processor
Lead Center: ARC
Participating Center(s): GSFC

Many subsystems and components are gaining benefit from miniaturization and reduction in mass and power requirements. Often many different avionic control system components are necessary for small spacecraft missions with stringent pointing requirements. A considerable saving in mass, power, and system complexity can be obtained by integrating components into a single unit. Of particular interest is a GPS, IMU, and timing signal combination in a single unit with an internal low-power processor to perform the internal calculations to provide the spacecraft with the necessary location and attitude knowledge.

Proposals are sought for an integrated GPS, IMU, and timing signal unit coupled with a low power processor to provide the necessary signals to spacecraft components.

The integrated unit should address or consider the following performance parameters:

- Mass less than 2.5kg
- Average power usage less than 15W
- GPS:
  - Position accuracy:1-5m
  - Velocity accuracy: 1m/s
  - Time to first fix: 1 minute
  - Use L1 signals; desirable to incorporate L2 signals
- IMU:
  - Rate Range: 500 deg/sec
  - Bias repeatability: 0.005 deg/hr
  - Scale Factor Accuracy:1 to 5 ppm
  - Angle random walk: 0.005 deg/rt-hr
- Timing:
  - 10^{-8} to 10^{-10} Allan deviation
- Able to tolerate an acceleration load of ~25g
- Stable over standard internal spacecraft bus operating temperatures of -25ºC to 40ºC
- Radiation tolerant with Total Ionizing Dose (TID) of 10 – 400 kRad (Si) with an average goal of 100 kRad (Si)

- Compatible with the Space Plug and Play Architecture (SPA) developed at AFRL (See http://www.dukeworks.org for information on SPA)
- Capable of surviving space launch environments

Although these are baseline goals, proposals that are able to achieve near comparable values will also be considered.

The proposer to this subtopic is advised that the products proposed may be included in a future small satellite flight opportunity.

S4.03 Wireless Data and/or Power Connectivity for Small Spacecraft
Lead Center: ARC
Participating Center(s): GSFC, JPL

New advances in wireless connectivity for mobile computing and other electronic devices have opened up the possibilities for wireless spacecraft busses. There are two potential applications, the transfer of data, commands, and signals and delivery of power to components. The use of wireless technology can be beneficial to small spacecraft designs by eliminating the need for data and power connects, thus reducing spacecraft overall mass and volume requirements. Wireless applications for a spacecraft bus must also ensure that the many different signals do not interfere and there is complete transfer of data and power.

The proposed wireless technologies should address or consider the following performance parameters:

- Data transmission capability from 5 - 100 unique devices within the spacecraft;
- Data transfer rates of 500 Megabits per second to 1 Gigabit per second per device;
- Scalable wireless power transfer from ~1mW up to ~20W;
- Overall wireless architecture mass from 3-50kg dependent on the size of the spacecraft bus;
- Both systems (power and data) should be capable of utilizing the Space Plug-and-Play Architecture (SPA) developed by the AFRL. See http://www.dukeworks.org for information on SPA;
- Power and data architectures should be tolerant to the space environment including temperatures (25ºC to 40ºC) and radiation [Total Ionizing Dose (TID) of 10-400kRad (Si) with an average goal of 100kRad (Si)];
- Capable of surviving space launch environments.

Although these are baseline goals, proposals that are able to achieve near comparable values will also be considered.

The proposer to this subtopic is advised that the products proposed may be included in a future small satellite flight opportunity.

S4.04 Low Cost, High Accuracy Timing Signals
Lead Center: ARC
Participating Center(s): GSFC

Radio science is an important element of many missions, including small spacecraft missions, to planetary bodies and asteroids where mass determination is derived from perturbations of the spacecraft trajectory by the body. Traditionally these missions have required the inclusion of an Ultra Stable Oscillator (USO) with timing signal accuracy on the order of 10^{-12} to 10^{-13} Allan Deviation. Unfortunately these devices are currently prohibitively expensive for low cost missions. Other devices such as precision clocks can provide accuracy on the order of 10^{-8} Allan Deviation. It is envisioned that recent improvements in timing signal devices from other industries or new developments can provide a significant reduction in cost while still providing the necessary accuracy in the timing signal.

Proposals are sought for highly accurate timing signals that address or consider the following performance parameters:

- Provide timing signals with an accuracy of 10^{-10} to 10^{-12} Allan deviation;
- Be capable of utilizing the Space Plug-and-Play Architecture (SPA) developed at AFRL (See http://www.dukeworks.org);
- Small enough to fit within a 3U form factor or integrated avionics chassis;
- Mass less than 1kg;
- Power draw less than 5W;
- Stable over standard internal spacecraft bus operating temperatures of -25ºC to 40ºC;
- Radiation tolerant with Total Ionizing Dose (TID) of 10 - 400 kRad (Si) with an average goal of 100 kRad (Si);
- Capable of surviving space launch environments.

Although these are baseline goals, proposals that are able to achieve near comparable values will also be considered.

The proposer to this subtopic is advised that the products proposed may be included in a future small satellite flight opportunity.

S4.05 High Torque, Low Jitter Reaction Wheels or Control Moment Gyros
Lead Center: ARC

NASA is becoming increasingly interested in using small spacecraft to execute space missions where possible. Many of these missions will require low cost, high torque and low jitter reaction wheels or control moment gyros. Currently there are limited sources of these systems applicable for small spacecraft. Therefore, development of a family of reaction wheels with the appropriate characteristics for nano- and small spacecraft (5 to 100 kg spacecraft mass) with reduced lead times will result in significant benefits to a number of NASA programs and missions.

Proposals are sought for the development of reaction wheels and/or control moment gyros with the following performance parameters:

- Mass less than 2 kg
- Average power usage less than 5W
- Compatible with the Space Plug-and-Play Architecture (SPA) developed at AFRL (See http://www.dukeworks.org)
- Reaction wheels
    - Angular momentum capacity of 1 to 2 Nms
    - Torque capacity greater that 50mN-m
    - Speed range greater than ±20000rpm
- Control Moment Gyros
    - Torques of 0.1 to 5 Nm
- Induced jitter noise TBR:
    - < 5e-4 Nm torque noise in 0 - 20 Hz
    - < 1e-3 Nm torque noise in 20 - 50 Hz
    - < 5e-3 Nm in 50 - 200 Hz
    - < 6e-3 total RMS in all frequencies
- The use of built in control electronics with rate sensor abilities is also desirable
    - Rate sensor should have a range of 500 deg/sec
    - Drift rate 0.5 deg/hr
- Stable over standard internal spacecraft bus operating temperatures of -25ºC to 40ºC
- Radiation tolerant with Total Ionizing Dose (TID) of 10 - 400 kRad (Si) with an average goal of 100 kRad (Si)
- Capable of surviving space launch environments

Although these are baseline goals, proposals that are able to achieve near comparable values will also be considered.

The proposer to this subtopic is advised that the products proposed may be included in a future small satellite flight opportunity.

S4.06 AI&T Planner and Scheduler
Lead Center: ARC

Proposals are sought for the development of a software tool (or suite of integrated tools) to assist in the planning, scheduling, and operations activities that occur during small spacecraft Assembly, Integration and Test (AI&T). AI&T is a complex period for small spacecraft with many different procedures, dependencies, operations, and tests occurring in parallel. To streamline the process and ensure compliance with mission and science requirements, NASA is interested in a software tool to support planning, scheduling, and management of the small spacecraft AI&T flow. The tool must be scalable for a variety of different mission and spacecraft classes from nanosatellites, which are typically secondary payloads weighing around 5 - 10 kg, up to primary sciences missions, which may weigh more than 100 kg.

Proposals are sought for the development of an AI&T tool with the following capabilities:

- Resource(s) availability determination and planning function
    - Facilities
    - Personnel
    - GSE
- Requirement mapping for qualification tests along with verification and validation functions
- Compatible with NASA proposal development processes to assist in a Phase A schedule and cost generation for the AI&T flow
- Compatible with NASA NPR 7120.5D Program and Project planning requirements

TOPIC: S5 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. See URL: http://marstech.jpl.nasa.gov/ for additional information on Mars Exploration technologies.

S5.01 Planetary Entry, Descent and Landing Technology
Lead Center: JPL
Participating Center(s): ARC, JSC, LaRC

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 which 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 and the rigors of landing on the Martian surface. 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 the situational awareness during landing by identifying hazards (rocks, craters, slopes), or providing indications of approach velocities and touchdown;
- Substantially reducing the amount of external processing needed to calculate the measurements; and
- 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 just prior to planetary ascent vehicle launch, 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.

S5.02 Sample Collection, Processing, and Handling
Lead Center: JPL
Participating Center(s): ARC, GSFC, JSC

Robust systems for sample acquisition, handling and processing are critical to the next generation of robotic explorers for investigation of planetary bodies (http://books.nap.edu/openbook.php?record_id=10432&page=R1). Limited spacecraft resources (power, volume, mass, computational capabilities, and telemetry bandwidth) demand innovative, integrated sampling systems that can survive and operate in challenging environments (extremes in temperature, pressure, gravity, vibration and thermal cycling). Special interest lies in sampling systems and components (actuators, gearboxes, etc.) that are suitable for use in the extremely hot high pressure environment at the Venusian surface (460ºC, 93 bar). Relevant systems could be integrated on multiple platforms, however of primary interest are samplers that could be mounted on a mobile platform, such as a rover. For reference, current Mars-relevant rovers range in mass from 200 - 800 kg.

Sample Acquisition
Research should be conducted to develop compact, low-power, lightweight subsurface sampling systems that can obtain 1 cm diameter cores of consolidated material (e.g., rock, icy regolith) up to 10 cm below the surface. Systems should be capable of autonomously acquiring and ejecting samples reliably. Also of interest are methods of autonomously exposing rock interiors from below weathered rind layers. Other sample types of interest are unconsolidated regolith, dust, and atmospheric gas.

Sample Manipulation (core management, sub-sampling/sorting, powder transport)
Sample manipulation technologies are needed to enable handling and transfer of structured and unstructured samples from a sampling device to instruments and sample processing systems. Core, cuttings, and regolith samples may be variable in size and composition, so a sample manipulation system needs to be flexible enough to handle the sample

variability. Core samples will be on the order of 1 cm diameter and up to 10 cm long. Soil and rock fragment samples will be of similar volumes.

Sample Integrity (encapsulation and contamination)
For a sample return mission, it is critical to find solutions for maintaining physical integrity of the sample during the surface mission (rover driving loads, diurnal temperature fluctuations) as well as the return to Earth (cruise, atmospheric entry and impact). Technologies are needed for characterizing state of sample in situ – physical integrity (e.g., cracked, crushed), sample volume, mass or temperature, as well as retention of volatiles in solid (core, regolith) samples, and retention of atmospheric gas samples.

Also of particular need are means of acquiring subsurface rock and regolith samples with minimum contamination. This contamination may include contaminants in the sampling tool itself, material from one location contaminating samples collected at another location (sample cross-contamination), or Earth-source microorganisms brought to the Martian surface prior to drilling ('clean' sampling from a 'dirty' surface). Consideration should be given to use of materials and processes compatible with 110 - 125°C dry heat sterilization. In situ sterilization may be explored, as well as innovative mechanical or system solutions – e.g., single-use sample "sleeves," or fully-integrated sample acquisition and encapsulation systems.

For a sample return mission, sample transfer of a payload into a planetary ascent vehicle: Automated payload transfer mechanisms; and Orbiting Sample (OS) sealing techniques.

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.

S5.03 Surface and Subsurface Robotic Exploration
Lead Center: JPL
Participating Center(s): ARC, GSFC, JSC

Technologies are needed to enable access and sample acquisition at surface and subsurface sampling sites of scientific interest on Mars or the Moon. Mobility technology is needed to enable access to difficult-to-reach sites such as access through difficult and steep terrain. Manipulation technologies are needed to deploy instruments and sampling tools from vehicles. Many scientifically valuable sites are accessible only via terrain that is too difficult or steep for state-of-the-art planetary rovers to traverse. Sites include crater walls, canyons, and gullies. Tethered systems, non-wheeled systems, and marsupial systems are examples of mobility technologies that are of interest. Tether technology could enable new approaches for deployment, retrieval and mobility. Innovative marsupial systems could allow a pair of vehicles with different mobility characteristics to collaborate to enable access to challenging terrain. Single vehicle systems might utilize a 200 kg class rover and dual vehicle systems might utilize a 500 - 800 kg primary vehicle that provides long traverse to the vicinity of a challenging site and then deployment of a smaller 20 - 50 kg vehicle with steep mobility capability for access and sampling at the site.

Technologies to enable acquisition of subsurface samples are also needed. For Mars in particular, technologies are needed to acquire core samples in the shallow subsurface to about 10cm and to enable subsurface sampling in multiple holes at least 1 - 3 meters deep through rock, regolith or ice compositions. Shallow subsurface sampling systems need to be low mass and deeper subsurface sampling solutions need to be integratable onto 500 - 800 kg stationary landers and mobile platforms. Consideration should be given for potential failure scenarios, such as platform slip and borehole misalignment for integrated systems, and the challenges of dry drilling into mixed media including icy mixtures of rock and regolith. Systems should ensure minimal contamination of samples from Earth-source contaminants and cross-contamination from samples at different locations or depths.

Innovative component technologies for low-mass, low-power, and modular systems are of particular interest. Technical feasibility should be demonstrated during Phase 1 and a full capability unit of at least TRL level 4 - 6 should be delivered in Phase 2. Specific areas of interest include the following:

- Tether play-out and retrieval systems including tension and length sensing;
- Low-mass tether cables with power and communication;
- Steep terrain adherence for vertical and horizontal mobility;
- Modular actuators with 1000:1 scale gear ratios;
- Electro-mechanical couplers to enable change out of instruments on an arm end-effector;
- Drill, core, and boring systems for subsurface sampling to 10cm or 1 to 3 meters.
- High power piezoelectric mechanisms for drilling into Lunar Regolith; must be able to deliver high torque for short impulses to clear any obstacles;
- Shared intelligence allowing systems to collaborate and adapt exploration scenarios to new conditions.

Proposals should show an understanding of relevant science needs and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S5.04 Rendezvous and Docking Technologies for Orbiting Sample Capture
Lead Center: JPL
Participating Center(s): GSFC, JSC

NASA seeks an innovative suite of products or technologies that will enable and enhance the successful tracking and capture of a sample canister in Mars orbit.

The principal means of detection and tracking is optically with visual-band cameras. The challenging technology of long-range optical sensors for detection and distant tracking is not part of this call, however, short-range optical (or other) sensors and an on-sample radio-metric-based back-up detection and tracking method is desired, including a low-power, low-mass illuminator for short-range imaging of up to 0.5km.

Sample capture mechanisms are sought, of very low mass and volume, and of low complexity and extremely high reliability, including detection of contact with the capture mechanism. Appropriate on-sample radio-beacons are sought that are compatible with NASA's radio systems; requirements for these are for long life, and independent initiation of on-orbit operation. Sample capture mechanisms should include close-proximity/contact sensors, including immediate-field imaging.

Command and sequencing software is sought that will robustly operate the onboard GN&C systems, including providing health and safety monitoring of the rendezvous and capture operation, adaptive response to anomalies and abort commanding. Onboard resources can be assumed to be those necessary to perform navigation from images or other data, compute maneuvers, and maintain the spacecraft attitude.

Methods are sought to provide a practice mechanism for testing rendezvous and proximity operations with a test sample canister on Mars orbit. The test carrier and release mechanism must be of very low mass and volume, and the test sample canister(s) should carry a radio beacon. Test canisters should be of limited life after release, ceasing broadcast, and degrading in surface reflectance in approximately one month to avoid confusion with the actual canister. The test articles may be deployed on a previous mission, or on the actual sample return mission for operational readiness testing.

Products or technologies are sought that can be made compatible with the environmental conditions of interplanetary spaceflight and the rigors normal Mars orbits. 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. Successful candidate products or technologies can address this call by providing one or more of the following functions, and giving estimated expected performance capabilities of the approach, including, but not limited to, accuracies, ranges, limits of operation, references to previous or related flight experience:

- Autonomously actuated mechanisms for orbiting sample capture;
  - Mechanical capture mechanisms;
  - Transfer mechanisms from capture device to containment transfer mechanism;
- Optical and contact sensors;
  - Near field imagers (optical or other) (e.g. 10m to 1km);
  - Immediate field imagers (optical) (0.25 to 10m);
  - Detection of orbiting sample for triggering capture mechanism;
  - Near field illuminator;
- Coherent Radio Doppler and range beacon (high-performance);
  - Low power, low mass and long life beacon for detection aid;
  - 2-way communication for activation, ranging and coherency;
  - Programmable intermittent transmission for power saving and very long dormancy period;
- Simple Radio beacon (low-performance);
  - Simple 1-way beacon, for long-range detection and 1-way Electra Doppler extraction;
  - Timer activated, multi-year dormant life, and long active life battery;
- Autonomous Rendezvous GN&C Command and Control system;
  - Utilize existing GN&C computation elements to command and sequence robust and safe rendezvous and capture;
  - Provide self-monitoring, correction and self-abort capability;
  - Provide for high-level Mission scenario design, monitoring and simple implementation;
- Low-mass, low-cost sample OSC for proximity operations operational readiness tests;
  - A simple, low-cost, low-mass practice sample canister that could be deployed and provide low-risk practice runs, either for a precursor mission, or with the actual sample return mission;
  - The readiness test exercise would not capture the test article in the capture mechanism, but only perform the rendezvous and proximity ops operations.

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.

S5.05 Extreme Environments Technology
Lead Center: JPL
Participating Center(s): ARC, GRC, GSFC, MSFC

High Temperature, High Pressure, and Chemically Corrosive Environments
NASA is interested in expanding its ability to explore the deep atmosphere and surface of Venus through the use of long-lived (days or weeks) balloons and landers. Survivability in extreme high temperatures and high pressures is also required for deep atmospheric probes to giant planets. Proposals are sought for technologies that enable the in situ exploration of the surface and deep atmosphere of Venus and the deep atmospheres of Jupiter or Saturn for future NASA missions. Venus features a dense, CO_2 atmosphere completely covered by sulfuric acid clouds at about 55 km above the surface, a surface temperature of about 486ºC and a surface pressure of about 90 bars. Technologies of interest include high temperature electronics components, high temperature energy storage systems, light mass refrigeration systems, high temperature optical window systems (that are transparent in IR, visible and UV wavelengths) and pressure vessel components compatible with materials such as steal, titanium and beryllium such as low leak rate wide temperature (-50ºC to 500ºC) seals capable of operating between 0 and 90 bars.

Low Temperature Environments
Low temperature survivability is required for missions to Titan, the surface of Europa and comets. Also Moon equatorial regions experience wide temperature swings from -180ºC to +130ºC during the lunar day/night cycle, and the sustained temperature at the shadowed regions of lunar poles can be as low as -230ºC. Mars diurnal temperature changes from about -120ºC to +20ºC. Proposals are sought for technologies that enable NASA's long duration missions to low temperature and wide temperature environments. Technologies of interests include low power rad-tolerant RF electronics, mixed signal electronics, power electronics, electronic packaging (including passives,

connectors, wiring harness and materials used in advanced electronics assembly), actuators and energy storage sources capable of operating across an ultra-wide temperature range from -230ºC to 200ºC and computer Aided Design (CAD) tools for modeling and predicting the electrical performance, reliability, and life cycle for low-temperature electronic systems and components.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware/software demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

S5.06 Planetary Balloon Technology
Lead Center: JPL

Innovations in materials, structures, and systems concepts have enabled buoyant vehicles to play an expanding role in planning NASA's future Solar System Exploration Program. Balloons and airships are expected to carry scientific payloads on Venus and Titan in order to investigate their atmospheres in situ and their surfaces from close proximity. Their envelopes will be subject to extreme environments and must support missions with a range of durations. Proposals are sought in the following areas:

Metal Balloons for High Temperature Venus Exploration
Balloons made of metals are a potential solution to the problem of enabling long duration flight in the hot lower atmosphere of Venus. Proposals are sought for metal balloon concepts and prototypes that provide 1-5 m^3 of fully inflated volume, areal densities of 1 kg/m^2 or less, sulfuric acid compatibility at 85% concentration, and operation at 460°C for a period of up to 1 year.

Rapid Buoyancy Modulation System for a Titan Montgolfiere Balloon
Montgolfiere, or hot air, balloons are under development for use on a future mission to Titan. While systems are feasible based on the waste heat from a radioisotope power system (RPS), the large thermal inertias make it dangerous for such balloons to fly near the surface because of their inability to quickly respond to atmospheric turbulence or approach topographic hazards. Proposals are therefore sought for a rapid buoyancy modulation system that can be integrated into a 10 m diameter Titan Montgolfiere balloon operating at 90 K and using a steady-state RPS heat source in the range of 2 - 4 kW. This system needs to be lightweight (less than 10 kg) and consume a small amount of electrical power (less than 5 W average).

Gas Management Systems for Titan Aerobots
Hydrogen-filled aerobots at Titan must contend with the problem of gas leakage over long duration (1 year or more) flights. Proposals are sought for the development and testing of two kinds of prototype devices that can be carried on the aerobot to compensate for these gas leakage problems: one device is to produce make-up hydrogen gas from atmospheric methane; the other device is to remove atmospheric gas (mostly nitrogen) that leaks from the ballonets into the hydrogen-filled blimp. Both kinds of devices will need to operate on no more than 15 W of electrical power each while compensating for a leakage rate of at least 40 g/week of hydrogen or 500 g/week of nitrogen.

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: S6 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 this data to create knowledge. In particular, 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, and provide visualizations of datasets that are extremely large and complicated. 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 science information be 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.

S6.01 Technologies for Large-Scale Numerical Simulation
Lead Center: ARC
Participating Center(s): GSFC

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; and
- 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 (http://www.hec.nasa.gov/): 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 1 and show a path toward a Phase 2 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, many applications requiring tight coupling and 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 include:

- Integrated Environments: The user interface to a supercomputer is typically a command line in a text window. This subtopic element seeks more intuitive, intelligent, user-customized, 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 codes, running computations, managing files and data, analyzing and visualizing results, transmitting data, collaborating, etc.
- 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, more capable storage/interconnect/visualization technologies, improved algorithms for key codes, and power-aware "Green" computing technologies and techniques.
- HEC Ecosystem Modeling: NASA endeavors to maximize the productivity of its world-class HEC activities. To identify and prioritize improvement initiatives, this subtopic element seeks tools and techniques to routinely monitor and model the productivity of NASA's HEC ecosystem, including modeling change scenarios. The technology should model the workflows of HEC users, facility staff, and resources (supercomputers, storage, networks, etc.), and it should reflect constraints such as budget, power, and space. Offerors should minimize the effort of HEC staff to provide process information.
- Archive Data Use: NASA has a vast and rapidly growing wealth of Earth and space observational data, stored in various archives around the U.S. NASA's supercomputers could extract more value from this data and advance NASA's science missions through large-scale data analysis and visualization, and ingest into high-fidelity models. This subtopic element seeks technologies that facilitate efficient, automated use of data in NASA's observational data archives by its HEC centers and users.

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.

S6.02 Earth Science Applied Research and Decision Support
Lead Center: SSC
Participating Center(s): ARC, JPL

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 natural disasters.

This subtopic seeks new, advanced information systems and decision environments that take full advantage of multiple data sources and platforms. Tailored distribution networks and timely products delivered to a broad range of users are needed to support applications in disaster management, resource management, energy and urban sustainability.

- Development of new integrated multiple user requirements knowledge data bases and archival library tools to support researchers and promote infusion of successful technologies into existing processes.
- Development of new decision support strategies and presentation methodologies for applied earth science applications to reduce risk, cost, and time.

This subtopic is also soliciting proposals for utilities, plug-ins or enhancements to open source geobrowsers that improve their utility for earth science research and decision support. Examples of geobrowsers include NASA World Wind, World Wind Java (http://worldwindcentral.com/wiki/Main_page) and COAST (http://www.coastal.ssc.nasa.gov/coast/COAST.aspx). Special consideration will be given to tools for COAST. Examples of specific interest are:

- Tools and utilities to support creation or simplify the import and integration of new datasets;
- Tools and utilities to discover and integrate existing web-enabled sensor data (e.g., webcams, meteorology stations, beach monitors);
- Innovative output mechanisms for data layer sharing and collaboration;
- Enhancements to visualization of custom 3rd dimensional data;
- Enhancements to real time animation capabilities, or incorporation of existing animations into a geobrowser;
- Plug-ins that enable visualization of high resolution imagery in a COAST accessible data viewer;
- Utilities that enable regional estuarine or bay data compilations that are of interest to the major coastal ecosystem managers in those areas;
- Applications that subset, filter, merge, and reformat existing spatial data; provide links to attribute data; or visualize spatial or temporal analytic results in innovative value added fashion within the application.

Proposals should present a feasible plan to fully develop and apply the subject technology.

S6.03 Algorithms for Science Data Processing and Analysis
Lead Center: GSFC
Participating Center(s): ARC, JPL, LaRC, MSFC, SSC

This subtopic seeks technical innovation and unique approaches for the processing and the analysis of data from NASA science missions. Analysis of NASA science data enables insights into dynamic systems such as the sun, oceans, and earth's climate in addition to looking back in time to explore the origins of the universe. Complex algorithms and intensive data processing are needed to understand and utilize this data. Advances in such algorithms will support science data analysis and decision support systems related to current and future missions and mission concepts such as:

Current operational missions listed at http://www.nasa.gov/missions/current/index.html

- Landsat Data Continuity Mission (LDCM) (http://ldcm.nasa.gov/),
- NPOES Preparatory Project (NPP) (http://jointmission.gsfc.nasa.gov/),
- Lunar Reconnaissance Orbiter (LRO) (http://lunar.gsfc.nasa.gov/),
- Orbiting Carbon Observatory (OCO) (http://oco.jpl.nasa.gov/),
- Lunar Atmosphere and Dust Environment Explorer (LADEE) (http://nasascience.nasa.gov/missions/ladee),
- Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) (http://crism.jhuapl.edu),
- HyspIRI Earth orbiting hyperspectral instrument (http://hyspiri.jpl.nasa.gov/),
- Visual Infrared Mapping Spectrometer (VIMS) on Cassini (http://wwwvims.lpl.arizona.edu/),
- Moon Mineralogy Mapper (M3) on Chandrayaan (http://moonmineralogymapper.jpl.nasa.gov/),
- James Webb Space Telescope (JWST) (http://www.jwst.nasa.gov/).

Research proposed to this subtopic should demonstrate technical feasibility during Phase 1, in partnership with scientists, and subsequently show a path toward a Phase 2 prototype demonstration, with significant communication with missions and programs to ensure a successful Phase 3 infusion. Innovations are sought in data processing and analysis algorithms in the following areas:

- Optimization of Algorithms and Computational Methods that increase the utility of scientific research data, models, simulations, and visualizations. Of particular interest are innovative computational methods that will dramatically increase algorithm efficiency as well as the performance of scientific applications. Success will be measured by both speed improvements and output validation.

- Improvement of Data Collection, by identifying data gaps in real-time, and/or derive information through synthesis of data from multiple sources. The ultimate goal is to increase the value of data collected in terms of scientific discovery and application.
- Frameworks and Related Tools for Processing, Analyzing and Fusing image and vector data for the purpose of analyzing NASA's astrophysics, heliophysics, planetary and earth science mission data and therefore enable the advancement of NASA's scientific objectives. Of particular interest are open source frameworks that would enable sharing and validation of tools and algorithms.

Tools and products developed under this subtopic may be used for broad public dissemination or for use within a narrow scientific community. These tools can be plug-ins or enhancements to existing software or on-line data/computing services. They also can be new stand-alone applications or web services, provided that they are compatible with most widely used computer platforms and exchange information effectively (via standard protocols and file formats) with existing, standard or prevalent applications. To promote interoperability, tools shall use industry standard protocols, formats, and Application Programming Interfaces (APIs), including compliance with the Federal Geographic Data Committee (FDGC) and Open Geospatial Consortium (OGC) standards as appropriate.

It is highly desirable that the proposed projects lead to software that is infused into NASA programs and projects.

S6.04 Data Management - Mining and Visualization
Lead Center: GSFC
Participating Center(s): JPL, LaRC

This subtopic focuses on supporting science analysis through innovative approaches for managing and visualizing collections of science data which are extremely large, complicated, and highly distributed in a networked environment that encompasses large geographic areas. There are specific areas for which proposals are being sought:

- Collaborative visualization tools that enable data exploration, data sharing, and data manipulation among scientists worldwide that make use of innovative hardware and software technologies for data manipulation and display, including the use of large multi-touch input devices or 3 dimensional display devices.
- Social networking tools that enable secure high bandwidth scientific collaboration among scientists worldwide that promote the development of online communities for sharing thoughts and ideas and for arriving at consensus opinions and understanding.
- Tools for science data discovery, data mining, data search, and data subsetting in extremely large data sets in clustered processing and storage environments, cloud computing environments, or shared data and computation environments.
- Storage systems, file systems, and data management systems that promote the secure long term preservation of data in a distributed online storage environment, provide for recovery from system and user errors, and provide dynamically configurable high speed access to data shared over wide area high speed networks.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware/software demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

S6.05 Software Engineering Tools for Scientific Models
Lead Center: GSFC

This subtopic seeks to improve the productivity and quality of NASA's scientific modeling endeavors through customized tools, which enable and encourage improved software engineering practices. Because many of NASA's principal scientific models have evolved over decades to be hundreds of thousands of lines long with contributions from a wide variety of scientists, much of the software has become "brittle" in the sense that it has become difficult to extend, couple, and optimize. In other software communities (and other programming languages), access to modern software tools has enabled large gains in productivity by providing high-level tools for isolating software defects (bugs) as well as by automating common, albeit tedious, software processes. The goal is to extend these capabilities to support the Fortran programming language so that NASA's scientific models can extract similar benefits.

Target Programs, Missions and Mission Classes

Advances in developer productivity would be of significant benefit to several research and analysis programs within the Science Mission Directorate including:

- High-End Computing Program (http://hec.nasa.gov)
- Modeling, Analysis, and Prediction Program (http://map.nasa.gov)

Technology Areas

The objective is to create a suite of software tools, which directly ameliorate the most significant bottlenecks to productivity in the development of scientific models:

- Tools that assist in the construction of fine-grained unit-level software tests based upon existing functionality in a legacy Fortran application. Although tests written by developers are desirable, such tests are exceedingly difficult to create for legacy numerical software. Suites of these tests could provide a significant element of risk-reduction for maintenance and extension of these models, and would be incorporated into some sort of unit-testing framework.
- Tools that enable high-level source code transformations ("refactorings"). Although refactoring support for other programming languages, most notably Java, has shown significant gains in productivity, similar support for Fortran is rather limited. (http://www.eclipse.org/photran/).
- Integration of a Fortran unit-testing frameworks within an Integrated Development Environment (IDE). Although multiple Fortran unit-testing frameworks have been developed (http://sourceforge.net/projects/pfunit), adoption by the community has been slow in part due to lack of integration within IDE's. Integration of other Fortran capabilities is also encouraged.

Tools and products developed under this subtopic may be used for broad public dissemination or for use within a narrow scientific community. These tools can be plug-ins or enhancements to existing software or on-line data/computing services. They also can be new stand-alone applications or web services, provided that they are compatible with most widely used computer platforms and exchange information effectively (via standard protocols and file formats) with existing, standard or prevalent applications. To promote interoperability, tools shall use industry standard protocols, formats, and APIs (Application Programming Interfaces).

It is highly desirable that the proposed projects lead to software that is infused into NASA programs and projects.

9.1.4 SPACE OPERATIONS

The Space Operations Mission Directorate (SOMD) provides the foundation for NASA's space programs — space travel for human and robotic missions, in-space laboratories, processing and operations of space systems, and the means to return data to the Earth. The role of the directorate is to provide the daily operational capabilities for the agency. These capabilities: Communications and Navigation; Space Transportation; Launch Range Safety and Processing and On-board Operations must continue to evolve synergistically as the directorate guides their development and enhancement. In addition, as the Exploration Program provides new capabilities, potentially varying in size and complexity from micro satellites to manned missions, operation of these future spacecraft and missions must be integrated into SOMD's evolving operational capability. In summary, the Space Operations Mission Directorate provides space access and operations for our customers with a high standard of safety, reliability, and affordability.

In support of the Vision for Space Exploration, the Space Operations Mission Directorate will marshal its SBIR efforts around four key technology areas: (1) Space Communications; (2) Space Transportation; (3) Processing and Operations; and (4) Navigation enabling efficient and affordable technology development for communications and navigation for exploration; human operation in space; science and space access services; and operations. We go forward as explorers and as scientists to understand the universe in which we live.

http://www.nasa.gov/directorates/somd/home/index.html

TOPIC: O1 Space Communications

NASA's communications capability is based on the premise that communications shall enable and not constrain missions. Communications must be robust to support the 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, access links, reprogrammable communications systems, communications systems for EVAs, advanced antenna technology, transmit array concepts and communications in support of launch services including space based assets are very important to the future of exploration and science activities of the Agency. Emphasis is placed on size, weight and power improvements. Even greater emphasis is placed on these attributes as small satellites (e.g., micro and nano satellite) technology matures. Innovative solutions are needed which are centered on operational issues associated with the communication capability. Communication technologies enabling acquisition of range safety data from sensitive instruments is imperative. All technologies developed under this topic area to be aligned with the Architecture Definition Document and technical direction as established by the NASA Office of Space Communications and Navigation (SCaN). For more details, see:

https://www.spacecomm.nasa.gov/spacecomm/
https://www.spacecomm.nasa.gov/spacecomm/programs/default.cfm
https://www.spacecomm.nasa.gov/spacecomm/programs/technology/default.cfm
https://www.spacecomm.nasa.gov/spacecomm/programs/technology/sbir/default.cfm

A typical approach for flight hardware would include: Phase 1 - Research to identify and evaluate candidate telecommunications technology applications to demonstrate the technical feasibility and show a path towards a hardware/software demonstration. Bench or lab-level demonstrations are desirable. Phase 2 - 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 2 contract.

Some of the subtopics in this topic could result in products that may be included in a future flight opportunity. Please see the following for more details:

(1) SMD Topic S4 for more details concerning requirements for Small Satellite flight opportunities.
(2) Facilitated Access to the Space Environment for Technology Development and Training (FAST): http://ipp.nasa.gov/ii_fast.htm
(3) International Space Station payload opportunities: http://www.nasa.gov/mission_pages/station/science/experiments/Discipline.html
(4) Terrestrial analogs (Desert Rats, Haughton Field): http://science.ksc.nasa.gov/d-rats/, http://ti.arc.nasa.gov/projects/haughton_field

NOTE: Communications technologies for space-based range must be highly integrated with required navigation components; hence, space-based range technologies are solicited in Navigation Subtopic O4.05.

O1.01 Coding, Modulation, and Compression
Lead Center: JPL
Participating Center(s): ARC, DFRC, GRC, GSFC

This subtopic aims to develop innovative technology in three key areas of space communications: modulation, forward error-correction (FEC) coding, and data compression. The objective is to provide the best possible trade-off of coding gain, bandwidth efficiency, complexity (mass or power), and rate-distortion, so that the total science/engineering value can be maximized while using the smallest amount of spacecraft energy possible. This will enable NASA to meet a wide range of requirements for its future space missions at near Earth, lunar, and deep space distances.

These future missions will use many link types (direct-to-Earth, TDRS relay, lander-to-orbiter relay, and short-proximity links), frequencies (S-, X-, and Ka-bands), and application-specific performance requirements (latency, complexity). The state-of-the-art in the three areas addressed by this subtopic is summarized here:

- Modulation: BPSK and QPSK for deep space, and BPSK, QPSK, SQPSK, and 8-PSK for near Earth (TDRS) applications; GMSK for bandwidth efficient applications
- Coding: CCSDS turbo codes and LDPC codes
(See http://public.ccsds.org/publications/archive/131x0b1.pdf and
http://public.ccsds.org/publications/archive/131x1o2e2.pdf)
- Compression: the CCSDS standard (http://public.ccsds.org/publications/archive/122x0b1c2.pdf)

Technology development is needed in the following areas:

Modulation
There is a need for the implementation and demonstration of ground receivers and flight receivers that exhibit very low implementation loss for 8-PSK and GMSK (in addition to BPSK, QPSK, and SQPSK) for operation ranges from 8 bps (emergency) through 100 Mbps (high rate Ka-band). Emphasis is placed on minimizing implementation loss (< 0.25 dB) – as there are many commercial 8-PSK/GMSK receivers for terrestrial applications that operate in excess of 1 dB of loss from theoretical performance – through use of appropriate bit widths, careful carrier and symbol tracking loop design, and advanced signal processing.

Phase 1 tasks should target completion of a fixed-point design whose performance can be verified by simulation (in, e.g., Simulink or SPW). Phase 2 technology target is a hardware demonstration at TRL 5.

Coding
There is a need to interface a receiver as above with a high-performing LDPC decoder. Government licensing of LDPC decoding technology (Verilog source) is available. What is needed here is the development of the following:

- FPGA simulations of all 10 CCSDS LDPC codes down to a bit error rate of $1e^{-10}$ and a codeword error rate of $1e^{-9}$, and with a goal of identifying the "error floor" of each of the codes.
- Improved decoding algorithms that reduce the observed error floor. It is known that observed error floors for these codes are a characteristic of standard belief propagation (BP) decoding, and not because of the minimum distance properties of the codes. Variations of standard decoding may not be susceptible to the same trapping sets, thereby improving error floor performance. These methods include (a) optimally decoding the 4-cycles, (b) converting 4-cycles to equivalent trees, (c) BP decoding with damping, and (d) using min in place of min* in the later iterations of the decoder. These and other variations should be tested particularly on the k=1024, r=4/5 code, which is expected to exhibit the highest error floor.

The target is a finished product at TRL 5.

Data Compression
Development of a radiation-tolerant high-speed (over 100 Msamples/sec) lossless compression component conforming to CCSDS 121.0-B-1, "lossless data compression" (www.ccsds.org) allowing input dynamic range to over 24-bit/sample. Options should include user-supplied external predictor, as well as providing potential applications to hyper-spectral data by taking advantage of the spectral correlation in such data sets.

Development to TRL 5 is desired.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration and deliver a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

The proposer to this subtopic is advised that the products proposed may be included in a future small satellite flight opportunity. Please see the SMD Topic S4 on Small Satellites for details regarding those opportunities. If the proposer would like to have their proposal considered for flight in the small satellite program, the proposal should state such and recommend a pathway for that possibility.

O1.02 Antenna Technology
Lead Center: GRC
Participating Center(s): ARC, DFRC, GSFC, JPL, JSC, LaRC

NASA seeks advanced antenna systems in the following areas: phased array antennas; ground-based uplink antenna array designs; high-efficiency, miniature antennas; smart, reconfigurable antennas; large aperture inflatable/deployable antennas; antenna adaptive beam correction with pointing control; parallelized numerical solvers for antenna modeling and design; and communication antennas with improved performance.

Phased Array Antennas
High performance phased array antennas are needed for (1) high-data rate communication and (2) remote sensing applications. The frequencies of interest are P-, L-, C-, S-, X-, Ku-, Ka-, and W-band. Potential communications applications include: lunar and planetary exploration, landers, probes, Lunar Relay Satellites, lunar rovers, lunar habitats, lunar surface EVA, suborbital vehicles, sounding rockets, balloons, unmanned aerial vehicles (UAV's), TDRSS communication, and expendable launch vehicles (ELV's). Potential remote sensing applications include: radiometers, passive radar interferometer platforms, and synthetic aperture radar (SAR) platforms for planetary science.

Multi-band phased array technology such as S- and Ka-band phased array antennas, which can dynamically reconfigure active element coupling in order to operate in either band as required in order to maximize flexibility, efficiency and minimize the mass of hardware delivered to the moon for lunar surface system operations, are of interest. The goal is to maximize flexibility and capability to share lunar communications infrastructure and therefore minimize mass of radio components that must to be delivered to the lunar surface.

There is also a high interest in developing phased array antennas for space-based range applications to accommodate dynamic maneuvers.

The arrays are required to be aerodynamic or conformal in shape for sounding rockets, UAV's, and expendable platforms. They must also be able to withstand the launch environment. The balloon vehicles communicate primarily with TDRS and can tolerate a wide range of mechanical dimensions.

The main challenges/tradeoffs to be addressed are achieving low mass, low cost, high power efficiency, thermal stability of active array electronics, and coverage area (i.e., highly steerable arrays). Active arrays with features such as T/R module self-calibration for thermal stability, true time delay (TTD), low-cost highly-integrated MMIC-based T/R modules (e.g., SiGe/GaAs technology), multiple beam-forming capability, low-loss feeds for radiometer applications are also of interest. Advances in digital beam-forming techniques, including those based on superconducting digital signal processing methods, are also desirable.

Ground-based Uplink Antenna Array Designs
NASA is considering arrays of ground-based antennas to increase capacity and system flexibility, to reduce reliance on large antennas and high operating costs, and eliminate single point of failure of large antennas. A large number of smaller antennas arrayed together results in a scalable, evolvable system which enables a flexible schedule and support for more simultaneous missions. Some concepts currently under consideration are the development of medium-size (12-m class) antennas (hundreds of them are expected to be required) for transmit/receive (Tx/Rx) ground-based arrays. A significant challenge is the implementation of an array for transmitting (uplinking), which may or may not use the same antennas that are used for receiving. The uplink frequency will be in the 7.1-8.6 GHz range (X-band) in the near term, and may be at higher frequencies in the future; it will likely carry digital modulation at rates from 10 kbps to 30 Mbps. An EIRP of at least 500 GW is required, and some applications contemplate an EIRP as high as 10 TW. A major challenge in the uplink array design is minimizing the life-cycle cost of an array.

Other challenges for ground-based antennas include the development of low cost, reliable components for critical antenna systems; advanced, ultra-phase-stable electronics, and phase calibration techniques; improved understanding of atmospheric effects on signal coherence; and integrated low-noise receiver-transmitter technology. Phase calibration techniques needed to ensure coherent addition of the signals from individual antennas at the spacecraft are also required. It is important to understand whether space-based techniques are required or if ground-based techniques are adequate. In general, a target spacecraft in deep space cannot be used for calibration because of the long round-trip communication delay.

Design of ultra-phase-stable electronics to maintain the relative phase among antennas is also needed. These will minimize the need for continuous, extensive and/or disruptive calibrations. A primary related effort currently underway is understanding the effect of the medium (primarily the Earth's troposphere) on the coherence of the signals at the target spacecraft. Generally, turbulence in the medium tends to disrupt the coherence in a way that is time-dependent and site-dependent. A quantitative understanding of these effects is needed. Consequently, techniques for integrating a very low-noise, cryogenically cooled receiver with a medium power (1-200 W) transmitter, are desired. If transmitters and receivers are combined on the same antenna, the performance of each should be compromised as little as possible, and the low cost and high reliability should be maintained.

High-Efficiency, Miniature Antennas

High efficiency, low-cost, low-mass, broadband or dual-band miniaturized antennas (UHF or X-band) that radiate circular polarization with full hemispherical coverage are desirable. These antennas must be able to withstand launch and re-entry environments and must be low profile/conformal.

The emergence of frequency-agile radios increases emphasis of antenna capable of bidirectional communications across multiple bands. Accordingly, emphasis on small size, high efficiency and low cost of ownership is desirable. Miniaturization of L-, S-, and C- band for Micro Air Vehicles is also of interest.

Miniaturized antennas that are wearable or can be highly integrated into the host structure/entity, are also desirable. Examples include EVA's space suits made with textile antennas, fractal antennas, or visor mounted antennas. These miniaturized antennas should also be multi-directional to support astronaut mobility, support multi-band operation, and/or possess a broad bandwidth. Antennas should be low/self-powered, small, and efficient, and compatible with communication equipment that can provide high data rate coverage at short ranges (~1.5 - 3 km, horizon for the Moon for EVA).

Smart, Reconfigurable Antennas

NASA is interested in smart, reconfigurable antennas for applications in lunar and planetary operations. The characteristics to consider include the frequency, polarization, and the radiation pattern. Low-cost approaches are encouraged to reduce the number of antenna apertures needed to meet the requirements associated with lunar and planetary surface exploration (e.g., rovers, pressurized surface vehicles, habitats, etc.). Desirable features include multi-beam operation to support connectivity to different communication nodes on lunar and planetary surfaces, or in support of communication links for satellite relays around planetary orbits. The antenna shall also be highly directive, multi-frequency and compatible with the Multiple Input Multiple Output (MIMO) concept.

Large Aperture Inflatable/Deployable Antennas

Large aperture inflatable/deployable membrane antennas to significantly reduce stowage volume (packaging efficiencies as high as 50:1), provide high deployment reliability, and significantly reduced mass density (i.e., < 1kg/square meter) are needed. These large Gossamer-like antennas are required to provide high-capacity communication links with low fabrication costs from the Moon/Mars surface to relay satellites or Earth. These membrane antennas are deployed from a small package via some inflation/deployment mechanism. Techniques for rigidizing these membrane antennas without the use of gases (e.g., ultraviolet curing), as well as thin-membrane tensioning and support techniques to achieve precision and wrinkle-free surfaces, in particular for applications at Ka-band or higher frequencies, are desirable.

Novel materials (including memory matrix materials), low fabrication costs and deployment and construction methods using low emissive materials to enable passive microwave instrument application are also beneficial. Structural health monitoring systems are needed to support pre-flight integration, and test activities to determine in-flight system health, are of interest. The ability to incorporate structural considerations for mission applications is also desired (e.g., aero-braking for deep space planetary missions).

Membrane materials for large inflatable membrane antennas for remote sensing applications for earth and planetary science missions are of particular interest to the Science Mission Directorate. The current state of the art for mechanical deployable antennas is reaching limits on packaging efficiencies. Reflectors manufactured from polymer films could enable greater packaging efficiencies due to their low mass, high packaging efficiencies, solar radiation resistance, and cryogenic flexibility. However, most polymer films, including polyimide polymer films, have many challenges that limit their usefulness in practical space applications. Active membrane control system concepts, developed to reduce shape errors, often add unwanted bulk and mass to the antenna system. While other concepts will be entertained, specific membrane material technology innovations of interest are listed below:

- Polymer membrane (0.5 mil to 2.0 mil) material exhibiting zero or near-zero Coefficient of Thermal Expansion (CTE).
- Polymer membrane material exhibiting durability to the space environment, including atomic oxygen, VUV, solar particulate radiation, and temperature extremes.
- Thin film deployment methods that deploy the antenna surface substantially free of wrinkles.
- Innovative intrinsically electroactive polymer membrane actuation mechanisms that can be used to shape-correct the antenna surface.

Additionally, composite materials for large deployable antenna reflector structures for remote sensing applications for earth and planetary science missions with high specific stiffness composite materials that can be packed compactly and deployed multiple times for ground evaluation of the antenna structure prior to launch and deployment in space are of interest. Investigators should consider materials that can be folded and deployed on the order of 5 to 10 times with up to 180 degree bends that retain their structural integrity and shape accuracy upon final deployment. The deployment of these materials should require low energy. Rigidizable materials (Shape Memory Polymers, Shape Memory Composites, UV Activated Composites, etc.) could be considered to obtain the appropriate structural stiffness and post-deployment precision.

Prospective proposers are advised to review Subtopic S1.02, Active Microwave Technologies, for additional remote sensing applications needs, and indicate applicability in their proposal(s).

Antenna Adaptive Beam Correction with Pointing Control
Antenna adaptive beam correction with pointing control that can provide spacecraft knowledge with fine beam pointing with sub-milliradian precision (e.g., < 250 micro-radians) in order to point large spacecraft antennas (e.g., 10-m diameter) in Mars' vicinity is also desirable under this subtopic. The challenges include antenna reflector surface distortions in a space environment; compensation techniques to optimize antenna beam patterns; ground- and space-based methods to monitor spacecraft antenna distortions; and advanced technologies that enable antenna pointing accuracies in the sub-milliradian range for Ka-band spacecraft applications. Methods of dealing with extreme latency (e.g., 20 minutes) in beacon and monopulse systems are of interest. Advances would lead to enhanced space communication links. Size, weight, and power requirements are of concern.

Parallelized Numerical Solvers for Antenna Modeling/Design
Development of full 3-D electromagnetic (EM) solvers that take advantage of new software engineering approaches (e.g., object oriented programming) and parallel computing resources for fast and accurate modeling/design of antennas, antennas with feed structures, and antennas in multi-path environment are of interest. Numerical solvers offering fast and accurate synthesis via search algorithms (e.g., genetic algorithm) of patch arrays and waveguide slot arrays, to reduce design time, are also of interest. All solvers must aim toward experimental validation of actual antenna concept being simulated.

Communication Antennas with Improved Performance
High performance, low-cost antennas are needed for a variety of missions for communicating with TDRSS, GPS (L1, L2, and L5 bands), or the Deep Space Network (DSN). The frequency bands of interest are L-, S-, X-, Ku-, and Ka-band. Antenna concepts that offer significant improvement in cost and performance (e.g., mass, gain, efficiency, VSWR, axial ratio, bandwidth, power handling, vibration tolerance, etc.) over existing off-the-shelf antennas would be of interest. Novel isoflux antennas at S- and X-band would also be of interest. Antennas must be able to withstand launch environments.

Deliverables and Development Timeline
After a possible Phase 3 development activity, these technologies are expected to ready for insertion at TRL 6 by 2015. Therefore a TRL progression from an entry TRL of 1 - 2 for Phase 1 in January 2010 followed by an exit TRL of 3 - 4 after Phase 2 is reasonable.

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward Phase 2 hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

Phase 1 Deliverables
A final report containing optimal design for the technology concept including feasibility of concept and a detailed path towards Phase 2 hardware and/or software demonstration. The report shall also provide options for potential Phase 3 funding from other government agencies (OGA).

Phase 2 Deliverables
A working proof-of-concept demonstrated and delivered to NASA for testing and verification.

O1.03 Reconfigurable/Reprogrammable Communication Systems
Lead Center: GRC
Participating Center(s): ARC, DFRC, GSFC, JPL, JSC

NASA seeks novel approaches in reconfigurable, reprogrammable transceiver systems for Space Operations, Exploration, Science, and Aeronautics research. Exploration of Lunar and Mars environments will require advancements in radio communication systems to manage the demands of the harsh space environment on space electronics, maintain flexibility and adaptability to changing needs and requirements, and provide flexibility and survivability due to increased mission durations. NASA missions can have vastly different transceiver requirements (e.g., 1's to 10's Mbps at UHF- and S-band frequency bands up to 10's to 1000's Mbps at X- and Ka-band frequency bands.) and available resources depending on the science objective, operating environment, and spacecraft resources. For example, deep space missions are often power constrained; operating over large distances, and subsequently have lower data transmission rates when compared to near-Earth or near planetary satellites. These requirements and resource limitations are known prior to launch; therefore, the scalability feature can be used to maximize transceiver efficiency while minimizing resources consumed. Larger platforms such as vehicles or relay spacecraft may provide more resources but may also be expected to perform more complex functions or support multiple and simultaneous communication links to a diverse set of assets.

This solicitation seeks advancements in reconfigurable transceiver and associated component technology. The goal of the subtopic is to provide flexible, reconfigurable communications capability while minimizing on-board resources and cost. Topics of interest include the development of software defined radios or radio subsystems which demonstrate reconfigurability, flexibility, reduced power consumption of digital signal processing systems, increased performance and bandwidth, reduced software qualification cost, and error detection and mitigation technologies. Complex reconfigurable systems will provide multiple channel and multiple and simultaneous waveforms. Areas of interest to develop and/or demonstrate are as follows:

- Enable advancements in bandwidth capacity, reduced resource consumption, or adherence to the Space Telecommunications Radio System (STRS) standard and open hardware and software interfaces. Techniques should include fault tolerant, reliable software execution, reprogrammable digital signal processing devices.
- Reconfigurable software and firmware which provide access control, authentication, and data integrity checks of the reconfiguration process including partial reconfiguration which allows simultaneous operation and upload of new waveforms or functions.
- Operator or automated reconfiguration or waveform load detection failure and the ability to provide access back to a known, reliable operational state. An automated restore capability ensures the system can revert to a baseline configuration, thereby avoiding permanent communications loss due to an errant reconfiguration process or logic upset.
- Develop dynamic or distributed on-board processing architectures to provide reconfigurability and processing capacity. For example, demonstrate technologies to enable a common processing system capacity for communications, science, and health monitoring.
- Adaptive modulation and waveform recognition techniques are desired to enable transceivers to exchange waveforms with other assets automatically or through ground control.

- Low overhead, low complexity hardware and software architectures to enable hardware or software component or design reuse (e.g., software portability) that demonstrates cost or time savings. Emphasis should be on the application of open standards architecture to facilitate interoperability among different vendors to minimize the operational impact of upgrading hardware and software components.
- Software tools or tool chain methodologies to enable both design and software modeling and code reuse and advancements in optimized code generation for digital signal processing systems.
- Use of reconfigurable logic devices in software defined radios is expected to increase in the future to provide reconfigurability and on-orbit flexibility for waveforms and applications. As the densities of these devices continue to increase and feature size decreases, the susceptibility of the electronics to single event effects also increases. Novel approaches to mitigate single event effects in reconfigurable logic caused by charged particles are sought to improve reliability. New methods should show advancements in reduced cost, power consumption or complexity compared to traditional approaches such as voting schemes and scrubbing.
- Techniques and implementations to provide a core capability within the software defined radio in the event of failure or disruption of the primary waveform and/or system hardware. Communication loss should be detected and core capability (e.g., "gold" waveform code) automatically executed to provide access control and restore operation.
- Innovative solutions to software defined radio implementations that reduce power consumption and mass. Solutions should enable future hardware scalability among different mission classes (e.g., low rate deep space to moderate or high rate near planetary, or relay spacecraft) and should promote modularity and common, open interfaces.
- In component technology, advancements in analog-to-digital converters or digital-to-analog converters to increase sampling and resolution capabilities, novel techniques to increase memory densities, and advancements in processing and reconfigurable logic technology each reducing power consumption and improving performance in harsh space environments.
- Development of radio technology that allows the incorporation of Space Network (SN) waveforms and candidate Lunar Surface System (LSS) wideband waveforms such as 802.11 and 802.16 into a single multimode radio capable of supporting simultaneous communications with space and lunar network assets. Development and implementation of direct RF to digital technologies that are currently emerging and can offer significant improvements in the flexibility of software or multi-mode radios. The goal is to maximize flexibility and capability to share lunar communications infrastructure and therefore minimize mass of radio components that must to be delivered to the lunar surface.
- Small, lightweight all-digital reconfigurable radios and transceivers that eliminate analog front ends that operate across multiple bands, are sought for applications that involve network enhanced telemetry, leading towards adaptive and cognitive radio applications. Application of reconfigurable systems in airborne and terrestrial systems is of interest.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward Phase 2 hardware and software demonstration and delivering a hardware demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

O1.04 Miniaturized Digital EVA Radio
Lead Center: JSC
Participating Center(s): GRC

As NASA embarks upon deep space human exploration, the next-generation EVA radio will be a pivotal technology and integral part of lunar surface systems success. It will facilitate surface operations, enable crew mobility, and support point to multi-point communications across rovers, landers, habitat, and other astronauts. Driven by Communications, Command, Control, and Information (C3I) interoperability, tight power budgets, and extreme miniaturization, this mobile radio platform must be power efficient and highly adaptive. With a scant EVA radio power budget of less than four watts, the S-band (2.4 - 2.483 GHz) adaptive radio must deliver voice, telemetry, and high-definition motion imagery transmissions. To surmount interference, the radio must support frequency diversity over the specified S-band spectrum of 2.4 - 2.483 Ghz. During nominal operations, it is designed to operate with a mobile ad hoc network (MANET) so the coverage for communications can be extended indefinitely with node additions. It will communicate to fixed and mobile nodes, including lunar base stations, landers, habitats, rovers, and other astronauts. Therefore, it must support multiple bandwidths, waveforms, and energy profiles. To achieve the overarching communication goals of small form factor, ultra-power , and reconfigurability, NASA needs to extend the state-of-the art in two key areas:

Tunable RF Front End and Transceiver
The major impetus behind the MEMS technology stems from compactness which leads to lower power dissipation, higher levels of integration, lower weight, volume, and cost. To shrink form factor and enable efficient surface operations, one of the cornerstone radio components of this radio is the tunable filter. Recent advances in RF MEMs filters and resonator technology have permitted very high quality factors (>1000) at GHz frequencies. Achieving high and excellent tuning range (>2:1) to bandwidth ratio without cryogenic cooling is now viable for the S-band frequency. For reliability, the tunable filter should employ a contact-less tuning scheme.

Also, a new class of MEMS-based frequency synthesizers offers dramatic reduction in noise, power, and form factor. One should leverage emerging microscale resonator technologies to the maximum extent. Low phase noise synthesizers running at ultra low power levels are viable using high Q resonator technologies MEMS resonators-based phase lock loop offers compelling power and noise performance enhancements.

Power-Aware Processing
To support QoS of different applications, it's not enough to optimize power at design time, but dynamic power management must be employed to ensure power efficiency. To maximum power efficiency, it must be able to adjust power and update rates to suit diverse missions. Users should be able to specify Quality of Service (QoS) for different data streams. The radio must have the capability to scale power, select the optimum mode of operation, and minimum energy profile. During low-rate-processing intensive modes, including local processing and compression of telemetry data and voice, highly energy-efficient low-voltage, low-performance modes must be used. For high-rate-processing intensive modes, like advance signal encoding of high motion imagery, medium performance modes must be used; and during active communication modes (which may have a low duty-cycle), ultra-high-performance modes must be used. Accordingly, the digital platform must be highly agile and use-case aware to continuously minimize energy. Below are the desirable technology features.

Bear in mind, research should be conducted to demonstrate technical feasibility during Phase 1 and to show a path towards a hardware and software demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

Phase 1 Deliverables
Conduct design trade analyses between power, performance, and flexibility. Estimate mass, volume, power, max/min range, and data rates for dynamic quality of service- voice, telemetry, video- standard and high definition TV at S-band (2.4 - 2.483 GHz), backed with analyses and simulation to ensure achievable performance and power goals.

Develop a promising MEMS-based system-on-chip radio design with the following features:

- **Variation-tolerant, performance-scalable architectures:** Hardware must sense its own limitation at a dynamically varying, performance-driven optimal energy operating point, and reconfigure accordingly. If variability is stressed at the low-voltage operating point, redundant hardware should be used to improve reliability; if throughput is stressed at the high-performance operating point, redundant hardware should be used to increase parallelism.
- **Highly agile platform components (SRAM and logic):** Circuits should use functionality assists, including selective biasing, leakage-control, routing resources, etc., that get engaged dynamically depending on the operating point.
- **Energy-aware algorithms for adaptive hardware:** Algorithms must be aware of the different hardware operating-points and associated architecture. For instance, during low-power modes targeting voice and data (for telemetry), occasional high through-put applications (like high motion imagery) should dynamically switch to algorithms employing extreme parallelism in order to support a minimum operating voltage.
- **Extreme power converters:** To minimize off-chip components, DC-DC converters should use a single reconfigurable architecture that efficiently delivers load powers ranging from micro-Watts, at low-voltages, to Watts, at high voltages.

- **High performance ultra-low power ADCs:** Exploit novel ADCs with sampling frequencies in tunable multi GHz range (preferable double digits). Variable resolution up to 20 bits or higher with ultra-low power jitters for finer resolutions at higher bits and comparators managed for higher bits with minimum power overheads. A high sampling rate is desirable. SNR optimizations and efficient signal recovery demonstration is a requirement for validating ADC capabilities.
- **Modularity and extensibility:** Enabling platform must support open architecture and accommodate rapid upgrades, multiple protocols, new technology advances, complete re-configurability of functionality, and evolution of lunar communications and network infrastructure.

One significant prerequisite to Phase 2 is the development of most promising MEMS-based transceiver system-on-chip (SoC) architecture The offeror must demonstrate the ability to achieve significant advantage in compactness and ensure power efficiency and reliability.

Phase 2 Deliverables
Develop a reliable, intelligent, and power-efficient MEMS-based EVA digital radio prototype unit, demonstrating robust and dynamic power management. The miniaturized radio technology must reach TRL=5 at the end of Phase 2.

Demonstrate RF performance and power consumption of less than four watts, delivering voice, telemetry, and standard and high-definition video motion imagery at 2.4 - 2.483 GHz (S-band). With power constraints of under four watts, performance and reliability must be assured for multiple bandwidths and data transmissions of telemetry, voice, and high-rate video.

O1.05 Transformational Communications Technology
Lead Center: GRC
Participating Center(s): JSC

NASA seeks revolutionary, highly innovative, transformational communications technologies that have the potential to enable order of magnitude performance improvements for space operations, exploration systems, and science mission applications.

Research emphasizing both nearer-term and far-term technologies is focused (but not limited to) in the following areas:

Near-Term Focus Areas:
- Develop novel techniques to reduce the size, weight, and power (SWAP) of communications transceivers for space missions. Address SWAP challenges by addressing digital processing and logic implementation tradeoffs, static vs. dynamic power, voltage and frequency scaling, hardware and software partitioning such that operational modes are effectively managed. Great demands will be placed on these communication transceivers to assure crew safety and robustness in harsh deep-space environments for long duration missions. Investigate and demonstrate novel RF communication technologies to alleviate the demanding requirements on analog to digital converters (ADCs) and digital signal processors (DSPs). For software-defined radios, such requirements can result in high ADC power consumption, large form factor, and expensive components, which can pose problems for power and weight constrained deep space missions.
- Significant component-level technical advances are needed in the area of UHF/VHF filter technologies. Novel, smaller form factor, lower cost, higher performance, and lower weight than existing devices are to be demonstrated employing new technologies such as MEMS resonators (e.g., electrostatic, piezoelectric) and tunable dielectrics. Filter solutions that offer a bandwidth tunability or reconfigurability and filter banks are also sought. Fractional bandwidths of 0.1% to greater than 2% are of interest, where for narrower bandwidths, operating stability across temperature is necessary. At the conclusion of Phase 1, proposers should clearly delineate, through a combination of theoretical analysis and demonstrated prototypes, that the proposed solution can achieve better than 3 dB of insertion loss, better than 70 dB of rejection, less than 1 dB of ripple, small shape factors, power handling greater than +20 dBm, VSWR less than 2, and robust operation in a harsh space environment. Phase 2 will leverage the analysis and prototypes developed in Phase 1 to meet to the specifications for space-based communication links and will deliver a demonstration unit of the proposed technology for testing. Phase 2 will also evaluate component reliability to ensure ro-

bust operation across the harsh temperature, vibration, shock, and other conditions encountered in space operation.

- NASA seeks to integrate RFID, antenna, flexible organic material (e.g., Liquid-crystal polymer with constant dielectric properties from 1-110 GHz) and energy-scavenging technologies to develop ultra-low-cost enhanced range sensor surface nodes. This new generation of conformal wireless nodes based on the utilization of UHF semi-passive RFIDs on beacons and astronaut suits would enable the development of robust communication links through the implementation of very-large-scale ad-hoc networks for rugged and/or emergency response environments. Many technical challenges are associated with the development and enhancement of localization and precise tracking of assets for long-duration missions. To leverage terrain-adaptive navigation solutions, inventory tracking, and astronaut body area network applications, several quantum leap technologies including semi-passive RFID-enabled wearable tags and multi-hopping inflatable beacons need to be advanced to demonstrate ranges in excess of 200 m. Astronauts wearing at least 4 miniaturized ultra-low-power inertial sensors at spacings below the operation wavelength of 2.4GHz (EVA) could enable RFID-enabled inflatable beacons for accurate tracking and navigation. The capability of state-of-the-art wireless systems to provide precise timing/time-tracking with nanosecond accuracy coupled with ultra-low-power wearable inertial sensors and low-power multi-hopping algorithms between beacon-mounted and astronaut-mounted RFIDs can enable true mobility location awareness in ranges in excess of 500/1000 meters. Low power beacons (assuming a duty cycle of 5-10 %) can be solar powered and fabricated in an inflatable triangular shape. It has already been already been proven that some solar-powered "semi-passive" RFID's with a single-hop range of 100+m consumes only 80 microwatts and can improved by a factor of 3 to 5. Yet, to have a practical ad-hoc beacon network with effective beacon-to-beacon and beacon-to-RFID ranges in excess of 1 km, with beacon power levels between 20 microwatts to 5 milliwatts, various technical challenges need to be addressed: solar panels should achieve efficiencies greater than 50% and should be easily printed as a substrate of the printed beacon antennas, the electronics should operate in sub-threshold domain, the IC power consumption should be below 20 microwatts, and the antenna should feature at least two different frequencies for redundancy. Solutions should consider employing power scavenging merging dynamic/kinetic energy from the astronaut motion (mounted on boots), solar energy (through thin-films on uniform), thermal/vibration energy (through inkjet-printed nanotube-based wearable textiles), thus minimizing the use of portable battery. Phase 1 effort should introduce an "ad-hoc" wearable network of 3-5 RFID-enabled wearable inertial sensors that could provide voice-level communication with inflatable beacons with total power consumption below 500 microwatts. Up to 5 hops with 300m + hop will be investigated for enhanced range wireless links for 433 MHz, 900MHz and integration. The prototype should include 5+ wearable tags and 5+ inflatable beacons and 3 test frequencies. Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 multi-tag, multi-scenario hardware demonstration prototype unit.

Far-Term Focus Areas:

- The promise of high-performance, multi-functional, nanostructured materials has led to intense interest in developing them for applications for human spaceflight and exploration. These materials (notably single wall carbon nanotubes) exhibit extraordinary mechanical, electrical, and thermal properties at the nanoscale and possess exceptionally high surface area. The development of nano-scale communication devices and systems including nano-antennas, nano-transceivers, etc. are of interest for nano-spacecraft applications.
- Quantum entanglement or innovative breakthroughs in quantum information physics has sparked interest to specifically address this phenomenon and the critical unknowns relevant to revolutionary improvements in communicating data, information or knowledge. Methods or techniques that demonstrate extremely novel means of effectively packaging, storing, encrypting, and/or transferring information are sought.
- Innovative approaches to use of medium to high frequency (300 KHz-30MHz) bands for applications benefiting future lunar missions. Concepts, studies, development of key technologies are needed to perform non-line-of-sight communication for potential use on the surface of the Moon. Modulation and coding techniques, antennas, solid-state amplifiers, digital baseband circuitry, etc. are required to be developed and/or validated to enable over the horizon communication and communications into craters for robotic and human missions. Range of communications on the order of 10-20 kilometers at a data rate of 128 kbps is envisioned to support many of these types of lunar surface links.
- Ultra-wideband (UWB) or impulse radio wireless communications, navigation and tracking for lunar applications. UWB has the capability of pervasive wireless transmission of data, video, etc., very fine time resolution, low power spectral density, and resistance to multipath. Device, component and/or subsystems

that can enable use of UWB for space-based applications are sought, including but not limited to: transceivers, highly efficient antennas; array beamformers; space-time processing techniques; accurate timing generators for sub-nanosecond pulse widths; matched filters; channel estimators; low power, high bandwidth A/D converters with extended time sampling.

O1.06 Long Range Optical Telecommunications
Lead Center: JPL
Participating Center(s): ARC, GRC, GSFC

This subtopic seeks innovative technologies for long range Optical Telecommunications supporting the needs of space missions. Proposals are sought in the following areas:

- **Systems:** 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.
- **Small lightweight two-axis gimbals:** Approximately 1 kg in mass capable to actuating payload mass of approximately 6 kg at rates up to 5 degrees/second, with less than 30 micro-radian rms error and blind-pointing accuracy of less than 35 micro-radian. Assume that the payload is shaped as an 8-cm diameter cylinder, 30-cm long, with uniformly distributed mass. Proposals should come up with innovative pragmatic designs that can be flown in space.
- **Photon counting Si, InGaAs, and HgCdTe detectors and arrays:** For the 1000 to 1600 nm wavelength range with single photon detection efficiencies greater than 60% and output jitters less than 20 pico-second, active area greater than 20 microns/pixel, and 1 dB saturation rates of at least 100 mega-photons (detected) per pixel and dark count rates of less than 1 MHz/square-mm.
- **Single-photon-sensitive, high-bandwidth, linear mode photo-detectors:** With high bandwidth (>1GHz), high gain (>1000), low-noise (<1kcps), large diameter (200 micron), HgCdTe avalanche photodiode and/or (small diameter) arrays for optical detection at 1060 nm or 1550 nm.
- **Uncooled photon counting imagers:** With >1024 x 1024 formats, ultra low dark count rates and visible to near-IR sensitivity.
- **Ultra-low fixed pattern non-uniformity NIR imagers:** With large format (1024x1024), non-uniformity of less than 0.1%, low noise (<1e- read, <1ke/pix/s dark) and high (>0.7) quantum efficiency.
- **Radiation hard photon counting detectors and arrays:** For the 1000 to 1600 nm wavelength range with single photon detection efficiencies greater than 40% and 1dB saturation rates of at least 30 mega-photons/pixel and operational temperatures above 220K and dark count rates of <10 MHz/mm. Radiation levels of at least 100 Mrad (unprotected).
- **Isolation platforms:** Compact, lightweight, low power, broad bandwidth (0.1 Hz -3 kHz) disturbance rejection.
- **Laser Transmitters:** Space-qualifiable, greater than 20% wall plug efficiency, lightweight, 20-500 pico-second pulse-width (10 to >100 MHz PRF), tunable (~0.2 nm) pulsed 1064-nm or 1550-nm laser transmitter fiber MOPA sources with greater than1 kW of peak power per pulse (over the entire pulse-repetition rate), with Stimulated Brillouin Scattering suppression and >10 W of average power, near transform limited spectral width, and less than 10 pico-second pulse rise and fall times. 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.
- **Low-cost ground-based telescope assembly:** With diameter greater than 2-m, primary mirror with f–number of ~1.1 and Cassegrain focus to be used as optical communication receiver optics. Maximum RMS surface figure error of 1-wave at 1000 nm wavelength. Telescope shall be positioned with a two-axis gimbal capable of 0.25mrad pointing. Combined telescope, gimbal and dome shall be manufacturable in quantity (tens) for ~$1.5M each.
- **Daytime atmospheric compensation techniques:** Capable of removing all significant atmospheric turbulence distortions (tilt and higher-order components) on an uplink laser beam; and/or for a 2-m diameter downlink receiver telescope. Also of interest are technologies to compensate for the static and dynamic (gravity sag and thermal) aberrations of 2-m diameter telescopes with a surface figure of 10's of waves.

Research should be conducted to convincingly prove technical feasibility during Phase 1, with clear pathways to demonstrating and delivering functional hardware, meeting all objectives and specifications, in Phase 2.

O1.07 Long Range Space RF Telecommunications
Lead Center: JPL
Participating Center(s): ARC, GRC, GSFC

Solicitation Summary
This solicitation seeks to develop innovative long-range RF telecommunications technologies supporting the needs of space missions.

Purpose (based on NASA needs) and current state-of-the-art
In the future, spacecraft with increasingly capable instruments producing large quantities of data will be visiting the moon and the planets. To support the communication needs of these missions and maximize the data return to Earth, innovative long-range telecommunications technologies that maximize power efficiency, transmitted power density and data rate, while minimizing size, mass and power are required.

The current state-of-the-art in long-range RF space telecommunications is about 2 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%.

Specifications and Requirements

- Ultra-small, light-weight, low-cost, low-power, modular deep-space transceivers, transponders and components, incorporating MMICs and Bi-CMOS circuits;
- MMIC modulators with drivers to provide large linear phase modulation (above 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-efficiency (> 60%) 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 techniques and/or wide band-gap semiconductor devices at X-band (8.4 GHz) and Ka-band (26 GHz, 32 GHz and 38 GHz);
- Epitaxial GaN films with threading dislocations less than 106 per cm2 for use in space qualified wide band-gap semiconductor devices at X- and Ka-band;
- Utilization of nano-materials and/or other novel materials and techniques for improving the power efficiency or reducing the cost of reliable vacuum electronics amplifier components (e.g. TWTAs and Klystrons);
- SSPAs, modulators and MMICs for 26 GHz Ka-band (lunar communication);
- Improved integrated non-linear amplifier/modulator designs that reduce crest-factor impacts and significantly enhance the efficiency of high peak-to-average power ratio waveforms, such as 802.11 and 802.16;
- TWTAs operating at millimeter wave frequencies (e.g. W-Band) and at data rates of 10 Gbps or higher;
- Ultra low-noise amplifiers (MMICs or hybrid) for RF front-ends (< 50 K noise temperature); and
- MEMS-based RF switches and photonic control devices needed for use in reconfigurable antennas, phase shifters, amplifiers, oscillators, and in-flight reconfigurable filters. Frequencies of interest include VHF, UHF, L-, S-, X-, Ka-, V-band (60 GHz) and W-band (94 GHz). Of particular interest is Ka-band from 25.5 - 27 GHz and 31.5 - 34 GHz.

Phase 1 Deliverables
Feasibility study, including simulations and measurements, proving the proposed approach to develop a given product. Verification matrix of measurements to be performed at the end of Phase 2, along with specific quantitative pass-fail ranges for each quantity listed.

Phase 2 Deliverables
Working engineering model of proposed product, along with full report of on development and measurements, including populated verification matrix from Phase 1.

O1.08 Lunar Surface Communication Networks and Orbit Access Links
Lead Center: GRC
Participating Center(s): JPL, JSC, GSFC

This solicitation seeks to develop a highly robust, bidirectional, and disruption-tolerant communications network for the lunar surface and lunar orbital access links. Exploration of lunar and planetary surfaces will require short-range (~1.6 km line-of sight, ~5.6 km non-line-of-sight) bi-directional, often highly asymmetric, and robust multiple-point links to provide on-demand, disruption and delay-tolerant, and autonomous interconnection among surface-based assets. Minimization of communication asset scheduling, and other ground operation support, is highly desirable. Some of the nodes will be fixed, such as base stations and relays to orbital assets, and some transportable, such as rovers and humans. The ability to meet the demanding environment presented by lunar and planetary surfaces will encompass the development and integration of a number of communication and networking technologies and protocols.

NASA lunar surface networks will be dynamic in nature, and required to deliver multiple data flows with different priorities (operational voice, command/control, telemetry, various qualities of video flows, and others). Bandwidth and power efficient approaches to mobile ad hoc networks are desired. Quality of Service (QoS) algorithms in a Mobile Ad hoc NETwork (MANET) setting will need to be developed and tailored to NASA mission specific needs and for the lunar surface environment. Exploitation of delay/disruption tolerant network (DTN) technology to maximize autonomy of the communication infrastructure and to minimize demands on channel capacity is of significant interest. Advantages and disadvantages associated with parallel DTN and IP networks, and a competing DTN-over-IP network architecture, should be considered. Possible associated considerations include routing, security, and QoS.

These lunar and planetary surface networks will need to seamlessly interface with communications access terminals and orbiting relays that also can provide autonomous connectivity to Earth based assets. The access link communications system will encompass the development and integration of a number of communications and networking technologies and protocols to meet the stringent demands of continuous interoperable communications. Human exploration, therefore, requires the development of innovative communication protocols that exploit persistent storage on mobile and stationary nodes to ensure timely and reliable delivery of data even when no stable end-to-end paths exist. Solutions must exploit stability when it exists to nearly approximate the performance of conventional MANET protocols. The capability of the network to provide infrastructure-based position determination and navigation is of interest to NASA, especially when coverage issues arise and/or orbiter access links are unavailable. The extent to which the network can support localization of mobile nodes should be addressed, and network architecture options that could further support navigation should be identified.

Frequency bands of interest are UHF (401 - 402 MHz, 25 kHz bandwidth), S-band (2.4 - 2.483 GHz), and Ka-band (22.55 - 23.55 GHz). Existing commercial standards for the PHY and MAC layers should be leveraged to the extent possible while meeting other requirements, with modifications considered when necessary. Results from NASA's Lunar Architecture Team, as well as technology trade studies performed for NASA's Constellation Systems, should be referenced for input regarding data flows, coverage, network requirements, etc. EVA study results can be found at:

EVA Technology Development path loss study: http://gltrs.grc.nasa.gov/reports/2007/TM-2007-214825.pdf

Specific Subtopic Capabilities to Address This Year
This year's call intends to focus innovations in 4 key areas. Participants should focus their proposed innovation in one or more of these key areas:

- Differentiated services and QoS support in dynamic wireless networks when safety-of-life and data flows critical to the mission are traversing the network.
- DTN prototype protocol development and demonstration in an emulated operational network.
- Secure data transfers over mobile, dynamic wireless networks with potential interferers and/or interceptors.
- Position determination and navigation based novel uses of the network infrastructure (e.g. utilizing radiometric information from the network signaling).

Proposal should address the following:

- Network traffic models
- Network architecture (both hardware and software)
- Spectrum usage
- Security plan (if the proposal deals with particular innovations in this area)
- Identification of software and/or hardware technologies common to networking components that will have the largest impact on size, weight, and power reduction while not compromising the goals of the network architecture as listed above.

Phase 1 Deliverables
A trade analysis identifying novel software and/or hardware technologies common to networking components that will have the largest impact on size, weight, and power reduction while not compromising the goals of the network architecture is the most important aspect of the Phase 1 deliverable. It is not reasonable to expect that all issues and technologies concerning the network architecture proposed will be developed under a Phase 2 contract. However, the proposer should identify and rank novel hardware/software components based on size/weight/power reduction that will enable the proposed network architecture. The proposer should also identify how they are uniquely qualified to develop the novel technologies to products beneficial to NASA, DoD, and perhaps commercial interests.

The Phase 1 proposal should clearly state the assumptions, proposed network architecture, and innovations regarding the 4 key areas mentioned above.

Phase 2 Deliverables
The novel software and/or hardware component identified in Phase 1 will be developed to a state in which it may be demonstrated and the feasibility of the approach on an actual platform may be quantitatively evaluated by NASA testing at the completion of the Phase 2 contract. (TRL 4 or better).

O1.09 Software for Space Communications Infrastructure Operations
Lead Center: JPL
Participating Center(s): GRC, GSFC

New technology is sought to improve resource optimization and the user interface of planning and scheduling tools for NASA's Space Communications Infrastructure. The software created should have a commercialization approach with the new modules fitting into an existing or in development planning and scheduling tool.

Purpose (based on NASA needs) and the current state of the art:
The current infrastructure for NASA Space Communications provides services for near-Earth spacecraft and deep space planetary missions. The infrastructure assets include the Deep Space Network (DSN), the Ground Network (GN), and the Space Network (SN). Recent planning for the Vision for Space Exploration (VSE) for human exploration to the Moon and beyond as well as maintaining vibrant space and Earth science programs resulted in a new concept of the communications architecture. The future communications architecture will evolve from the present legacy assets and with addition of new assets.

NASA seeks automation technologies that will facilitate scheduling of oversubscribed communications resources to support: (1) Increased numbers of missions and customers; (2) Increased number and complexity of constraints (as required by new antenna types); and (3) decreased operations budgets (both core communications network operations and mission side operations budgets.

Core Capabilities:

Intelligent Assistants
In order to automate the user's provision of requirements and refinement of the schedule, "intelligent assistant" software should manage the user interface. Assistants should streamline access and modification of requirement and schedule information. By modeling the user, this software can adjust the level of autonomy enabling decisions to be made by the user or the automated system. Assistants should try to minimize user involvement without making

decisions the user would prefer to make. The assistants should adapt to the user by learning their control preferences. This technology should apply to local/centralized and collaborative scheduling.

In a conflict-aware scheduling system (especially in a collaborative scheduling environment), conflicts are prevalent. With the concept of one big schedule from the beginning of time, real time, to the end of time, resolving conflicts become a difficult task especially since resolving conflicts in a local sense may affect the global schedule. Therefore, an intelligent assistant may provide decision support to the system or the users to assist conflict resolution. This may involve a set of rules combining with certain local/global optimization to generate a list of options for the system or users to choose from.

Resource Optimization
The goal of schedule optimization is to produce allocations that yield the best objectives. These may include maximizing DSN utilization, minimizing loss of desired tracking time, and optimizing project satisfaction. Each project may have their own definition of satisfaction such as maximal science data returned, maximal tracking time, best allocation of the day/week, etc. The difficulty is that we may not satisfy all of these objectives during the optimization process. Obviously, optimal solution for one objective may produce worse results for the other objectives. One possible solution is to map all of these objectives to an overall system goal. This mapping is normally non-linear. Technology needs to be developed for this non-linear mapping for scoring in addition to regular optimization approaches.

Optional Capabilities:

Multiple Agents
In an environment where all system variables can be controlled by a single controller, an optimal solution for the objective function can be achieved by finding the right set of variables. In a collaborative environment with multiple decision makers where each decision maker can only control a subset of the variables, modeling and optimization become a very complex issue. In the proposed collaborative scheduling approach, there are many users/agents that will control their own allocations with interaction with the others. How we model their interactions and define system policy so the interaction can achieve the overall system goal is an important topic. The approach for multiple decision-maker collaboration has been studied in the area of Game Theory. The applications cover many areas including economics and engineering. The major solutions include Pareto, Nash, and Stackelberg. There are many new research areas including incentive control, collaborative control, Ordinal Games, etc. Note that intelligent assistants and multiple agents represent different points on the spectrum of automation. Current operations utilize primarily manual collaborative scheduling, intelligent assistants would enhance users ability to participate in this process and intelligent agents could more automate individual customers scheduling. Ideally, proposed intelligent assistants and distributed agents would also be able to represent customers who do not wish to expose their general preferences and constraints.

A start for reference material on this subtopic may be found at the following:

http://ai.jpl.nasa.gov in the publications area;
http://scp.gsfc.nasa.gov/gn/gnusersguide3.pdf, NASA Ground Network User's Guide, Chapter 9 Scheduling; and
http://scp.gsfc.nasa.gov/tdrss/guide.html, Space Network User’s Guide, SpaceOps Conference Proceedings.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

Phase 1 Deliverables
Propose demonstration of Intelligent Assistants, Resource Optimization, or Multiple Agents on a number of communication asset allocation problem sets (involving dozens of missions, communications assets, and operational constraints). End Phase deliverable would include a detailed rationale for ROI in usage of said technology to communications asset allocation based on knowledge of current and future operations flows.

Phase 2 Deliverables
Demonstrate Intelligent Assistants, Resource Optimization, or Multiple Agents on actual or surrogate communication asset scheduling datasets. Deliverables would include use cases and some evidence of utility of deployment of developed technology.

The proposer to this subtopic is advised that the products proposed may be included in a future small satellite flight opportunity. Please see the SMD Topic S4 on Small Satellites for details regarding those opportunities. If the proposer would like to have their proposal considered for flight in the small satellite program, the proposal should state such and recommend a pathway for that possibility.

TOPIC: O2 Space Transportation

Achieving space flight can be astonishing. It is an undertaking of great complexity, requiring numerous technological and engineering disciplines and a high level of organizational skill. Overcoming Earth's gravity to achieve orbit demands collections of quality data to maintain the security required of the range. The harsh environment of space puts tight constraints on the equipment needed to perform the necessary functions. Not only is there a concern for safety but the 2004 Space Transportation Policy directive states that the U.S. must maintain robust transportation capabilities to assure access to space. Given this backdrop, this topic is designed to address technologies to enable a safer and more reliable space transportation capability. Automated collection of range data, acquisition of specialized weather data, and instrumentation for space transportation system testing are all required. The following subtopics are required to secure technologies for these capabilities.

O2.01 Automated Collection and Transfer of Launch Range Data (Surveillance/Intrusion, Weather)
Lead Center: KSC
Participating Center(s): GRC, GSFC

NASA is seeking innovative technologies for sensors and instrumentation technologies which expedite range clearance by providing real-time situational awareness for safe Range operations from processing to launch and recovery. These sensors and instruments are expected to operate, as a payload, on mobile or deployable Unmanned Aerial Systems (UAS), High Altitude Airships (HAA), buoys, etc. NASA is also seeking innovative technologies to remotely measure electric fields aloft in order to reduce the threat of destruction of a launch vehicle by rocket triggered lightning.

Purpose: NASA is embarking on a new era of space exploration with new launch vehicles and demands for availability to support launch times within hours of one another to ensure mission success. This availability requirement is allocated across the entire launch operations which includes the Range that provides clear corridor of land, air and sea for the vehicles to transit through, as they ascent or return. The current Range infrastructure is aging, labor intensive and independent, and would benefit from new sensors and instrumentation that improve the situational awareness (including weather) of those that are responsible for ensuring public safety, mission assurance and efficient operations.

To aid in this situational awareness the new sensors and instrumentation must be able to operate in the environment that takes advantage of mobile or deployable Unmanned Aerial Systems (UAS), High Altitude Airships (HAA), buoys, etc. Use of these vehicles as a platform is intended to increase the Ranges availability while reducing the cost of operations. Size, power, weight and stability of these systems, that operate on these platforms, will be a major constraint their use.

These sensors and instrumentation provide for the remote detection, recognition, and identification of persons and objects that have intruded into areas of the range that must be cleared in order to conduct safe launch operations. This would include a wide spectrum of optical, infrared, Radio Frequency (RF), and millimeter wave sensors for this purpose. In order to achieve accurate identification, time and position of intruding entities multiple sensors and instruments may be used, or combined through the use of neural networks and data fusion techniques. This will require the use of standards for communications, so that, data from individual sensors or instruments can be combined on a platform and processed on-board, or communicated to central location where a fused solution is processed.

The sensors, instrumentation and algorithms to remotely measure electric fields aloft will reduce the threat of destruction of launch vehicles during ascent by improving the prediction of potential lightning strikes to vehicles due to triggered lightning. Potential candidate technologies include new algorithms to take advantage of existing dual-polarized Doppler five-cm weather radar capability, or entirely new technologies for the remote sensing of electric fields. The ability to economically measure the incremental ballistic wind velocities along the predicted trajectory of launch vehicles at remote and evolving launch ranges at altitudes up to 100 kft via fixed and mobile LIDAR approaches is also highly desirable.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

O2.02 Ground Test Facility Technologies
Lead Center: SSC
Participating Center(s): GRC, MSFC

NASA's Stennis Space Center (SSC) is interested with expanding its suite of test facility modeling tools as well as non-intrusive plume technologies that provide information on propulsion system health, the environments produced by the plumes and the effects of plumes and constituents on facilities and the environment.

Facility Modeling Tools and Methods
Developing and verifying test facilities is complex and expensive. The wide range of pressures, flow rates, and temperatures necessary for engine testing results in complex relationships and dynamics. It is not realistic to physically test each component and the component-to-component interaction in all states before designing a system. Currently, systems must be tuned after fabrication, requiring extensive testing and verification. Tools using computational methods to accurately model and predict system performance are required that integrate simple interfaces with detailed design and/or analysis software. SSC is interested in improving capabilities and methods to accurately predict dynamic responses for transient fluid structure interactions, convective, conductive, and radiant heat transfer for propellant systems, exhaust systems and other components used in rocket propulsion testing. Also of interest is the modeling and prediction of condensation, diffusion, stratification, and concentration gradients for fluid mixtures commonly encountered in testing, such as propellants and purges.

Vacuum System Technologies
Stennis is constructing the new A3 test stand which is designed to test a very large (294,000 lbf thrust) cryogenic rocket engine at a simulated altitude of 100,000 feet. When the air in the engine test chamber is evacuated, the simulated altitude pressures inside the test chamber will be less than 0.20 PSIA. This will result in a very unique environment with extremely low pressures inside a very large chamber and ambient pressures outside this chamber. Due to the unique nature of this test facility, new technologies and measurement techniques will need to be developed to monitor and analyze this environment. These include but are not limited to instrument closeouts at vacuum pressures for hundreds of channels of instrumentation entering the chamber, new sealing technologies for large cryogenic piping entering this very large test cell wall to seal against this unique environment, material fatigue measurement and predictions, inspection techniques for the vacuum chamber structures and diffuser ducting, etc.

Component Design, Prediction and Modeling
Improved capabilities to predict and model the behavior of components (valves, check valves, chokes, etc.) during the facility design process are needed. This capability is required for modeling components in high pressure (to 12,000 psi), with flow rates up to several thousand lb/sec, in cryogenic environments and must address two-phase flows.

Challenges include: accurate, efficient, thermodynamic state models; cavitation models for propellant tanks, valve flows, and run lines; reduction in solution time; improved stability; acoustic interactions; fluid-structure interactions in internal flows.

Plume Environments Measurements
Advanced instrumentation and sensors to monitor the near field and far field effects and products of exhaust plumes. Examples are the levels of acoustic energy and thermal radiation and their interaction/coupling with test articles and facilities and measurements of the final exhaust species that will affect the environment.

Major challenge: Large scale engine plume dispersion modeling and validation.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract. Expected TRL range from 3 to 5.

TOPIC: O3 Processing and Operations

The Space Operations Mission Directorate (SOMD) is responsible for providing mission critical space exploration services to both NASA customers and to other partners within the U.S. and throughout the world: from flying the Space Shuttle, to assembling 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. Each of the activities includes both ground-based and in-flight processing and operations tasks. Support for these tasks that ensures they are accomplished efficiently and accurately enables successful missions and healthy crew.

O3.01 Human Interface Systems and Technologies
Lead Center: GRC
Participating Center(s): ARC, GSFC

The focus of this sub topic is on the development of systems and technologies that advance TRL of man/machine interfaces for humans in space environments. Specific areas of interest include, but are not limited to, high fidelity inbound and outbound speech and audio systems along with data entry/data presentation devices, cameras, metabolic monitoring, health monitoring devices, interfaces that support human/robot interaction, high-level communications protocols and/or standardized interfaces for transmitting and receiving data related to human monitoring systems or human interface systems. Technologies and systems should resolve issues that are peculiar to human/machine interaction in the space environments or exploit unique features of the space environment or both. Interest exists for application to micro-gravity space suits, planetary space suits as well as space-based “shirtsleeve environments” such as onboard the ISS, shuttle or other crew modules. The particular focus area of the topic this year is on Advanced Data Entry systems.

Advanced Data Entry
Terrestrial user-interface devices for controlling portable processing equipment such as laptop computers typically rely on keyboard or touchpad input. Such devices are problematic in the space environment since a suited crewmember must interact with the processing equipment while wearing a pressurized glove. Speech recognition technologies have been proposed and investigated to provide a data entry capability for suited crewmembers. However, speech recognition technologies typically incur a high computational loading burden. Alternative methods and technologies for data entry are anticipated to result in significantly lower processing burden and therefore reduced Size Weight and Power (SWaP) and enhanced system reliability. Preference will be given to proposals that indicate the resulting system will have a low computational burden.

Currently, the main purpose of a suit’s processing system is for providing life-support data-acquisition, monitoring, telemetry, and crewmember alerts. The traditional approach to interact with the EVA processing system is with suit-mounted toggle switches optimally sized for a gloved hand and located in the suit’s chest area. NASA envisions future generations of suits to contain advanced communication, navigation, and information processing capabilities that will require better ways of interacting with the suited crewmember. It is likely that the processing unit(s) will be installed within the suit’s backpack-mounted portable life support unit or in close proximity.

Crewmember usability and efficient operation are prime features of the next-generation input device. The device must operate robustly in the space environment and on the surface of remote planetary bodies. Devices must be tolerant of dust, vacuum, and radiation exposure. During Extra-Vehicular Activity (EVA), a suited crewmember needs to achieve as high a level of mobility as possible, so a suit-mounted computer-input device must not impede the movements of the suited crewmember or unduly burden the suit system with weight, volume, or electrical power constraints.

NASA is seeking systems, subsystems and/or technologies in support of improvements in suit-mounted computer system data entry user-interface devices. Devices or systems should allow the suited crewmember to control a computer processing system and provide text input and/or spatial indication accurately, at high speed, without little or no user fatigue. Possible interactions for data entry include, but are not limited to: inputting direction or positions (for navigation or robotic-aid purposes), inserting notes (e.g., field or experiment notes, images, labeling of images), and selecting/marking items on lists (e.g., zooming, drilling down lists, scrolling through lists, moving items). Concepts may consider that provide solutions installed internally (within the pure-oxygen pressurized envelop of the suit), externally (mounted on the exterior of the suit), or a combination of the two:

Particular interest is in the areas of:

- Human interface devices that support manual control of mechanical devices such as rovers or tools;
- Chording keyboards, suit or glove mounted fabric keyboards or touch-pads;
- Techniques for routing wires or connections between the user interface device and the computer-processing unit;
- Techniques for routing the wires past bearings or avoidance of such.

Other technologies will be considered.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract. Preference will be given to proposals that support in-flight demonstration opportunities on the ISS at the completion of the Phase 2 contract.

O3.02 Vehicle Integration and Ground Processing
Lead Center: KSC
Participating Center(s): MSFC, SSC

This solicitation seeks to create new and innovative technology solutions for assembly, test, integration and processing of the launch vehicle, spacecraft and payloads; end-to-end launch services; and research and development, design, construction and operation of spaceport services. The following areas are of particular interest.

Propellant Servicing Technologies Enabling Lower Life Cycle Costs
Technologies for advanced cryogenic fluid storage and transfer, servicing of chilled/densified fluids and advances in state-of-the-art ground insulation are needed to reduce launch operation costs by minimizing consumable losses. Solutions in support of helium conservation and recovery; recapture, reduction, and elimination of cryogenic propellants vented to atmosphere (zero boil-off); insulation for improved storage and distribution minimizing thermal losses; fire resistant liquid oxygen pumping systems; and instrumentation advances to enable high efficiency operations. Providing solutions with higher efficiency, lower maintenance and longer life while improving safety and improving liquid quality delivery.

Corrosion Control
Technologies for the prevention, detection and mitigation of corrosion/erosion in spaceport facilities and ground support equipment including refractory concrete. Solutions for: damage responsive coatings with corrosion inhibitors; poor-performing refractory concrete; protective coatings for non-painted surfaces; and new environmentally friendly protective coating options to replace products lost due to EPA regulation changes. Providing coating/protection solutions that meet current and emerging environmental restrictions and can endure the corrosive and highly acidic launch environment.

Spaceport Processing Systems Evaluation/Inspection Tools
Technologies in support of defect detection in composite materials; methods for determining structural integrity of bonded assemblies; and non-intrusive inspection of Composite Overwrapped Pressure Vessels (COPV), Orion heat shield and painted surfaces. Solutions for detecting and pinpointing corrosion under painted surfaces; predicting remaining coatings effectiveness/life expectancy; identifying composite defects and evaluating integrity; non-destructive measurement and evaluation of COPV; and damage inspection and acceptance testing of Orion heat shield. Providing solutions that reduce inspection times and provide higher confidence in system reliability and safety concerns and lower life cycle costs.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

This subtopic is also a subtopic for the “Low-Cost and Reliable Access to Space (LCRATS)” topic. Proposals to this subtopic may gain additional consideration to the extent that they effectively address the LCRATS topic (See topic O5 under the Space Operations Mission Directorate).

O3.03 Enabling Research for ISS
Lead Center: JSC
Participating Center(s): GRC, KSC, MSFC

The focus of this sub-topic is on the development of systems and technologies that provide innovative ways to leverage the existing ISS facilities for new payloads or provide on orbit analysis to enhance capabilities, reduce sample return requirements, or enable sample return for existing payloads.

Current utilization of ISS is limited by upmass, downmass, crew time and by the capabilities of the interfaces and hardware already developed. Innovative ways of interfacing existing hardware such as being able to use the light microscopy module (LMM) in the Fluids Integrated Rack (FIR) as a life science microscope could increase biotechnology research capabilities. Enabling additional cell and molecular biology culture techniques by providing innovative hardware to allow for safe, contained transfer of cells from container to container within the Microgravity Sciences Glove Box (MSG) would permit new types of studies on ISS. On orbit analysis techniques that would reduce or remove the need for downmass (such as a system for gene array tests, or kits for DNA extractions for long term storage) are also examples of hardware possibilities that would extend and enable additional research.

Capabilities that extend the types of studies that can be completed in orbit are not limited to the above examples or to biotechnology disciplines. Innovative methods for further subdividing payloads lockers to enable numerous pico-payloads, or developing an innovative generic control system to interface with existing ISS control systems are a further examples of the type of technology that is requested under this subtopic.

The existing hardware suite and interfaces available on ISS can be found at:
http://www.nasa.gov/mission_pages/station/science/experiments/Discipline.html

Due to the difficulty and complexity of qualifying hardware for human spaceflight, proposals under this subtopic are expected to advance the development to a level demonstrating the technology in the lab or relevant environment under the SBIR program.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward Phase 2 hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

TOPIC: O4 Navigation

NASA is seeking innovative research in the areas of positioning, navigation, and timing (PNT) that have relevance to Space Communications and Navigation programs and goals, as described at http://www.spacecomm.nasa.gov. NASA's Space Communication and Navigation Office considers the three elements of PNT to represent distinct, constituent capabilities: (1) positioning, by which we mean accurate and precise determination of an asset's location and orientation referenced to a coordinate system; (2) 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; and (3) timing, by which we mean an asset's acquiring from a standard, maintaining within user-defined parameters, and transferring where required, an accurate and precise representation of time. NASA has divided its PNT interests into six focus areas: (1) Global Positioning System (GPS) (2) Distress Alerting Satellite System (DASS) (3) Flight Dynamics (4) Tracking and Data Relay Satellite System (TDRSS) (5) TDRSS Augmentation Service for Satellites (TASS) (6) Geodesy. This year, NASA seeks technology in focus areas (1), (3), (4), and (5), and related areas that provides PNT support and services for NASA's current tracking and communications networks and systems—including tracking during launch and landing operations, and research and technology relevant to the planning and development of PNT support and services for NASA's Project Constellation, including lunar surface operations, and other Exploration and Science Programs that NASA may undertake over the next two decades. Some of the subtopics in this topic could result in products that may be included in future flight opportunities. Please see the Science MD Topic S4 for more details as to the requirements for small satellite flight opportunities, and the Facilitated Access to the Space Environment for Technology Development and Training (FAST) website at http://ipp.nasa.gov/ii_fast.htm.

O4.01 Metric Tracking of Launch Vehicles
Lead Center: KSC
Participating Center(s): GSFC, MSFC

Range Safety requires accurate and reliable tracking data for launch vehicles. Onboard GPS receivers must maintain lock, reacquire very quickly and operate securely in a highly-dynamic environment. GPS Course Acquisition Code (CA) does not require classified decryption codes and has an accuracy of better than 30 m and 1 m/s. Although this accuracy is good enough for most Range Safety needs, better accuracy is needed for antenna pointing, docking maneuvers and attitude determination. CA code also offers little protection against deliberately transmitted false signals or "spoofing".

This solicitation seeks proposals in the following areas:

- Innovative technologies to increase the accuracy of the L1 C/A navigation solution by combining the pseudo ranges and phases of the L1 C/A signals, and use of the L2 and L5 carrier. Factors that degrade the GPS signal can be obtained by differencing the available carrier phase and pseudo range measurements and then removing this difference from the navigation solution.
- Technologies that combine spatial processing of signals from multiple antennas with temporal processing techniques to mitigate interference signals received by the GPS receiver. The coordinated response of adaptive pattern control (beam and null steering) and digital excision of certain interfering signal components minimizes strong jamming signals. Adaptive nulling minimizes interfering signals by the optimal control of the GPS antenna pattern (null steering).

These technologies should be independent of any particular GPS receiver design.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

O4.02 On-orbit PNT (Positioning, Navigation, and Timing) Sensors and Components
Lead Center: GSFC
Participating Center(s): GRC, JPL, JSC

This solicitation seeks proposals that will serve NASA's ever-evolving set of near-Earth and interplanetary missions that require precise determination of spacecraft position and velocity in order to achieve mission success. While the definition of "precise" depends upon the mission context, typical scenarios have required meter-level or better position accuracies, and sub-millimeter-level or better velocity accuracies.

Research should be conducted to demonstrate technical feasibility during Phase 1, and show a path toward a Phase 2 hardware and/or software demonstration of a demonstration unit or software package that will be delivered to NASA for testing at the completion of the Phase 2 contract. The Small Spacecraft Build effort highlighted in Topic S4 (Low-cost Small Spacecraft and Technologies) of the solicitation participates in this subtopic. Offerors are encouraged to take this in consideration as a possible flight opportunity when proposing work to this subtopic.

Purpose: NASA Needs vs. Current State of the Art
This solicitation is primarily focused on NASA's needs in three focused areas: onboard near-Earth navigation systems; onboard deep-space navigation systems; technologies supporting improved TDRSS-based navigation. Proposals that leverage state-of-the-art capabilities already developed by NASA such as GEONS (http://techtransfer.gsfc.nasa.gov/ft-tech-GEONS.html), Navigator (http://techtransfer.gsfc.nasa.gov/ft-tech-GPS-NAVIGATOR.html), GIPSY, Electra, and Blackjack are especially encouraged. NASA is not interested in funding efforts that seek to "re-invent the wheel" by duplicating the many investments that NASA and others have already made in establishing the current state-of-the-art.

General Operational Specifications and Requirements:

Core Capabilities:

Onboard Near-Earth Navigation System
NASA seeks proposals that would develop a commercially viable transceiver with embedded orbit determination software that would provide enhanced accuracy and integrity for autonomous onboard GPS- and TDRSS-based navigation and time-transfer in near-Earth space via augmentation messages broadcast by TDRSS. The augmentation message should include information on the TDRS orbits, status, and health that could be provided by future TDRS, and should provide information on the GPS constellation that is based on NASA's TDRSS Augmentation for Satellites Signal (TASS). Proposers are advised that NASA's GEONS and GIPSY orbit determination software packages already support the capability to ingest TASS messages.

Onboard Deep-Space Navigation System
NASA seeks proposals that would develop an onboard autonomous navigation and time-transfer system that can reduce DSN tracking requirements. Such systems should provide accuracy comparable to delta differenced one-way ranging (DDOR) solutions anywhere in the inner solar system, and exceed DDOR solution accuracy beyond the orbit of Jupiter. Proposers are advised that NASA's GEONS and DS-1 navigation software packages already support the capability to ingest many one-way forward Doppler, optical sensor observation, and accelerometer data types.

Technologies Supporting Improved TDRSS-based Navigation
NASA seeks proposals that would provide improvements in TDRS orbit knowledge, TDRSS radiometric tracking, ground-based orbit determination, and Ground Terminal improvements that improve navigation accuracy for TDRS users. Methods for improving TDRS orbit knowledge should exploit the possible future availability of accelerometer data collected onboard future TDRS.

Optional Capabilities:
NASA may consider other proposals relevant to NASA's needs for precise spacecraft navigation and tracking that demonstrably advance the state-of-the-art.

Development Timeline Associated with NASA Needs:
Phase 1 deliverables should include documentation of technical feasibility, which should at minimum show a path toward hardware and/or software demonstration of a demonstration unit or software package in Phase 2.

Phase 2 deliverables should include a demonstration unit or software.

The proposer to this subtopic is advised that the products proposed may be included in a future small satellite flight opportunity. Please see the SMD Topic S4 on Small Satellites for details regarding those opportunities. If the proposer would like to have their proposal considered for flight in the small satellite program, the proposal should state such and recommend a pathway for that possibility.

O4.03 Lunar Surface Navigation
Lead Center: GRC
Participating Center(s): GSFC, JPL, JSC

In order to provide location awareness, precision position fixing, best heading and traverse path planning for planetary EVA, manned rovers and lunar surface mobility units NASA has established requirements for onboard navigation capabilities for surface-mobile elements of lunar missions. Proposals are specifically sought which address the following needs:

- Asset localization within a work area. Specifically, real-time relative location of vehicles and EVA crew-members for safety and task efficiency.
- EVA crew localization for emergency walk back to a safe haven (lander, habitat, fixed reference point, etc.)
- Fixed asset localization with respect to global coordinates.
- Traverse-path planning systems and navigation-specific displays are also of interest.
- Novel navigation techniques that utilize repurposed flight vehicle sensors (INS, AHRS, low light imager, star trackers, etc.)

This topic will develop systems, technologies and analysis in support of the required capabilities of lunar surface mobility elements. Contemplated navigation systems could employ celestial references, passive or active optical information such as optical flow or range to local terrain features, inertial sensor information or other location-specific sensed data or combinations thereof. However, radiometric measurements are considered to be concomitant to the lunar communications network and the lunar network will likely be used to communicate state information between lunar mission elements. As such, the main emphasis of this topic is on systems that exploit radiometric measurements such as range, Doppler or Angle of Arrival. Radiometric measurements can be considered between lunar mission elements such as surface mobility units, elements of a lunar surface architecture (such as surface landers or habitation units or other surface mobility units) or elements of the lunar communications and navigation infrastructure such as surface communications towers or lunar communication/navigation orbiters. Note that the constellation of moon-orbiting communication/navigation satellites will support both polar outpost missions as well as short term sortie missions that can occur anywhere on the lunar surface. This constellation will likely consist of no more than six satellites and may be only be one or two satellites. Earth-based nodes are not excluded from consideration, nor are two-way radiometric measurements, nor are non-NASA-standard modulation schemes.

Emphasis of the development is on navigation accuracy, position estimate update rate (minimized correlation time), minimum Size Weight and Power (SWaP), systems that operate effectively with minimal communica-tions/navigation infrastructure (such as towers or orbiters) or with complete autonomy, with minimal crew involvement or completely automatically. Unified concepts and systems that provide a range of hardware capabili-ties (possibly trading accuracy with SWaP) and/or support dual-use (e.g., navigation and communication) are of interest.

Mature system concepts and technologies including system demonstration with TRL 6 components and internalized (by NASA) standards are required at the end of a Phase 2. Candidates for technology infusion include developmen-tal EVA space suits and prototype crew and robotic rovers. An example rover system is the Lunar Electric Rover (LER). The LER (http://www.nasa.gov/exploration/home/LER.html) is a sport utility sized, 12-wheeled, pressurized vehicle capable of supporting 14-day missions with two astronauts. Recent tests have included 140km treks across rugged terrain in Arizona. Future testing will extend the distance. Examples of a developmental EVA space suit include the Mark iii spacesuit and the REI suit (c.f. http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20080012574_2008010837.pdf). Demonstration opportunities occur several times a year at lunar analog exercises such as the Desert Research and Technology Studies (D-RATS, c.f. http://en.wikipedia.org/wiki/Desert_Research_and_Technology_Studies) and the Haughton Field test (c.f. http://ti.arc.nasa.gov/projects/haughton_field/).

O4.04 Flight Dynamics Technologies and Software
Lead Center: GRC
Participating Center(s): GSFC, JPL

NASA is beginning to invest in re-engineering its suite of tools and facilities that provide navigation and mission design services for design and operations of near-Earth and interplanetary missions. This solicitation seeks proposals that will develop flight dynamics technologies and software that support these efforts.

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 Position, Navigation, and Timing (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 needs in the following focused areas:

- Applications of cutting-edge estimation techniques, such as sigma-point and particle filters, to spaceflight navigation problems.
- Applications of estimation techniques that have an expanded state vector (beyond position and velocity components) to monitor non-Gaussian noise processes to improve upon the overall system accuracy.
- Applications of creative estimation techniques that combine measurements from multiple sensor suites to improve upon the overall system accuracy.
- Applications of advanced dynamical theories to space mission design and analysis, especially in the context of unstable orbital trajectories in the vicinity of small bodies and libration points.
- Addition of novel measurement technologies to existing NASA onboard navigation software that is licensed by the proposer.
- Addition of 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 such as GPS-Enhanced Onboard Navigation Software (http://techtransfer.gsfc.nasa.gov/ft-tech-GEONS.html), 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/), are especially encouraged. Proposers who contemplate licensing NASA technologies are highly encouraged to coordinate with the appropriate NASA technology transfer offices prior to submission of their proposals.

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, for example rendezvous and docking, or formation flying, are the subject of other solicitations by the relevant sponsoring organizations and should not be submitted in response to this solicitation.

Research should be conducted to demonstrate technical feasibility during Phase 1, and show a path toward a Phase 2 demonstration of a software package that will be delivered to NASA for testing at the completion of the Phase 2 contract.

The proposer to this subtopic is advised that the products proposed may be included in a future small satellite flight opportunity. Please see the SMD Topic S4 on Small Satellites for details regarding those opportunities. If the proposer would like to have their proposal considered for flight in the small satellite program, the proposal should state such and recommend a pathway for that possibility.

O4.05 Space-Based Range Technologies
Lead Center: GSFC
Participating Center(s): DFRC, GRC

The vision of Space-Based Range architecture is to assure public safety, reduce the costs of launch operations, enable multiple simultaneous launch operations, decrease response time, and improve geographic and temporal flexibility. This sub-topic seeks to reduce or eliminate the need for redundant range assets and deployed down-range assets that are currently used to provide for Line-of-Sight (LOS) Tracking Telemetry and Control (TT&C) with sub-orbital platforms and orbit-insertion launch vehicles. In order to achieve this, specific advancements are needed in TT&C.

Position, Attitude, and Inertial Metrics
Realization of a Space-Based Range requires the development of highly accurate and stable integrated metric tracking and inertial measurement units. The focus is on technologies that enable and advance development of low Size, Weight, and Power (SWaP), tactical grade, integrated metric tracking units that provide highly accurate and stable positioning, attitude, and inertial measurements on high dynamic platforms.

Factors to address include:

- Easy coupling of IMUs, gyros, accelerometers, and/or attitude determining GPS receivers that will provide very high frequency integrated metric solutions;
- The ability to reliably function on spin-stabilized rockets (up to 7 rps), during sudden jerk and acceleration maneuvers, and in high vibration environments is critical;
- Advancements in MEMs-based IMUs and accelerometers, algorithm techniques and Kalman filtering, phased-based attitude determination, single aperture systems, quick Time to First Fix and reacquisition.

Space-Based Telemetry
There are varying applications for space-based transceivers, each necessitating a different set of requirements. The desired focus is very low SWaP, tactical grade, highly reliable, and easily reconfigurable transceivers capable of establishing and maintaining unbroken satellite communication links for telemetry and/or control. This technology will serve applications which include low-cost sub-orbital missions, secondary communications systems for orbit insertion vehicles, low cost and size orbital payloads (typically LEO), and flight test articles. Durations will range from minutes to several weeks and the ability to operate on highly dynamic platforms is critical. High data rate links are highly desired, thus the use of NASA's TDRSS is emphasized, although other commercial satellite systems which can provide nearly global and high data rate links can also be explored.

Factors to address include:

- Advancements in software based radios and coding techniques;
- Use of the latest semiconductor technologies (GaN or other);
- Advanced heat dissipation techniques (to allow small packaging and long duration operating times);
- Immunity to corona breakdown;
- Ease of data interfacing.

RF power output requirements range from a few watts to as high as 100 W. Special consideration should be given to transceiver capability vs. packaging that would allow for customizable configurations depending on the target application. That is, a modular or stacking design with a common bus architecture should be considered where the RF and digital sections are separated. This could allow for a base digital and DC power design that will support multiple RF slices (such as a low, medium, or high power slice). Also, to satisfy missions who require unidirectional communications, a modular design could allow for separate transmitter and receiver modules/slices.

Phase 1 Deliverables
A final report containing optimal design for the technology concept including feasibility of concept, a detailed path towards Phase 2 hardware and/or software demonstration. The report shall also provide options for potential Phase 2 funding from other government agencies (OGA).

Phase 2 Deliverables
A working proof-of-concept demonstrated and delivered to NASA for testing and verification.

TOPIC: O5 Low-Cost and Reliable Access to Space (LCRATS)

This Crosscutting SBIR Topic seeks commercial solutions that will enable American commercial space transportation systems to provide significant reductions in cost, and increases in reliability, flight-rate, and frequency of access to space. 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 that can be demonstrated on interim suborbital vehicles.

This Topic is in support of NASAs' Strategic Plan Goal 5, "Encourage the pursuit of appropriate partnerships with the emerging commercial space sector", and targets a competitive marketplace with multiple commercial providers of highly-reusable space transportation systems and services with aircraft-like operations, high-flight rates, and short turnaround times (days-to-hours, rather than months). Cheap 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, and to national security.

While other strategies can support frequent, low-cost and reliable space access, this topic focuses on reusability, reliability and operability as a game-changer for next generation space access systems. This crosscutting topic addresses the need to inspire the next generation of Americans and public-private partnerships with industry to develop new markets and jobs for the American people. Cheap and reliable space access will enable a significant increase in scientific discoveries, technology development and verification, human and robotic space exploration and development, hands-on educational opportunities for students of all ages, commercial development of space, and new national security benefits.

This topic also supports Science Mission Directorate goals by providing more frequent and reliable access to space at lower cost for a wide variety of science missions and the Exploration Systems Mission Directorate by providing a cost-effective strategy for flight-testing and qualifying new technologies in the near-term, thereby lowering the risk of incorporating higher performance approaches in exploration architectures, and significant cost reductions and savings in the long-term that will enable NASA to refocus limited resources on missions beyond Earth orbit. Such as, lower-cost and highly reliable systems for resupply of the ISS, including potential crew transport, can provide considerable benefits to the Space Operations Mission Directorate and the success of International Space Station National Laboratory. Commercial firms are already designing, developing and using advanced hypersonic technologies in complex aerospace systems, and are natural industry partners of the Aeronautics Mission Directorate for both technology spin-offs and technology infusion.

In summary, this crosscutting topic is using subtopics from other Mission Directorate topics (see list below) to address the goal of LCRATS. Bidders on this topic must also address the objectives of the originating topic descriptions. Additional value may be given to proposals that also address the LCRATS topic.

Subtopic Cross Reference:

A2.01 Materials and Structures for Future Aircraft
X5.01 Composite Structures - Practical Monitoring and NDE for Composite Structures
X5.03 Composite Structures - Manufacturing
X9.01 Ablative Thermal Protection Systems
X9.02 Advanced Integrated Hypersonic Entry Systems
O3.02 Vehicle Integration and Ground Processing

9.2 STTR Research Topics

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.

TOPIC: T1 Information Technologies for System Health Management and the Study of Space Radiation Environments and Associated Health Risks

This topic seeks advances in the design, development, and operation of complex aerospace systems to enable safe operation in the event of system failures, innovative technologies for robotic exploration of planetary surfaces, and emerging technologies that will enable the optimization of limited resources and management of sustainable systems for space operations and Earth-based development.

T1.01 Information Technologies for System Health Management and Sustainability
Lead Center: ARC

Information technology is a key element in the successful achievement of NASA's strategic goals. Modern tools and techniques have the capability to redefine many design and operational processes as well as enable grand exploration and science investigations. This subtopic seeks innovative solutions to the following information technology challenges:

- Enabling technologies for sustainable systems such as life-cycle cost analysis, including production impact of system maintenance and upgrades, testing methodologies to maximize the efficiency of energy systems, optimization of limited resources, and smart energy systems that self-monitor and adjust accordingly to changing conditions;
- Health management systems that perform quickly enough to monitor a flight control system in a highly dynamic environment and respond to anomalies with suggested recovery or mitigation actions;
- Data fusion, data mining, and automated reasoning technologies that can improve sustainability, increase identification of system degradation, and enhance scientific understanding;
- Techniques for analyzing and reasoning from development and operational data sets to identify degradation of components and predict remaining useful life;
- Techniques for interconnecting and understanding large heterogeneous or multidimensional data sets or data with complex spatial and/or temporal dynamics;
- Computational and human/computer interface methodologies for inferring causation from associations and background knowledge for scientific, engineering, control, and performance analyses.

T1.02 Information Technologies for Intelligent Planetary Robotics
Lead Center: ARC

The objective of this subtopic is to develop information technologies that enable planetary robots to better support human exploration. Since February 2004, NASA has been actively engaged in a long-term program to explore the solar system and beyond, beginning with robotic missions to the Moon and leading eventually to human exploration of Mars. Several NASA studies have concluded that extensive and pervasive use of intelligent robots can significantly enhance human exploration, particularly for surface missions that are progressively longer, more complex, and must operate with fewer ground control resources.

Robots can do a variety of work to increase the productivity of human explorers on the Moon or Mars. Robots can perform tasks that are tedious, highly-repetitive or long-duration. Robots can perform tasks that help prepare (or help optimize planning) for future crew activity. Robots can perform "follow-up" work, completing tasks started by humans. Example tasks include: robotic recon (advance scouting), systematic site surveys, documenting sites or samples, and unskilled labor (initial site prep, site clean-up, etc).

Proposals are sought which address the following technology needs:

- Intelligent subsystems (algorithms, software and hardware) to improve the mobility or manipulation performance of planetary rovers. Mobility subsystems, such as traction control or active suspension, that enable MER- to MSL- scale rovers to drive at 3 m/s over lunar-relevant terrain while carrying a 100 kg payload are of particular interest. Manipulation subsystems, such as modular end-effectors for deploying instruments or placing markers, are also sought.

- Ground control user interfaces and data management systems for robotic exploration. Proposals should focus on software tools for planning variable-duration and variable-complexity command sequences; for event summarization and notification; for interactively monitoring/replaying task execution; for managing geospatial information; and for automating ground control functions.
- Autonomous surface navigation (localization and hazard avoidance) over long-distances and in permanently shadowed regions. Novel "infrastructure free" techniques that utilize passive computer vision (real-time dense stereo, optical flow, etc.), active illumination (e.g., line striping), repurposed flight vehicle sensors (low light imager, star trackers, etc.), and wide-area simultaneous localization and mapping (SLAM) are of particular interest.
- Physics-based simulation to develop and test planetary rover algorithms and systems. Existing mobile robot simulators (e.g., Player-Stage) lack the fidelity required to test high (and varying) levels of rover autonomy in non-terrestrial environments. Proposals are sought that provide robot simulation frameworks with models for planetary illumination, surface composition, specialized sensor and scientific instruments, communication, and rover resources.
- Robot software architecture that radically reduces ground control requirements for remote operations of planetary rovers. This may include: on-board health management and prognostics, on-board automated data triage (to prioritize information for downlink to ground), and learning algorithms to improve hazard detection and manage locomotion control modes switching.

TOPIC: T2 Atmospheric Flight Research of Advanced Technologies and Vehicle Concepts

Atmospheric Flight Research of Advanced Technologies and Vehicle Concepts Flight Research separates "the real from the imagined" and makes known the "overlooked and the unexpected." NASA's flight research mission is to prove unique and novel concepts through discoveries in flight. The chief areas of research interests encompass aerospace flight research and technology integration; validation of space exploration concepts; and airborne sensing and science. This topic solicits innovative proposals that would advance aerospace technologies for the nation in all flight regimes.

T2.01 Foundational Research for Aeronautics Experimental Capabilities
Lead Center: DFRC

This subtopic is intended to solicit innovative technologies that enhance flight research competences at Dryden by advancing capabilities for in-flight experimentation and for the supporting test facilities in the following areas:

- Methods and associated technologies for conducting flight research and acquiring test information from experiments in flight.
- Numerical techniques for the planning, analysis and validation of flight test experimentation conditions through simulation, modeling, control, or test information assessment.

The emphasis of this subtopic is proving feasibility, developing, and maturation technologies for advanced flight research experimentation that demonstrate new methodologies, technologies, and concepts (or new applications of existing approaches). It seeks advancements that promise significant gains in Dryden's flight research capabilities or addresses barriers to measurements, operations, safety, and cost. Proposals that demonstrate and confirm reliable application of concepts and technologies suitable for flight research and the test environment are a high priority. Proposals in any of these areas will be considered:

- Measurement techniques are needed to acquire aerodynamic, structural, flight control, and propulsion system performance characteristics in-flight and to safely expand the flight envelope of aerospace vehicles. The goals are to improve the effectiveness of flight-testing by simplifying and minimizing sensor installation, measuring new parameters, improving the quality of measurements, 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.

- Safer and more efficient design of advanced aerospace vehicles requires advancement in current predictive design and analysis tools. The goal is to develop more efficient software tools for predicting and understanding the response of an airframe under the simultaneous influences of structural dynamics, thermal dynamics, steady and unsteady aerodynamics, and the control system to increase understanding of the complex interactions between the vehicle dynamics and subsystems.
- Proposals for novel multidisciplinary nonlinear dynamic systems modeling, identification, and simulation for control objectives are encouraged. Control objectives include feasible and realistic boundary layer and laminar flow control, aero-elastic maneuver performance and load control (including smart actuation and active aero-structural concepts), autonomous health monitoring for improved stability, safety, performance, and drag minimization for high efficiency and extended range capability.

Proposals are encouraged that advocate technologies or methodologies that enable real-time location independent collaboration from experimenters from both domestic and international organizations. This approach holds the promise of increasing effectiveness, reducing cost, and adding significant value to the experimental results. This topic solicits proposals for improvements in all flight regimes - subsonic, transonic, supersonic, and hypersonic.

TOPIC: T3 Technologies for Space Exploration

This topic seeks to solicit advanced innovative technologies and systems in space power and propulsion to fulfill our Nation's goal of space exploration. The anticipated technologies should advance the state-of-the-art or feature enabling technologies to allow NASA to meet future exploration goals.

T3.01 Technologies for Space Power and Propulsion
Lead Center: GRC

Development of innovative technologies are sought that will result in durable, long-life, light-weight, high performance space power and in-space propulsion systems to substantially enhance or enable future missions.

In space power systems, innovations are sought that will offer significant improvements in efficiency, mass specific power, operating temperature range, radiation hardness, stowed volume, design flexibility/reconfigurability, autonomy, and affordability. In the area of power generation, advances are needed in photovoltaic cell technology (e.g., materials, structures, and incorporation of nanomaterials); solar array module/panel integration (e.g., advanced coatings, advanced structural materials, monolithic interconnects, and high-voltage operational capability); and solar array designs (e.g., ultra-lightweight deployment techniques for planar and concentrator arrays, restowable/redeployable designs, high power arrays, and planetary surface concepts). For energy storage technology, advances are needed in primary and rechargeable batteries, fuel cells, flywheels, regenerative fuel cell systems, and innovative design methods. Advances are also needed in power management and distribution systems, power system control, energy conversion technology (such as Stirling and Brayton systems) and integrated health management.

In space propulsion, innovations are sought that will improve electric propulsion technology. Concepts for subcomponent improvements are needed for ion and Hall thruster systems, including cathodes, neutralizers, electrode-less plasma production, low-erosion materials, high-temperature permanent magnets, and power processing systems. Innovations are also needed for xenon and krypton fuel distribution systems. In small chemical thruster propulsion technology, advances are sought for non-catalytic ignition methods for advanced monopropellants and high-temperature, reactive combustion chamber materials. Advances are also sought for chemical, electrostatic, or electromagnetic miniature and precision propulsion systems. Alternative fuels for space propulsion are also sought.

TOPIC: T4 Innovative Sensors, Detectors and Instruments for Science Applications

This topic solicits innovative sensors, detectors and instruments that support the research in Earth and its environment, the solar system, and the universe through observations from space. To assure that our Nation maintains leadership in this endeavor, we are committed to excellence in scientific investigation, in the development and operation of space systems, and in the advancement of essential technologies.

T4.01 Lidar, Radar and Passive Microwave
Lead Center: GSFC

As part of its mission, NASA needs advanced remote sensing measurements to improve the scientific understanding of the Earth, its responses to natural and human-induced changes, and to improve model predictions of climate, weather, and natural hazards. By using improved technologies in terrestrial, airborne, and spaceborne instruments, NASA seeks to better observe, analyze, and model the Earth system to aid in the scientific understanding and the possible consequences for life on Earth.

This STTR solicitation is to help provide advanced remote sensing technologies to enable future measurements. Components are sought that demonstrate a capability that is scalable to space or can be mounted on a relevant platform (Unmanned Aircraft Systems (UAS) or aircraft). New approaches, instruments, and components are sought that will:

- Enable new Earth Science measurements;
- Enhance an existing measurement capability by significantly improving the performance (spatial/temporal resolution, accuracy, range of regard); and/or
- Substantially reduce the resources (cost, mass, volume, or power) required to attain the same measurement capability.

Lidar Remote Sensing Instruments and Components
Lidar instruments and components are required to furnish remote sensing measurements for future Earth Science missions. NASA particularly needs advanced components for direct-detection lidar that can be used on new UAS platforms available to NASA, on the ground as test beds, and eventually in space. Important aspects for components are electro-optic performance, mass, power efficiency and lifetimes. Key components for direct-detection lidar (particularly efficient lasers and sensitive detectors) are solicited that enable or support the following Earth Science measurements:

- Profiling of cloud and aerosol backscatter, with emphasis on multiple beam systems to provide horizontal coverage of relevance to the Aerosol-Clouds-Ecosystems (ACE) mission;
- Wind measurements (using direct-detection techniques).

Radar Remote Sensing Instruments and Components
Active microwave remote sensing instruments are required for future Earth Science missions with initial concept development and science measurements on aircraft and UASs. New systems, approaches, and technologies are sought that will enable or significantly enhance the capability for: 1) tropospheric wind measurements within precipitation and clouds at X- through W-band, and 2) precipitation and cloud measurements. Systems and approaches will be considered that demonstrate a capability that can be mounted on a relevant platform (UAS or aircraft). Specific technologies include:

- High efficiency solid state power amplifiers (>5W at W-band, >20W at Ka-band and >50W at Ku-band);
- High duty cycle (~10%) power supplies and modulators for high-power Klystrons at Ka and W-band (~2 kW peak) for high-altitude (65,000 ft) operation;
- Cross track scanning Ka or W-band Doppler radar technologies with high sensitivity for clouds;
- Low sidelobe (better than -30 dB), high power phased array antennas (X, Ku, or Ka) for high-altitude operation (65,000 ft);

- High speed (output center frequency > 500 MHz), wide bandwidth (>200 MHz) adaptive versatile waveform generator for FM chirp (with amplitude modulation for ultra-low sidelobe pulse compression) generation;
- High power (>5W at W-band, >20W at Ka-band), high-speed, low loss T/R switches;
- Ultra-low sidelobe pulse compression technologies for cloud/precipitation applications.

Combined Radar and Radiometer Instruments and Components
Combined passive and active microwave remote sensing instruments are required for future Earth Science missions with initial concept development and science measurements on aircraft and, in particular, on UASs. Next-generation radar-radiometer packaging concepts are to fit into an active and passive module (1.5 -5 lb. mass allocation) at X-band, Ku-band, and Ka-band for measuring snow water equivalent to support calibration/validation activities for the Snow and Cold Land Processes (SCLP) mission. Packaging concepts are similar for L-band and C-band for measuring sea surface salinity and soil moisture in support of the Soil Moisture Active and Passive (SMAP) mission. L-band also measures sea surface temperature/roughness and thus supports "coastal" Aquarius calibration. Systems and approaches will be considered that demonstrate a capability that can be mounted on a relevant platform (in particular, UASs). Specific technologies include:

- Solid State Power Amplifier (SSPA) technology that can demonstrate ultra-high (70%) efficiency, thus enabling both low power operation for radars and thermal stability for radiometers. Design efforts should include on-wafer load-pull measurements for all frequency bands; analysis of thermal performance and comparison with present commercially available amplifiers; and design for packaged amplifiers (including efficiency, system noise parameters, and weight constraint). Each module should deliver 2W at frequency. This technology enables higher level packaging concepts for snow water equivalent (X-, Ku-, Ka-band), and soil moisture (L-, C-band). Four modules can be combined into a 2 X 2 package on a UAS experiment.

TOPIC: T5 Modeling and Simulation

This topic addresses the ability to measure the predictive capability of integrated spacecraft system models. Future spacecraft mission concepts are being considered that will be difficult or impossible to fully test on the ground. Such mission concepts may include large space telescopes, planet-finding coronagraphs, large microwave sensors for Earth science, and long duration robotic planetary missions, as examples. It is expected that models and simulations will play a central role in the flight qualification of these systems. Doing so will require substantial advancement in modeling and simulation technology.

T5.01 Quantification of Margins and Uncertainties in Integrated Spacecraft System Models
Lead Center: JPL

This subtopic is focused on modeling and simulation technologies for the quantification of margins and uncertainties (QMU) in integrated spacecraft system models. The goal is to develop generic capabilities in QMU either from analysis or from test. The outcomes of the research projects selected under this subtopic may include software packages, benchmark databases, or test methods that support QMU of complex, integrated models.

Possible areas of interest include:

- Reduced order modeling (ROM) for QMU of large scale simulations;
- Methods for efficient QMU for models that couple multiple, large scale commercial or proprietary simulation codes;
- Methods for the roll-up of lower level benchmark or component level tests to subsystem and system uncertainties;
- Methods for early life cycle (simple) system models that evolve into complex, coupled system models;
- Development of "open source" databases with unit tests or benchmark tests that support model verification and validation for integrated models;
- Effective methods for treating epistemic uncertainty in large scale simulations;

- User interfaces for preparation and execution of large scale QMU analyses, on either commercial or proprietary codes;
- Methods for inverse statistical modeling or inverse epistemic modeling from test data;
- Methods for extrapolation of margins and uncertainties outside the domain of model validation tests.

Projects selected under this subtopic should address at least one of the above areas of interest. Multiple-area proposals are encouraged. Proposers should consider:

- Scalability to problems with hundreds or thousands of uncertain parameters;
- Competition against traditional, sampling based methods (e.g., Monte Carlo);
- Application of the methods or techniques throughout the project life cycle, from concept development to flight operations.

TOPIC: T6 Innovative Technologies and Approaches for Space

To accomplish the Agency's goals and objectives for a robust space exploration program, innovative technologies and approaches are needed to meet these major challenges for human space explorers. This topic solicits technologies to support outposts, habitats, science packages, and state-of-the-art materials that will be safe as well as provide specific energy for primary or secondary batteries in excess of 300 mAh/g. The high specific energy will greatly help to reduce the mass of batteries that will have to be launched for the various applications for long duration Lunar as well as Mars Exploration Missions. The anticipated proposed technologies shall have a dramatic impact on achieving the goals of the Space Exploration Vision.

T6.01 Safe High Energy Density Batteries and Ultracapacitors
Lead Center: JSC

Commercial batteries have been used extensively by NASA to provide portable power for space applications for more than four decades. The cells range in capacity from 0.75 Ah to about 100 Ah, with a wider range of capacities and voltages at the battery level. Due to the high energy densities and the nature of the cell components, most battery chemistries are not inherently safe and have a tendency to be hazardous under off-nominal conditions. The top level requirement for crewed space vehicles and environments is two-fault tolerance to catastrophic failures.
With the future long duration manned missions to Moon and Mars in mind, NASA seeks to develop high specific energy (reduced mass) primary and secondary batteries that are safe and capable of performing under a wide temperature range and/or vacuum environments.

This solicitation seeks state-of-the-art materials that will be safe as well as provide specific energy for primary or secondary batteries in excess of 300 mAh/g. The high specific energy will greatly help reduce the mass of batteries that will have to be launched for the various applications for long duration Lunar as well as Mars Exploration Missions.

A second area that requires improvement is in the area of safe performance under the wide temperature ranges seen on Moon or Mars. The goals at this time are to obtain materials that will provide operation and be safe in a temperature range of -40 to +60°C. At least 50% performance should be obtained at the quoted extreme temperatures as compared to that at ambient (23°C).

A third area that would benefit from improvements is with respect to safe performance of pouch cells under vacuum conditions. Both primary and rechargeable batteries may be expected to perform in unpressurized environments for long periods on Lunar as well as Mars surfaces. Pouch cells provide a very high advantage in mass as well as design flexibility over hard case containers, but they do not provide stable performance under vacuum conditions. This solicitation seeks pouch cell designs for primary or secondary battery chemistries that are capable of safely providing greater than 95% of the capacity obtained at ambient pressures at the beginning of life and greater than 80% capacity after 500 cycles.

A fourth area of interest is in the field of ultracapacitors. Ultracapacitors with a voltage range of 2.0 to 4.0 V (single unit), low self discharge (< 3% a month), high cycle life (100,000 cycles), and low internal resistance(< 1.5 mohms) may be used to power Lunar surface system vehicles. An appropriately sized ultracapacitor design should have the capability to run up to 100 miles on a single charge and should not exhibit irreversible dielectric breakdown when configured into a high-voltage module (270 V). Ultracapacitors can be used as independent power sources or in a hybrid mode with rechargeable batteries to power Lunar surface mobility systems and/or portable electronic equipment such as cameras, camcorders and power tools.

For the above-mentioned areas of interest, Phase 1 will require demonstration of feasibility of concept at the lab scale and Phase 2 will require demonstration of concept in prototype or small capacity completed cells.

T6.02 Planetary Surface Analog Support Technologies
Lead Center: JSC

Current testing of Lunar Surface System elements (such as rovers, habitats, space suits, etc.) is performed either piecemeal in laboratory testing facilities or in an integrated fashion at remote site field exercises. Large-scale controlled facilities in which lunar surface outpost elements and operations can be tested in integrated scenarios are needed to reduce the risk of future human lunar missions and eventually Mars missions. Development of such facilities provides many advantages to planetary exploration programs but also poses many technological challenges. Such technology development challenges include non-hazardous lunar/Mars soil/regolith simulants, lunar/Mars lighting systems, lunar/Mars gravity off-load systems, etc.

TOPIC: T7 Launch Site Technologies

With the advent of the Constellation program new inspection requirements will be required at the launch site and one area of specific interest is the examination of non-metallic materials, such as foam, cork, Avcoat, and others. When these materials are applied to the spacecraft there is a possibility that voids will be created, either due to missing material or to missing adhesive. Also, some materials may be applied in a non-uniform manner or become non-uniform after exposure to the environment, for example from water absorption. A capability that can be used at the launch site to examine these materials and produce a 3D image highlighting non-uniformities will be beneficial to the new program. In addition, access is usually limited to one side of the material since it is being applied to a spacecraft or fuel tank, so the imaging technique will need to operate in a reflective rather than a transmissive manner.

T7.01 One-Sided 3D Imaging of Non-uniformities in non-metallic Space Flight Materials
Lead Center: KSC

In the Space Shuttle program as well as the Constellation program, limited assembly occurs at the launch site. For example, most of the insulation on the Space Shuttle's External Tank is applied during construction, but a few access areas are left bare and must be coated after the External Tank is attached to the Solid Rocket Boosters and Orbiter. Since this insulation is often applied in layers it is possible that voids may be formed, necessitating an evaluation method to ensure integrity. One approach, a backscatter x-ray technique, was recently demonstrated that allows one-sided 2D imaging of defects and voids in the Space Shuttle External Tank's sprayed on foam insulation (SOFI) http://sxi.nre.ufl.edu/research/papers/SPIE50_6.pdf. This method works well for large thin acreage sheets, but for smaller, more complicated volumes a 3D imaging method would improve the location and subsequent repair of the foam.

Recently x-ray backscatter was also demonstrated as a technique for locating voids in the adhesive used to attach sections of a Phenolic Impregnated Carbon Ablator (PICA) heat-shield to each other and to a capsule. The concern was in examining the workmanship of this assembly after completion to ensure that adequate adhesive had been used. The x-ray backscatter technique worked well for this application, but required imaging at relatively steep angles in order to see the various planes of adhesive. A 3-D capability would improve the performance of this technique and help determine where voids or imperfections were located. NASA has now selected Avcoat as the heat-shield material for the Orion Spacecraft and similar inspections will be required for it.

These two examples highlight the need for a system that can generate 3D images of non-metallic materials when access is limited to one side of the material. In many cases contact with the material is allowed opening the range of possible solutions to include ultrasonic and capacitive, in addition to the noncontact x-ray approach mentioned above and TeraHertz or Millimeter Wave (MMW) systems, as well as others. The primary technical advance being sought here is to extend methods that normally supply a 2D projected image through a sheet of material, to a 3D image of a more complicated volume, such as foam sprayed over a strut. It would be advantageous if the proposed method were potentially portable, allowing it to be brought to the spacecraft; rugged, allowing it to be handled in the field; and inexpensive, allowing several to be available for multiple applications.

TOPIC: T8 Computational Fluid Dynamics (CFD) Mesh Creation

NASA's work in advanced aeronautics and space vehicle development relies on Computational Fluid Dynamics (CFD) codes such as FUN3D, which numerically solve equations of fluid motion over a discrete mesh of points in three dimensions. Extensive CFD modeling is required for a wide range of NASA missions, which include subsonic commercial aircraft, rotorcraft, supersonic and hypersonic vehicles, and planetary exploration vehicles.

T8.01 Computational Fluid Dynamics Mesh Creation
Lead Center: LaRC

A critical step in CFD modeling is mesh creation. A judicious placement of mesh points is required to optimize computing efficiency while maintaining a specified level of discretication accuracy. This placement is further constrained by the need to capture disparate characteristic length scales and flow feature orientations. A result of these constraints is that many mesh elements formed by connecting points can have very high aspect ratio -- O(10,000:1) or more. Rapid generation of such a mesh and its subsequent adaptation to better resolve the problem physics and reduce discretization errors are critical to the application of CFD to complex real world problems of interest. While current meshing methods, those using advancing front/layer, and/or Delaunay algorithms, have been successfully applied to complex problems, additional research and development is needed in the area of mesh generation to reduce human involvement and increase robustness.

Proposals are sought, resulting in the development and improvement of software packages for high-aspect ratio, three-dimensional meshing and re-meshing. The mesher must accommodate cell aspect ratio requests of at least 10,000:1 even in the presence of a curved metric tensor field to enable high Reynolds number finite-volume Computational Fluid Dynamics applications. In regions of high anisotropy, mesh cells should be layers of semi-structured hexahedra or triangular prisms to allow non-dissipative capture of bow shocks, boundary layers, free shear layers, wakes, contact surfaces, and so forth. Furthermore, to provide uncertainty estimates for the computational results, the mesher should enable mesh adaptation, whereby an existing mesh is adapted to improve the solution based on the problem physics and/or a solution error estimate.

TOPIC: T9 Technologies for Human and Robotic Space Exploration Propulsion Design and Manufacturing

Achieving the Space Exploration Goals that NASA has defined will hinge on continued development of improved capabilities in propulsion system design and manufacturing techniques. NASA is interested in innovative design and manufacturing technologies that enable sustained and affordable human and robotic exploration of the Moon, Mars, and solar system. Implementing certain aspects of the NASA Vision for Space Exploration will require versatile, reliable space propulsion engines that can operate over a wide range of thrust levels, high specific impulse, and have multiple restart capability. The development of and operation of these propulsion systems will benefit greatly from improvements in design and analysis tools and from improvements in manufacturing capabilities.

T9.01 Technologies for Human and Robotic Space Exploration Propulsion Design and Manufacturing
Lead Center: MSFC

This subtopic solicits partnerships between academic institutions and small businesses in the following specific areas of interest: Innovative design and analysis techniques, manufacturing, materials, and processes relevant to propulsion systems launch vehicles, crew exploration vehicles, and lunar orbiters and landers. Improvements are sought for increasing safety and reliability and reducing cost and weight of systems and components.

- Polymer Matrix Composites (PMCs) Large-scale manufacturing; innovative automated processes (e.g., fiber placement); advanced non-autoclave curing; damage-tolerant; advanced materials and manufacturing processes for both cryogenic and high-temperature applications.
- Ceramic Matrix Composite (CMCs) and Ablatives CMC materials and processes are projected to significantly increase safety and reduce costs simultaneously while decreasing system weight for space transportation propulsion.
- Solid-state and friction stir welding, which target aluminum alloys, especially those applicable to high-performance aluminum-lithium alloys and aluminum metal-matrix composites, and high strength and high temperature or functionally graded materials.
- New advanced superalloys that resist hydrogen embrittlement and are compatible with high-pressure oxygen; innovative thermal-spray or cold-spray coating processes that substantially improve material properties, combine dissimilar materials, application of dense deposits of refractory metals and metal carbides, and coating on nonmetallic composite materials.
- Improvement in techniques for predicting the acoustic field produced by the operation of a space propulsion system in near ground operation.
- Predictive capability of the performance and environment for systems, solid or liquid propellants, undergoing multi-phase combustion.
- Improvements in prediction of stability and stability margins for liquid, gaseous, and solid propulsion systems.
- Zero net positive suction pressure pump design and analysis techniques.
- Design and analysis tools that accurately model small valves and turbopumps.
- Data bases and instrumentation advances required for validation of previously mentioned predictive capabilities.

TOPIC: T10 Rocket Propulsion Testing Systems

NASA's Stennis Space Center (SSC) seeks advanced vacuum technologies to support its new test stand for testing rocket engines in a vacuum. Also needed are technologies for reclamation of the large amounts of helium and hydrogen gases used during engine testing.

T10.01 Test Area Technologies
Lead Center: SSC

Vacuum System Technologies
John C Stennis Space Center is embarking on a very ambitious era in its rocket engine propulsion test history. The construction of the new A3 test stand is in progress which is designed to test a very large (294,000 lbf thrust) cryogenic rocket engine at a simulated altitude of 100,000 feet. When the air in the engine test chamber is evacuated, the simulated altitude pressures inside the test chamber will be less than 0.20 PSIA. This will result in a very unique environment with extremely low pressures inside a very large chamber and ambient pressures outside this chamber. Due to the unique nature of this test facility, new technologies and measurement techniques will need to be developed which includes but is not limited to:

- Instrument closeouts at vacuum pressures for hundreds of channels of instrumentation entering the chamber;
- New sealing technologies for large cryogenic piping entering this very large test cell wall to seal against this unique environment;

- Methods of generating vacuum for test, measurement and calibration of test stand systems and instrumentation;
- Fatigue life prediction techniques for the thousands of square feet of sheet metal used in the construction of the test chamber and diffuser ducting which will be cycling between ambient and vacuum pressures;
- Inspection techniques for the vacuum chamber structures and diffuser ducting.

GHe Reclamation

Due to the size of the cryogenic rocket engines and the test facilities required to test the engines, extremely large quantities of helium are used during testing each year. This requirement makes Stennis one of the world's largest users of gaseous helium which is a non-renewable natural resource. Cost of helium is increasing as the supply diminishes. The cost and shortage of helium are beginning to impact testing of the rocket engines for the space propulsion systems.

Innovative solutions are needed for efficient, cost effective, in-situ methods to recapture helium used during the engine purging and testing processes, to reclean the captured helium, to repressurize it, and then to reintroduce it for reuse. Research into technologies in these areas, demonstration of the technology capability, and conceptual design for the technology installation at Stennis are desired to assist in the helium reuse.

Helium used in rocket engine purge must meet very specific cleanliness standards. One of the challenges will be to develop and in-situ, on-site helium re-utilization system capable of recycling the helium to the cleanliness standards requirements.

The technologies developed to recapture and clean the helium must be cost effective and able to perform the recycling process in an in-situ rocket engine test area environment. It will be required to comply with all safety and quality standards required in this environment.

Hydrogen Reclamation

Due the testing of cryogenic rocket engines, SSC is one of the world's largest users of hydrogen. Currently, the LH2 is brought to SSC by trucks. During transfers and test operations, there huge amounts of LH2 lost due to boiloff as the heat in the systems causes the LH2 to phase into gaseous hydrogen. Conservatively, approximately one half of the hydrogen bought for use in test programs is lost or wasted during these operations.

The vast majority of this hydrogen boiloff is burned in the facility flare stacks as a safety precaution. The capability to reclaim and reutilize this hydrogen boiloff could offer potential savings of millions of dollars annually. The emerging hydrogen economy has developed systems and technologies that could potentially make use of this wasted hydrogen if methods were developed to recover at least a portion of the boiloff for reuse. A potential utilization would need to capture, reclean, repressurize and store this boiloff for reuse by the test facility. Options for the reuse of this reclaimed hydrogen could be as GH2 in the test facility or potentially even other alternate energy uses. Another possible option would be to reliquify and reuse the boiloff as propellant if this were economically efficient.

Innovative solutions are needed for efficient, cost effective, in-situ methods to recapture the hydrogen boiloff, to reclean and repressurize it, and then to store it for reuse. Research into technologies in these areas, demonstration of the technology capability, and conceptual design for the technology installation at Stennis are desired to assist in the hydrogen recovery and reuse.

The primary challenge will be to safely capture, process and store the large amounts of gaseous hydrogen released during test operations. Gaseous hydrogen used in rocket engine test operations must meet very specific cleanliness standards. Another challenge will be to develop an in-situ, on-site system capable of recycling the captured hydrogen to the cleanliness standards requirements. An additional challenge will be to determine the appropriate utilization of the recaptured hydrogen for test operations or alternative energy uses.

The technologies developed to capture and clean the hydrogen must be cost effective and able to perform the recycling process in an in-situ rocket engine test area environment. It will be required to comply with all safety and quality standards required in this environment.

T10.02 Energy Conservation and Sustainability
Lead Center: SSC

John C Stennis Space Center (SSC) is a large rocket propulsion test facility located in southern Mississippi close to the Louisiana state line. Due to the size of the test facilities, energy consumption is very large. In an effort to conserve on energy, there is an interest in pursuing innovation in the following areas:

Innovative Geothermal Technology
SSC is interested in innovative geothermal technology in an effort to reduce energy consumption, reducing the Center's carbon footprint. The feasibility and application of geothermal technology has not been investigated for use at SSC. SSC is looking for geothermal technology that is cost effective to implement and maintain. There are potential commercial and residential applications. The feasibility of geothermal technology will require an assessment of the local topography, underground soil composition, location of water "sinks", and determination of the area's ground "constant" temperature. Concepts will be evaluated based on their potential efficiency, ease of implementation and maintenance, and flexibility of applications (including, but not limited to, HVAC, preheating hot water heaters, and other means of extracting energy). Proposals will also be evaluated based on the maturity level to which the technology will be developed and innovative techniques.

Innovative Lighting Technology
Stennis Space Center is interested in developing innovative technologies, systems, or methodologies that will reduce the energy consumption and heat generation from facility lighting while maintaining the desired level of illumination for safety and effective work environments. SSC is interested in innovative lighting technologies for the test area and parking lots. These lighting technologies will need to reduce energy consumption while maintaining a comfortable and safe working environment. SSC is particularly interested in replacing costly lighting in the test area (test stands, hydrogen/oxygen environments, hazardous and potentially corrosive environments). The lighting should be in compliance with IESNA RP 7-01, Practice for Industrial Lighting. Proposals will be evaluated based on the maturity level to which the technology will be developed and innovative techniques that will provide a reasonable life expectancy. Proposals will also be evaluated on implementation strategy and ease of maintenance.

Assessment of Best Practices to Determine Test Programs Carbon Footprint and Environmental Impact
SSC is interested in technologies, systems, or methodologies for measuring and analyzing the carbon footprints of rocket engine testing activities. Due to the variety of rocket engine propulsion systems testing and the nature of the facilities required for testing, it would be useful to have ways to measure and understanding the carbon footprint generated by these test activities to effectively control and mitigate them as much as possible. A relatively generic methodology that can be suited for different test programs is desirable. Proposals will be evaluated based on the feasibility and applicability of Life Cycle Assessment on test programs or other applicable carbon assessment tools. Tools developed should be in compliance with ISO 14044 and ISO 14040.

Appendices

Appendix A: Example Format for Briefing Chart

NASA SBIR/STTR Technologies

Title of Proposal

Firm – City, ST

PI: PI's Name

Proposal No.: _ _ . _ _ - _ _ _ _

Identification and Significance of Innovation

<Place graphic related to innovation here>

Estimated TRL (1 – 9) at beginning and end of contract:

Technical Objectives and Work Plan

NASA and Non-NASA Applications

Firm Contacts

NON-PROPRIETARY DATA

Appendix B: Technology Readiness Level (TRL) Descriptions

Technology Readiness Level - (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 or application formulated	Invention begins, practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture.	Invention begins, practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture. Underlying Algorithms are clarified and documented.	Documented description of the application/concept that addresses feasibility and benefit
3	Analytical and/or experimental critical function 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 predicitions of key parameters
4	Component or breadboard validation in laboratory	A low fidelity system/component breadboard is built and operated to demonstrate basic functionality and critical test environments and associated performance predicitions 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 Evironments defined and performance in this environment predicted.	Documented test performance demonstrating agreement with analytical predictions. Documented definition of relevant environment.
5	Component or breadboard validation in a relevant environment	A mid-level 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 conforming to target environment, including the target o software environment. End to End Software System, Tested in Relevant Environment, Meets Predicted Performance. Operational Environment Performance Predicted.	Documented test performance demonstrating agreement with analytical predictions. Documented definition of scaling requirements
6	System/subsystem 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 software partially integrated with existing hardware/software sytems and demonstrated on full-scale realistic problems.	Documented test performance demonstrating agreement with analytical predictions
7	System prototype demonstration in space	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 is fully integrated with operational harware/software sytems demonstrating operational feasibility.	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).	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).	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.	The final product is successfully operated in an actual mission.	Documented mission operational results

Appendix C: SBIR Phase 1 Model Contract

SUPPLIES OR SERVICES AND PRICES/COSTS

52.213-4 Terms and Conditions - Simplified Acquisitions (Other Than Commercial Items). (MAR 2009)

(a) The Contractor shall comply with the following Federal Acquisition Regulation (FAR) clauses that are incorporated by reference:

(1) The clauses listed below implement provisions of law or Executive order:

(i) 52.222-3, Convict Labor (June 2003) (E.O. 11755).

(ii) 52.222-21, Prohibition of Segregated Facilities (Feb 1999) (E.O. 11246).

(iii) 52.222-26, Equal Opportunity (MAR 2007) (E.O. 11246).

(iv) 52.222-50, Combating Trafficking in Persons (FEB 2009) (22 U.S.C. 7104(g)).

(v) 52.225-13, Restrictions on Certain Foreign Purchases (FEB 2006) (E.o.s, proclamations, and statutes administered by the Office of Foreign Assets Control of the Department of the Treasury).

(vi) 52.233-3, Protest After Award (AUG 1996) (31 U.S.C. 3553).

(vii) 52.233-4, Applicable Law for Breach of Contract Claim (OCT 2004) (Pub. L. 108-77, 108-78).

(2) Listed below are additional clauses that apply:

(i) 52.232-1, Payments (APR 1984).

(ii) 52.232-8, Discounts for Prompt Payment (Feb 2002).

(iii) 52.232-11, Extras (APR 1984).

(iv) 52.232-25, Prompt Payment (OCT 2008).

(v) 52.233-1, Disputes (JUL 2002).

(vi) 52.244-6, Subcontracts for Commercial Items. (MAR 2009)

(vii) 52.253-1, Computer Generated Forms (JAN 1991).

(b) The Contractor shall comply with the following FAR clauses, incorporated by reference, unless the circumstances do not apply:

(1) The clauses listed below implement provisions of law or Executive order:

(i) 52.222-19, Child Labor--Cooperation with Authorities and Remedies (FEB 2008) (E.O. 13126). (Applies to contracts for supplies exceeding the micro-purchase threshold.)

(ii) 52.222-20, Walsh-Healey Public Contracts Act (Dec 1996) (41 U.S.C. 35-45) (Applies to supply contracts over $10,000 in the United States, Puerto Rico, or the U.S. Virgin Islands).

(iii) 52.222-35, Equal Opportunity for Special Disabled Veterans, Veterans of the Vietnam Era, and Other Eligible Veterans (SEP 2006) (38 U.S.C. 4212) (Applies to contracts of $100,000 or more).

(iv) 52.222-36, Affirmative Action for Workers with Disabilities (June 1998) (29 U.S.C. 793). (Applies to contracts over $10,000, unless the work is to be performed outside the United States by employees recruited outside the United States.) (For purposes of this clause, United States includes the 50 States, the District of Columbia, Puerto Rico, the Northern Mariana Islands, American Samoa, Guam, the U.S. Virgin Islands, and Wake Island.)

(v) 52.222-37, Employment Reports on Special Disabled Veterans, Veterans of the Vietnam Era, and Other Eligible Veterans (SEP 2006) (38 U.S.C. 4212) (Applies to contracts of $100,000 or more).

(vi) 52.222-41, Service Contract Act of 1965 (Nov 2007) (41 U.S.C. 351), *et seq*.) (Applies to service contracts over $2,500 that are subject to the Service Contract Act and will be performed in the United States, District of Columbia, Puerto Rico, the Northern Mariana Islands, American Samoa, Guam, the U.S. Virgin Islands, Johnston Island, Wake Island, or the outer continental shelf lands.)

(vii) 52.223-5, Pollution Prevention and Right-to-Know Information (Aug 2003) (E.O. 13148) (Applies to services performed on Federal facilities).

(viii) 52.223-15, Energy Efficiency in Energy-Consuming Products (DEC 2007) (42 U.S.C. 8259b) (Unless exempt pursuant to 23.204, applies to contracts when energy-consuming products listed in the ENERGY STAR Program or Federal Energy Management Program (FEMP) will be--

(A) Delivered;

(B) Acquired by the Contractor for use in performing services at a Federally-controlled facility;

(C) Furnished by the Contractor for use by the Government; or

(D) Specified in the design of a building or work, or incorporated during its construction, renovation, or maintenance.)

(ix) 52.225-1, Buy American Act--Supplies (FEB 2009) (41 U.S.C. 10a-10d) (Applies to contracts for supplies, and to contracts for services involving the furnishing of supplies, for use in the United States or its outlying areas, if the value of the supply contract or supply portion of a service contract exceeds the micro-purchase threshold and the acquisition--

(A) Is set aside for small business concerns; or

(B) Cannot be set aside for small business concerns (see 19.502-2), and does not exceed $25,000).

(x) 52.232-34, Payment by Electronic Funds Transfer - Other than Central Contractor Registration (May 1999). (Applies when the payment will be made by EFT and the payment office does not use the CCR database as its source of EFT information.)

(xi) 52.247-64, Preference for Privately Owned U.S.-Flag Commercial Vessels (FEB 2006) (46 U.S.C. Appx 1241). (Applies to supplies transported by ocean vessels (except for the types of subcontracts listed at 47.504(d).)

(2) Listed below are additional clauses that may apply:

(i) 52.209-6, Protecting the Government's Interest When Subcontracting with Contractors Debarred, Suspended, or Proposed for Debarment (SEP 2006) (Applies to contracts over $30,000).

(ii) 52.211-17, Delivery of Excess Quantities (Sept 1989) (Applies to fixed-price supplies).

(iii) 52.226-6, Promoting Excess Food Donation to Nonprofit Organizations. (MAR 2009) (Pub. L. 110-247) (Applies to contracts greater than $25,000 that provide for the provision, the service, or the sale of food in the United States.)

(iv) 52.247-29, F.o.b. Origin (FEB 2006) (Applies to supplies if delivery is f.o.b. origin).

(v) 52.247-34, F.o.b. Destination (Nov 1991) (Applies to supplies if delivery is f.o.b. destination).

(c) *FAR 52.252-2, Clauses Incorporated by Reference (Feb 1998*). This contract incorporates one or more clauses by reference, with the same force and effect as if they were given in full text. Upon request, the Contracting Officer will make their full text available. Also, the full text of a clause may be accessed electronically at this/these address(es):

http://www.acqnet.gov/far/

NASA FAR Supplement (NFS) clauses:

http://www.hq.nasa.gov/office/procurement/regs/nfstoc.htm

(d) *Inspection/Acceptance*. The Contractor shall tender for acceptance only those items that conform to the requirements of this contract. The Government reserves the right to inspect or test any supplies or services that have been tendered for acceptance. The Government may require repair or replacement of nonconforming supplies or reperformance of nonconforming services at no increase in contract price. The Government must exercise its postacceptance rights -

(1) Within a reasonable period of time after the defect was discovered or should have been discovered; and

(2) Before any substantial change occurs in the condition of the item, unless the change is due to the defect in the item.

(e) *Excusable delays*. The Contractor shall be liable for default unless nonperformance is caused by an occurrence beyond the reasonable control of the Contractor and without its fault or negligence, such as acts of God or the public enemy, acts of the Government in either its sovereign or contractual capacity, fires, floods, epidemics, quarantine restrictions, strikes, unusually severe weather, and delays of common carriers. The Contractor shall notify the Contracting Officer in writing as soon as it is reasonably possible after the commencement of any excusable delay, setting forth the full particulars in connection therewith, shall remedy such occurrence with all reasonable dispatch, and shall promptly give written notice to the Contracting Officer of the cessation of such occurrence.

(f) *Termination for the Government's convenience*. The Government reserves the right to terminate this contract, or any part hereof, for its sole convenience. In the event of such termination, the Contractor shall immediately stop all work hereunder and shall immediately cause any and all of its suppliers and subcontractors to cease work. Subject to the terms of this contract, the Contractor shall be paid a percentage of the contract price reflecting the percentage of the work performed prior to the notice of termination, plus reasonable charges that the Contractor can demonstrate to the satisfaction of the Government, using its standard record keeping system, have resulted from the termination. The Contractor shall not be required to comply with the cost accounting standards or contract cost principles for this purpose. This paragraph does not give the Government any right to audit the Contractor's records. The Contractor shall not be paid for any work performed or costs incurred that reasonably could have been avoided.

(g) *Termination for cause*. The Government may terminate this contract, or any part hereof, for cause in the event of any default by the Contractor, or if the Contractor fails to comply with any contract terms and conditions, or fails to provide the Government, upon request, with adequate assurances of future performance. In the event of termination for cause, the Government shall not be liable to the Contractor for any amount for supplies or services not accepted, and the Contractor shall be liable to the Government for any and all rights and remedies provided by law. If it is determined that the Government improperly terminated this contract for default, such termination shall be deemed a termination for convenience.

(h) *Warranty*. The Contractor warrants and implies that the items delivered hereunder are merchantable and fit for use for the particular purpose described in this contract.

(End of clause)

1852.216-78 Firm Fixed Price. (DEC 1988)

The total firm fixed price of this contract is $[*Insert the appropriate amount*].

(End of clause)

SUPPLIES AND/OR SERVICES TO BE PROVIDED

The Contractor shall provide all resources (except as may be expressly stated in the contract as furnished by the Government) necessary to deliver and/or perform the items below in accordance with the Description/Specifications/Statement of Work incorporated [*insert attachment number and/or section identifier of the Spec/SOW*].

(End of clause)

DESCRIPTION/SPECIFICATIONS/STATEMENT OF WORK

SPECIFICATION/STATEMENT OF WORK

The Contractor shall provide the item or services specified in Section B in accordance with the following:

[*Insert the Title of the Specification and/or Statement of Work*]

(End of text)

INSPECTION AND ACCEPTANCE

52.246-9 Inspection of Research and Development (Short Form). (APR 1984)

52.246-16 Responsibility for Supplies. (APR 1984)

DELIVERIES OR PERFORMANCE

52.242-15 Stop-Work Order. (AUG 1989)

PERIOD OF PERFORMANCE

The period of performance of this contract is [*Insert specific dates (i.e. "from___ to ___") or the negotiated period in terms of weeks, months, or years (ex: "12 months from the effective date of the contract").*]

(End of clause)

DELIVERY AND/OR COMPLETION SCHEDULE

The Contractor shall deliver and/or complete performance of the items required under this contract as follows:

[*Insert a table which details for each item, the item number, description, quantity, unit of measure, and delivery/completion date.*]

(End of clause)

ADDITIONAL REPORTS OF WORK - SBIR/STTR Phase I

(a**)** Interim Technical Progress Reports.
(1) The Contractor shall submit an interim progress report of all work accomplished. The report shall be in narrative form, be brief, and informal. This report shall include:
(i) A quantitative description of work performed during the period;
(ii) An indication of any current problems which may impede performance or impact program schedule or cost, and proposed corrective action;
(iii) A discussion of the work to be performed during the next reporting period;
(iv) A description of any changes to the planned use of subcontractors since contract award: and
(v) Estimated percentage of physical completion of the contract.
This report shall be submitted via the NASA SBIR Contract Administration Electronic Handbook.
Instructions for the electronic submission process are available to contractors on the NASA SBIR Home Page at: http://sbir.gsfc.nasa,gov/SBIR/SBIR.html
(2) Interim Technical Progress Reports are to be submitted within ten (10) days following the period to be reported, except for the Final Report which shall be submitted no later than the final day of the contract performance period.
(b) **Final Report & Project Summary Document.** The Contractor shall submit a Final Report within six (6) months from the effective date of this contract. The report shall be in narrative form documenting and summarizing the results of the entire contract work. The following instructions apply to the final report and are in addition to the requirements of the "Final Scientific and Technical Reports" clause of this contract (NFS 1852.235-73).
(1) **The Final Report shall include a single-page project summary as the first page,** identifying the purpose of the research, a brief description of the research carried out, the research findings or results (including the degree to which the Phase I objectives were achieved), and whether the results justify Phase II continuation. The project summary is to be submitted without restriction for NASA publication. This document should not contain any proprietary data and should be submitted without any restrictive markings. Instructions for the electronic submission of the project summary are posted on the NASA SBIR Electronic Contract Administration Handbook located in the NASA SBIR/STTR Forms Library.
(2) **The project summary shall be submitted with each copy of the final report and as a separate electronic submission via the NASA SBIR Electronic Contract Administration Handbook.**
(3) The balance of the report should indicate in detail the project objectives, work carried out, results obtained, and assessment of technical merit and feasibility. The potential applications of the project results **for a potential Phase 3** effort both for NASA purposes and for commercial purposes shall also be included. Rights to both interim and final report data (except for the project summary) shall be in accordance with clause 52.227-20, Rights in Data -- SBIR Program, of this contract. The Contractor shall mark all pages of reports (except the project summary) with the SBIR Rights notice set forth in clause 52.227-20.
(c) **The final report shall serve as the last interim report.**

NOTE: Only unclassified reports shall be submitted to the CASI

CONTRACT ADMINISTRATION DATA

1852.227-11 Patent Rights - Retention by the Contractor (Short Form).

1852.227-72 Designation of New Technology Representative and Patent Representative. (JUL 1997)

(a) For purposes of administration of the clause of this contract entitled "New Technology" or "Patent Rights - Retention by the Contractor (Short Form)," whichever is included, the following named representatives are hereby designated by the Contracting Officer to administer such clause:

Title
[ ]

Office Code
[ ]
Address (including zip code)
[ ]
New Technology Representative
[ ]
Patent Representative
[ ]

(b) Reports of reportable items, and disclosure of subject inventions, interim reports, final reports, utilization reports, and other reports required by the clause, as well as any correspondence with respect to such matters, should be directed to the New Technology Representative unless transmitted in response to correspondence or request from the Patent Representative. Inquires or requests regarding disposition of rights, election of rights, or related matters should be directed to the Patent Representative. This clause shall be included in any subcontract hereunder requiring a "New Technology" clause or "Patent Rights - Retention by the Contractor (Short Form)" clause, unless otherwise authorized or directed by the Contracting Officer. The respective responsibilities and authorities of the above-named representatives are set forth in 1827.305-370 of the NASA FAR Supplement.

(End of clause)

SECTION G CONTRACT SPECIFIC ADDITIONAL CLAUSE ONE

INVOICES AND PAYMENTS

Contractor shall submit one (1) copy of each invoice electronically through the Electronic Handbook; no other copies or actions are required. All invoices submitted by the SBC shall be marked with the contract number and invoice number. Hard copies of reports or invoices are not required. Failure to comply with requirements stipulated herein will delay payment.

Payment of invoices will be based upon acceptance and approval of each deliverable by the COTR and CO. Payment may be withheld if the required deliverables have not been properly submitted or accepted by the COTR. All reports and invoices shall be submitted by uploading one (1) copy into the Electronic Handbook (https://sbir.gsfc.nasa.gov/sbir/contract-admin/). The only exception to this requirement is that a copy of the New Technology Report and/or New Technology Summary Report shall be uploaded into the Electronic Handbook AND a copy shall be submitted using the eNTRe reporting system http://invention.nasa.gov/.

(End of clause)

SECTION G CONTRACT SPECIFIC ADDITIONAL CLAUSE TWO

REQUEST FOR PROPOSAL FOR PHASE II FOLLOW-ON CONTRACT

(a) This Phase I contract serves as a request for proposal for an SBIR Phase II follow-on contract except: (i) when NASA notifies the contractor that the area or topic of research is no longer suitably high enough within the Agency's research priorities; or (ii) when NASA notifies the contractor that the Phase I research results are not worthy of continuation. Submission of a Phase II proposal is strictly voluntary and NASA assumes no responsibility for proposal preparation costs. Phase II proposals are due at the end of the Phase I contract. NOTE THAT PHASE II PROPOSALS MUST BE RECEIVED BY THE GOVERNMENT NO LATER THAN 5:00 pm EDT ON THE LAST DAY OF THE PHASE I CONTRACT PERIOD [(Insert the end date of the Phase I contract)]. LATE PROPOSALS MAY BE ELIMINATED FROM FURTHER CONSIDERATION FOR PHASE II AWARDS.
All information necessary to submit a SBIR Phase II proposal is available at:
http://sbir.gsfc.nasa.gov/SBIR/SBIR.html.

(End of clause)

SPECIAL CONTRACT REQUIREMENTS

1852.223-72 Safety and Health (Short Form). (APR 2002)

1852.225-70 Export Licenses. (FEB 2000)

(a) The Contractor shall comply with all U.S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this contract. In the absence of available license exemptions/exceptions, the Contractor shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of hardware, technical data, and software, or for the provision of technical assistance.

(b) The Contractor shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of this contract, including instances where the work is to be performed on-site at [*insert name of NASA installation*], where the foreign person will have access to export-controlled technical data or software.

(c) The Contractor shall be responsible for all regulatory record keeping requirements associated with the use of licenses and license exemptions/exceptions.

(d) The Contractor shall be responsible for ensuring that the provisions of this clause apply to its subcontractors.

(End of clause)

1852.235-71 Key Personnel and Facilities. (MAR 1989)

(a) The personnel and/or facilities listed below (or specified in the contract Schedule) are considered essential to the work being performed under this contract. Before removing, replacing, or diverting any of the listed or specified personnel or facilities, the Contractor shall (1) notify the Contracting Officer reasonably in advance and (2) submit justification (including proposed substitutions) in sufficient detail to permit evaluation of the impact on this contract.

(b) The Contractor shall make no diversion without the Contracting Officer's written consent; provided, that the Contracting Officer may ratify in writing the proposed change, and that ratification shall constitute the Contracting Officer's consent required by this clause.

(c) The list of personnel and/or facilities (shown below or as specified in the contract Schedule) may, with the consent of the contracting parties, be amended from time to time during the course of the contract to add or delete personnel and/or facilities.

[*List here the personnel and/or facilities considered essential, unless they are specified in the contract Schedule.*]

(End of clause)

1852.235-73 Final Scientific and Technical Reports. (DEC 2006) -- Alternate III (JAN 2005)

1852.235-74 Additional Reports of Work - Research and Development. (FEB 2003)

In addition to the final report required under this contract, the Contractor shall submit the following report(s) to the Contracting Officer:

(a) Quarterly progress reports. The Contractor shall submit separate quarterly reports of all work accomplished during each three-month period of contract performance. In addition to factual data, these reports should include a separate analysis section interpreting the results obtained, recommending further action, and relating occurrences to the ultimate objectives of the contract. Sufficient diagrams, sketches, curves, photographs, and drawings should be included to convey the intended meaning.

(b) Submission dates. Quarterly reports shall be submitted within 10 days the following the period to be reported.

No quarterly report need be submitted for the final three months of contract effort since that period will be covered in the final report. The final report shall be submitted within ____days after the completion of the effort under the contract.

(End of clause)

NEW TECHNOLOGY REPORTING - SBIR/STTR PROGRAM

Federal Acquisition Regulation clause 52.227-11, "Patent Rights Retention by the Contractor (Short Form)", as modified by NASA FAR Supplement 1852.227-11, requires that contractors provide NASA:

(a) A disclosure of each subject invention, within two months after the inventor discloses it to contractor personnel responsible for patent matters.

"Subject invention," means any invention, discovery, improvement, or innovation of the contractor that is or may be patentable or otherwise protectable under Title 35 of the United States Code, made in the performance of any work under any NASA contract. Subject inventions include, but are not limited to, new processes, machines, manufactures, and compositions of matter, and improvements to, or new applications of, existing processes, machines, manufactures, and compositions of matter. Subject Inventions also include new computer programs, and improvements to, or new applications of, existing computer programs, whether or not copyrightable or otherwise protectable under Title 17 of the United States Code.

NASA prefers that the contractor use either the electronic or paper version of NASA Form 1679, "Disclosure of Invention and New Technology (Including Software)" to disclose subject inventions. Both the electronic and paper versions of NASA Form 1679 may be accessed at the electronic New Technology Reporting Web site http://invention.nasa.gov. Alternate formats may be used if the information provided is equivalent to that found on the NASA Form 1679.

(b) The Contractor must also provide:

(1) "Interim New Technology Summary Reports", due 12 months from the effective date of the contract, with additional reports due annually thereafter, listing subject inventions during that period, and certifying that all subject inventions have been disclosed, or that there were no such subject inventions.

(2) "Final New Technology Summary Report", due within 3 months after completion of the contracted work, listing all subject inventions and certifying that all subject inventions have been disclosed (or that there were no such subject inventions). A listing of all subcontracts at any tier containing a patent rights clause or certification that there were no such subcontracts should be included with the report as well. Note: Final payment will not be made until the Final New Technology Summary Report has been received and accepted, so Contractors are advised to submit this report with the other final deliverables to avoid delay in receiving payment.

Contractors should use the "New Technology Summary Report" form for both interim and final summary reports. NASA Summary Forms may be accessed at the electronic New Technology Reporting Web site http://invention.nasa.gov. Alternate formats may be used if the information provided is equivalent to that found on the NASA Summary Form.

All disclosures and interim/final reports as well as any correspondence with respect to such matters should be submitted to the Center's New Technology Representative at the address listed in the following paragraph.

Company New Technology Representative Designation: Upon contract award, the Contractor shall send the name, address, telephone number and email address of the Contractor's New Technology Representative responsible for submitting the New Technology Reports (include the contract number with this submission), to the NASA New Technology Representative at the following address:
[*Insert address of Center New Technology Representative*]

All inquiries or requests regarding disposition of rights, election of rights, or related matters should be directed to the Center's Patent Representative at the following address:
[*Insert address for the Center Patent Representative*]

(End of clause)

SECTION 508 COMPLIANCE

(a) The Workforce Investment Act of 1998 amended section 508 of the Rehabilitation Act of 1973 to require that :
(1) When developing, procuring, maintaining or using Electronic and Information Technology (EIT), agencies must ensure that employees with disabilities have access to and use of information and data that is comparable to that for other employees; and
(2) Members of the public with disabilities seeking information or services from an agency have access to and use of information and data that is comparable to that for members of the public without disabilities.
(b) Section 508 standards should be taken into consideration in the design of prototypes. Failure to meet Section 508 standards will impact the Government's ability to make future purchases of the technology developed under this contract. Information regarding Section 508 standards can be obtained at http://www.access-board.gov/508.htm.

(End of clause)

CONTRACT CLAUSES

52.202-1 Definitions. (JUL 2004)

52.203-5 Covenant Against Contingent Fees. (APR 1984)

52.203-7 Anti-Kickback Procedures. (JUL 1995)

52.204-7 Central Contractor Registration. (APR 2008)

52.219-6 Notice of Total Small Business Set-Aside. (JUN 2003)

52.223-14 Toxic Chemical Release Reporting. (AUG 2003)

52.227-1 Authorization and Consent. (DEC 2007) -- Alternate I (APR 1984)

52.227-2 Notice and Assistance Regarding Patent and Copyright Infringement. (DEC 2007)

52.227-11 Patent Rights--Ownership by the Contractor. (DEC 2007)

(a) As used in this clause--

"Invention" means any invention or discovery that is or may be patentable or otherwise protectable under title 35 of the U.S. Code, or any variety of plant that is or may be protectable under the Plant Variety Protection Act (7 U.S.C. 2321, et seq.)

"Made" means--

(1) When used in relation to any invention other than a plant variety, the conception or first actual reduction to practice of the invention; or

(2) When used in relation to a plant variety, that the Contractor has at least tentatively determined that the variety has been reproduced with recognized characteristics.

"Nonprofit organization" means a university or other institution of higher education or an organization of the type described in section 501(c)(3) of the Internal Revenue Code of 1954 (26 U.S.C. 501(c)) and exempt from taxation under section 501(a) of the Internal Revenue Code (26 U.S.C. 501(a)), or any nonprofit scientific or educational organization qualified under a State nonprofit organization statute.

"Practical application" means to manufacture, in the case of a composition of product; to practice, in the case of a process or method; or to operate, in the case of a machine or system; and, in each case, under such conditions as to establish that the invention is being utilized and that its benefits are, to the extent permitted by law or Government regulations, available to the public on reasonable terms.

"Subject invention" means any invention of the Contractor made in the performance of work under this contract.

(b) Contractor's rights. (1) Ownership. The Contractor may retain ownership of each subject invention throughout the world in accordance with the provisions of this clause.

(2) License. (i) The Contractor shall retain a nonexclusive royalty-free license throughout the world in each subject invention to which the Government obtains title, unless the Contractor fails to disclose the invention within the times specified in paragraph (c) of this clause. The Contractor's license extends to any domestic subsidiaries and affiliates within the corporate structure of which the Contractor is a part, and includes the right to grant sublicenses to the extent the Contractor was legally obligated to do so at contract award. The license is transferable only with the written approval of the agency, except when transferred to the successor of that part of the Contractor's business to which the invention pertains.

(ii) The Contractor's license may be revoked or modified by the agency to the extent necessary to achieve expeditious practical application of the subject invention in a particular country in accordance with the procedures in FAR 27.302(i)(2) and 27.304-1(f).

(c) Contractor's obligations. (1) The Contractor shall disclose in writing each subject invention to the Contracting Officer within 2 months after the inventor discloses it in writing to Contractor personnel responsible for patent matters. The disclosure shall identify the inventor(s) and this contract under which the subject invention was made. It shall be sufficiently complete in technical detail to convey a clear understanding of the subject invention. The disclosure shall also identify any publication, on sale (i.e., sale or offer for sale), or public use of the subject invention, or whether a manuscript describing the subject invention has been submitted for publication and, if so, whether it has been accepted for publication. In addition, after disclosure to the agency, the Contractor shall promptly notify the Contracting Officer of the acceptance of any manuscript describing the subject invention for publication and any on sale or public use.

(2) The Contractor shall elect in writing whether or not to retain ownership of any subject invention by notifying the Contracting Officer within 2 years of disclosure to the agency. However, in any case where publication, on sale, or public use has initiated the 1-year statutory period during which valid patent protection can be obtained in the United States, the period for election of title may be shortened by the agency to a date that is no more than 60 days prior to the end of the statutory period.

(3) The Contractor shall file either a provisional or a nonprovisional patent application or a Plant Variety Protection Application on an elected subject invention within 1 year after election. However, in any case where a publication, on sale, or public use has initiated the 1-year statutory period during which valid patent protection can be obtained in the United States, the Contractor shall file the application prior to the end of that statutory period. If the Contractor files a provisional application, it shall file a nonprovisional application within 10 months of the filing of the provisional application. The Contractor shall file patent applications in additional countries or international patent offices within either 10 months of the first filed patent application (whether provisional or nonprovisional) or 6 months from the date permission is granted by the Commissioner of Patents to file foreign patent applications where such filing has been prohibited by a Secrecy Order.

(4) The Contractor may request extensions of time for disclosure, election, or filing under paragraphs (c)(1), (c)(2), and (c)(3) of this clause.

(d) Government's rights--(1) Ownership. The Contractor shall assign to the agency, on written request, title to any subject invention--

(i) If the Contractor fails to disclose or elect ownership to the subject invention within the times specified in paragraph (c) of this clause, or elects not to retain ownership; provided, that the agency may request title only within 60 days after learning of the Contractor's failure to disclose or elect within the specified times.

(ii) In those countries in which the Contractor fails to file patent applications within the times specified in paragraph (c) of this clause; provided, however, that if the Contractor has filed a patent application in a country after the times specified in paragraph (c) of this clause, but prior to its receipt of the written request of the agency, the Contractor shall continue to retain ownership in that country.

(iii) In any country in which the Contractor decides not to continue the prosecution of any application for, to pay the maintenance fees on, or defend in reexamination or opposition proceeding on, a patent on a subject invention.

(2) License. If the Contractor retains ownership of any subject invention, the Government shall have a nonexclusive, nontransferable, irrevocable, paid-up license to practice, or have practiced for or on its behalf, the subject invention throughout the world.

(e) Contractor action to protect the Government's interest. (1) The Contractor shall execute or have executed and promptly deliver to the agency all instruments necessary to--

(i) Establish or confirm the rights the Government has throughout the world in those subject inventions in which the Contractor elects to retain ownership; and

(ii) Assign title to the agency when requested under paragraph (d) of this clause and to enable the Government to obtain patent protection and plant variety protection for that subject invention in any country.

(2) The Contractor shall require, by written agreement, its employees, other than clerical and nontechnical employees, to disclose promptly in writing to personnel identified as responsible for the administration of patent matters and in the Contractor's format, each subject invention in order that the Contractor can comply with the disclosure provisions of paragraph (c) of this clause, and to execute all papers necessary to file patent applications on subject inventions and to establish the Government's rights in the subject inventions. The disclosure format should require, as a minimum, the information required by paragraph (c)(1) of this clause. The Contractor shall instruct such employees, through employee agreements or other suitable educational programs, as to the importance of reporting inventions in sufficient time to permit the filing of patent applications prior to U.S. or foreign statutory bars.

(3) The Contractor shall notify the Contracting Officer of any decisions not to file a nonprovisional patent application, continue the prosecution of a patent application, pay maintenance fees, or defend in a reexamination or opposition proceeding on a patent, in any country, not less than 30 days before the expiration of the response or filing period required by the relevant patent office.

(4) The Contractor shall include, within the specification of any United States nonprovisional patent or plant variety protection application and any patent or plant variety protection certificate issuing thereon covering a subject invention, the following statement, "This invention was made with Government support under (identify the contract) awarded by (identify the agency). The Government has certain rights in the invention."

(f) Reporting on utilization of subject inventions. The Contractor shall submit, on request, periodic reports no more frequently than annually on the utilization of a subject invention or on efforts at obtaining utilization of the subject invention that are being made by the Contractor or its licensees or assignees. The reports shall include information regarding the status of development, date of first commercial sale or use, gross royalties received by the Contractor, and other data and information as the agency may reasonably specify. The Contractor also shall provide additional reports as may be requested by the agency in connection with any march-in proceeding undertaken by the agency in accordance with paragraph (h) of this clause. The Contractor also shall mark any utilization report as confidential/proprietary to help prevent inadvertent release outside the Government. As required by 35 U.S.C. 202(c)(5), the agency will not disclose that information to persons outside the Government without the Contractor's permission.

(g) Preference for United States industry. Notwithstanding any other provision of this clause, neither the Contractor nor any assignee shall grant to any person the exclusive right to use or sell any subject invention in the United States unless the person agrees that any products embodying the subject invention or produced through the use of the subject invention will be manufactured substantially in the United States. However, in individual cases, the requirement for an agreement may be waived by the agency upon a showing by the Contractor or its assignee that reasonable but unsuccessful efforts have been made to grant licenses on similar terms to potential licensees that would be likely to manufacture substantially in the United States, or that under the circumstances domestic manufacture is not commercially feasible.

(h) March-in rights. The Contractor acknowledges that, with respect to any subject invention in which it has retained ownership, the agency has the right to require licensing pursuant to 35 U.S.C. 203 and 210(c), and in accordance with the procedures in 37 CFR 401.6 and any supplemental regulations of the agency in effect on the date of contract award.

(i) Special provisions for contracts with nonprofit organizations. If the Contractor is a nonprofit organization, it shall--

(1) Not assign rights to a subject invention in the United States without the written approval of the agency, except where an assignment is made to an organization that has as one of its primary functions the management of inventions, provided, that the assignee shall be subject to the same provisions as the Contractor;

(2) Share royalties collected on a subject invention with the inventor, including Federal employee co-inventors (but through their agency if the agency deems it appropriate) when the subject invention is assigned in accordance with 35 U.S.C. 202(e) and 37 CFR 401.10;

(3) Use the balance of any royalties or income earned by the Contractor with respect to subject inventions, after payment of expenses (including payments to inventors) incidental to the administration of subject inventions for the support of scientific research or education; and

(4) Make efforts that are reasonable under the circumstances to attract licensees of subject inventions that are small business concerns, and give a preference to a small business concern when licensing a subject invention if the Contractor determines that the small business concern has a plan or proposal for marketing the invention which, if executed, is equally as likely to bring the invention to practical application as any plans or proposals from applicants that are not small business concerns; provided, that the Contractor is also satisfied that the small business concern has the capability and resources to carry out its plan or proposal. The decision whether to give a preference in any specific case will be at the discretion of the Contractor.

(5) Allow the Secretary of Commerce to review the Contractor's licensing program and decisions regarding small business applicants, and negotiate changes to its licensing policies, procedures, or practices with the Secretary of Commerce when the Secretary's review discloses that the Contractor could take reasonable steps to more effectively implement the requirements of paragraph (i)(4) of this clause.

(j) Communications. [*Complete according to agency instructions.*]

(k) Subcontracts. (1) The Contractor shall include the substance of this clause, including this paragraph (k), in all subcontracts for experimental, developmental, or research work to be performed by a small business concern or nonprofit organization.

(2) The Contractor shall include in all other subcontracts for experimental, developmental, or research work the substance of the patent rights clause required by FAR Subpart 27.3.

(3) At all tiers, the patent rights clause must be modified to identify the parties as follows: references to the Government are not changed, and the subcontractor has all rights and obligations of the Contractor in the clause. The Contractor shall not, as part of the consideration for awarding the subcontract, obtain rights in the subcontractor's subject inventions.

(4) In subcontracts, at any tier, the agency, the subcontractor, and the Contractor agree that the mutual obligations of the parties created by this clause constitute a contract between the subcontractor and the agency with respect to the matters covered by the clause; provided, however, that nothing in this paragraph is intended to confer any jurisdiction under the Contract Disputes Act in connection with proceedings under paragraph (h) of this clause.

(End of clause)

52.227-16 Additional Data Requirements. (JUN 1987)

52.227-20 Rights in Data--SBIR Program. (DEC 2007)

52.232-2 Payments under Fixed-Price Research and Development Contracts. (APR 1984)

52.232-12 Advance Payments. (MAY 2001) - Alternate IV (APR 1984)

(a) *Requirements for payment*. Advance payments will be made under this contract (1) upon submission of properly certified invoices or vouchers by the Contractor, and approval by the administering office, [*insert the name of the office designated under agency procedures*], or (2) under a letter of credit. The amount of the invoice or voucher submitted plus all advance payments previously approved shall not exceed $[ ]. If a letter of credit is used, the Contractor shall withdraw cash only when needed for disbursements acceptable under this contract and report cash disbursements and balances as required by the administering office. The Contractor shall apply terms similar to this clause to any advance payments to subcontractors.

(b) Special account. Until (1) the Contractor has liquidated all advance payments made under the contract and related interest charges and (2) the administering office has approved in writing the release of any funds due and payable to the Contractor, all advance payments and other payments under this contract shall be made by check payable to the Contractor marked for deposit only in the Contractor's special account with the [*insert the name of the financial institution*]. None of the funds in the special account shall be mingled with other funds of the Contractor. Withdrawals from the special account may be made only by check of the Contractor countersigned by the Contracting Officer or a Government countersigning agent designated in writing by the Contracting Officer.

(c) *Use of funds*. The Contractor may withdraw funds from the special account only to pay for properly allocable, allowable, and reasonable costs for direct materials, direct labor, and indirect costs. Other withdrawals require approval in writing by the administering office. Determinations of whether costs are properly allocable, allowable, and reasonable shall be in accordance with generally accepted accounting principles, subject to any applicable subparts of Part 31 of the Federal Acquisition Regulation.

(d) *Repayment to the Government.* At any time, the Contractor may repay all or any part of the funds advanced by the Government. Whenever requested in writing to do so by the administering office, the Contractor shall repay to the Government any part of unliquidated advance payments considered by the administering office to exceed the Contractor's current requirements or the amount specified in paragraph (a) above. If the Contractor fails to repay the amount requested by the administering office, all or any part of the unliquidated advance payments may be withdrawn from the special account by check signed by only the countersigning agent and applied to reduction of the unliquidated advance payments under this contract.

(e) *Maximum payment*. When the sum of all unliquidated advance payments, unpaid interest charges, and other payments exceed [ ] percent of the contract price, the Government shall withhold further payments to the Contractor. On completion or termination of the contract, the Government shall deduct from the amount due to the Contractor all unliquidated advance payments and all interest charges payable. If previous payments to the Contractor exceed the amount due, the excess amount shall be paid to the Government on demand. For purposes of this paragraph, the contract price shall be considered to be the stated contract price of $ [ ], less any subsequent price reductions under the contract, plus (1) any price increases resulting from any terms of this contract for price redetermination or escalation, and (2) any other price increases that do not, in the aggregate, exceed $ [*insert an amount not higher than 10 percent of the stated contract amount inserted in this paragraph*]. Any payments withheld under this paragraph shall be applied to reduce the unliquidated advance payments. If full liquidation has been made, payments under the contract shall resume.

(f) *Interest*. (1) No interest shall be charged to the prime Contractor for advance payments except for interest charged during a period of default. The terms of this paragraph concerning interest charges for advance payments shall not apply to the prime Contractor. The Contractor shall pay interest to the Government on the daily unliquidated advance payments at the daily rate specified in subparagraph (f)(3) below. Interest shall be computed at the end of each calendar month for the actual number of days involved. For the purpose of computing the interest charge -

(i) Advance payments shall be considered as increasing the unliquidated balance as of the date of the advance payment check;

(ii) Repayments by Contractor check shall be considered as decreasing the unliquidated balance as of the date on which the check is received by the Government authority designated by the Contracting Officer; and

(iii) Liquidations by deductions from Government payments to the Contractor shall be considered as decreasing the unliquidated balance as of the date of the check for the reduced payment.

(2) Interest charges resulting from the monthly computation shall be deducted from payments, other than advance payments, due the Contractor. If the accrued interest exceeds the payment due, any excess interest shall be carried forward and deducted from subsequent payments. Interest carried forward shall not be compounded. Interest on advance payments shall cease to accrue upon satisfactory completion or termination of the contract for the convenience of the Government. The Contractor shall charge interest on advance payments to subcontractors in the manner described above and credit the interest to the Government. Interest need not be charged on advance payments to nonprofit educational or research subcontractors for experimental, developmental, or research work.

(3) If interest is required under the contract, the Contracting Officer shall determine a daily interest rate based on the higher of (i) the published prime rate of the financial institution (depository) in which the special account is established or (ii) the rate established by the Secretary of the Treasury under Pub. L. 92-41 (50 U.S.C. App. 1215(b)(2)). The Contracting Officer shall revise the daily interest rate during the contract period in keeping with any changes in the cited interest rates.

(4) If the full amount of interest charged under this paragraph has not been paid by deduction or otherwise upon completion or termination of this contract, the Contractor shall pay the remaining interest to the Government on demand.

(g) Financial institution agreement. Before an advance payment is made under this contract, the Contractor shall transmit to the administering office, in the form prescribed by the administering office, an agreement in triplicate from the financial institution in which the special account is established, clearly setting forth the special character of the account and the responsibilities of the financial institution under the account. The Contractor shall select a financial institution that is a member bank of the Federal Reserve System, an insured bank within the meaning of the Federal Deposit Insurance Corporation Act (12 U.S.C. 1811), or a credit union insured by the National Credit Union Administration.

(h) *Lien on special account*. The Government shall have a lien upon any balance in the special account paramount to all other liens. The Government lien shall secure the repayment of any advance payments made under this contract and any related interest charges.

(i) *Lien on property under contract*. (1) All advance payments under this contract, together with interest charges, shall be secured, when made, by a lien in favor of the Government, paramount to all other liens, on the supplies or other things covered by this contract and on material and other property acquired for or allocated to the performance of this contract, except to the extent that the Government by virtue of any other terms of this contract, or otherwise, shall have valid title to the supplies, materials, or other property as against other creditors of the Contractor.

(2) The Contractor shall identify, by marking or segregation, all property that is subject to a lien in favor of the Government by virtue of any terms of this contract in such a way as to indicate that it is subject to a lien and that it

has been acquired for or allocated to performing this contract. If, for any reason, the supplies, materials, or other property are not identified by marking or segregation, the Government shall be considered to have a lien to the extent of the Government's interest under this contract on any mass of property with which the supplies, materials, or other property are commingled. The Contractor shall maintain adequate accounting control over the property on its books and records.

(3) If, at any time during the progress of the work on the contract, it becomes necessary to deliver to a third person any items or materials on which the Government has a lien, the Contractor shall notify the third person of the lien and shall obtain from the third person a receipt in duplicate acknowledging the existence of the lien. The Contractor shall provide a copy of each receipt to the Contracting Officer.

(4) If, under the termination clause, the Contracting Officer authorizes the Contractor to sell or retain termination inventory, the approval shall constitute a release of the Government's lien to the extent that -

(i) The termination inventory is sold or retained; and

(ii) The sale proceeds or retention credits are applied to reduce any outstanding advance payments.

(j) *Insurance*. (1) The Contractor shall maintain with responsible insurance carriers -

(i) Insurance on plant and equipment against fire and other hazards, to the extent that similar properties are usually insured by others operating plants and properties of similar character in the same general locality;

(ii) Adequate insurance against liability on account of damage to persons or property; and

(iii) Adequate insurance under all applicable workers' compensation laws.

(2) Until work under this contract has been completed and all advance payments made under the contract have been liquidated, the Contractor shall -

(i) Maintain this insurance;

(ii) Maintain adequate insurance on any materials, parts, assemblies, subassemblies, supplies, equipment, and other property acquired for or allocable to this contract and subject to the Government lien under paragraph (i) of this clause; and

(iii) Furnish any evidence with respect to its insurance that the administering office may require.

(k) *Default*. (1) If any of the following events occurs, the Government may, by written notice to the Contractor, withhold further withdrawals from the special account and further payments on this contract:

(i) Termination of this contract for a fault of the Contractor.

(ii) A finding by the administering office that the Contractor has failed to -

(A) Observe any of the conditions of the advance payment terms;

(B) Comply with any material term of this contract;

(C) Make progress or maintain a financial condition adequate for performance of this contract;

(D) Limit inventory allocated to this contract to reasonable requirements; or

(E) Avoid delinquency in payment of taxes or of the costs of performing this contract in the ordinary course of business.

(iii) The appointment of a trustee, receiver, or liquidator for all or a substantial part of the Contractor's property, or the institution of proceedings by or against the Contractor for bankruptcy, reorganization, arrangement, or liquidation.

(iv) The service of any writ of attachment, levy of execution, or commencement of garnishment proceedings concerning the special account.

(v) The commission of an act of bankruptcy.

(2) If any of the events described in subparagraph (1) above continue for 30 days after the written notice to the Contractor, the Government may take any of the following additional actions:

(i) Withdraw by checks payable to the Treasurer of the United States, signed only by the countersigning agency, all or any part of the balance in the special account and apply the amounts to reduce outstanding advance payments and any other claims of the Government against the Contractor.

(ii) Charge interest, in the manner prescribed in paragraph (f) above, on outstanding advance payments during the period of any event described in subparagraph (k)(1) above.

(iii) Demand immediate repayment by the Contractor of the unliquidated balance of advance payments.

(iv) Take possession of and, with or without advertisement, sell at public or private sale all or any part of the property on which the Government has a lien under this contract and, after deducting any expenses incident to the sale, apply the net proceeds of the sale to reduce the unliquidated balance of advance payments or other Government claims against the Contractor.

(3) The Government may take any of the actions described in subparagraphs (k)(1) and (2) of this clause it considers appropriate at its discretion and without limiting any other rights of the Government.

(l) *Prohibition against assignment*. Notwithstanding any other terms of this contract, the Contractor shall not assign this contract, any interest therein, or any claim under the contract to any party.

(m) *Information and access to records*. The Contractor shall furnish to the administering office (1) monthly or at other intervals as required, signed or certified balance sheets and profit and loss statements together with a report on the operation of the special account in the form prescribed by the administering office; and (2) if requested, other information concerning the operation of the Contractor's business. The Contractor shall provide the authorized Government representatives proper facilities for inspection of the Contractor's books, records, and accounts.

(n) *Other security*. The terms of this contract are considered to provide adequate security to the Government for advance payments; however, if the administering office considers the security inadequate, the Contractor shall furnish additional security satisfactory to the administering office, to the extent that the security is available.

(o) *Representations*. The Contractor represents the following:

(1) The balance sheet, the profit and loss statement, and any other supporting financial statements furnished to the administering office fairly reflect the financial condition of the Contractor at the date shown or the period covered, and there has been no subsequent materially adverse change in the financial condition of the Contractor.

(2) No litigation or proceedings are presently pending or threatened against the Contractor, except as shown in the financial statements.

(3) The Contractor has disclosed all contingent liabilities, except for liability resulting from the renegotiation of defense production contracts, in the financial statements furnished to the administering office.

(4) None of the terms in this clause conflict with the authority under which the Contractor is doing business or with the provision of any existing indenture or agreement of the Contractor.

(5) The Contractor has the power to enter into this contract and accept advance payments, and has taken all necessary action to authorize the acceptance under the terms of this contract.

(6) The assets of the Contractor are not subject to any lien or encumbrance of any character except for current taxes not delinquent, and except as shown in the financial statements furnished by the Contractor. There is no current assignment of claims under any contract affected by these advance payment provisions.

(7) All information furnished by the Contractor to the administering office in connection with each request for advance payments is true and correct.

(8) These representations shall be continuing and shall be considered to have been repeated by the submission of each invoice for advance payments.

(p) *Covenants*. To the extent the Government considers it necessary while any advance payments made under this contract remain outstanding, the Contractor, without the prior written consent of the administering office, shall not -

(1) Mortgage, pledge, or otherwise encumber or allow to be encumbered, any of the assets of the Contractor now owned or subsequently acquired, or permit any preexisting mortgages, liens, or other encumbrances to remain on or attach to any assets of the Contractor which are allocated to performing this contract and with respect to which the Government has a lien under this contract;

(2) Sell, assign, transfer, or otherwise dispose of accounts receivable, notes, or claims for money due or to become due;

(3) Declare or pay any dividends, except dividends payable in stock of the corporation, or make any other distribution on account of any shares of its capital stock, or purchase, redeem, or otherwise acquire for value any of its stock, except as required by sinking fund or redemption arrangements reported to the administering office incident to the establishment of these advance payment provisions;

(4) Sell, convey, or lease all or a substantial part of its assets;

(5) Acquire for value the stock or other securities of any corporation, municipality, or governmental authority, except direct obligations of the United States;

(6) Make any advance or loan or incur any liability as guarantor, surety, or accommodation endorser for any party;

(7) Permit a writ of attachment or any similar process to be issued against its property without getting a release or bonding the property within 30 days after the entry of the writ of attachment or other process;

(8) Pay any remuneration in any form to its directors, officers, or key employees higher than rates provided in existing agreements of which notice has been given to the administering office; accrue excess remuneration without first obtaining an agreement subordinating it to all claims of the Government; or employ any person at a rate of compensation over $ [ ] a year;

(9) Change substantially the management, ownership, or control of the corporation;

(10) Merge or consolidate with any other firm or corporation, change the type of business, or engage in any transaction outside the ordinary course of the Contractor's business as presently conducted;

(11) Deposit any of its funds except in a bank or trust company insured by the Federal Deposit Insurance Corporation or a credit union insured by the National Credit Union Administration;

(12) Create or incur indebtedness for advances, other than advances to be made under the terms of this contract, or for borrowings;

(13) Make or covenant for capital expenditures exceeding $ [ ] in total;

(14) Permit its net current assets, computed in accordance with generally accepted accounting principles, to become less than $[ ]; or

(15) Make any payments on account of the obligations listed below, except in the manner and to the extent provided in this contract:

[*List the pertinent obligations*]

(End of clause)

52.232-12 Advance Payments. (MAY 2001) - Alternate V (MAY 2001)

ADVANCE PAYMENTS WITHOUT SPECIAL BANK ACCOUNT (MAY 1999)

(a) *Requirements for payment.* Advance payments will be made under this contract (1) upon submission of properly certified invoices or vouchers by the contractor, and approval by the administering office, [*insert the name of the office designated under agency procedures*], or (2) under a letter of credit. The amount of the invoice or voucher submitted plus all advance payments previously approved shall not exceed $[ ]. If a letter of credit is used, the Contractor shall withdraw cash only when needed for disbursements acceptable under this contract and report cash disbursements and balances as required by the administering office. The Contractor shall apply terms similar to this clause to any advance payments to subcontractors.

(b) *Use of funds*. The Contractor may use advance payment funds only to pay for properly allocable, allowable, and reasonable costs for direct materials, direct labor, and indirect costs. Determinations of whether costs are properly allocable, allowable, and reasonable shall be in accordance with generally accepted accounting principles, subject to any applicable subparts of Part 31 of the Federal Acquisition Regulation.

(c) *Repayment to the Government*. At any time, the Contractor may repay all or any part of the funds advanced by the Government. Whenever requested in writing to do so by the administering office, the Contractor shall repay to the Government any part of unliquidated advance payments considered by the administering office to exceed the Contractor's current requirements or the amount specified in paragraph (a) of this clause.

(d) Maximum payment. When the sum of all unliquidated advance payments, unpaid interest charges, and other payments exceed [ ] percent of the contract price, the Government shall withhold further payments to the Contractor. On completion or termination of the contract, the Government shall deduct from the amount due to the Contractor all unliquidated advance payments and all interest charges payable. If previous payments to the Contractor exceed the amount due, the excess amount shall be paid to the Government on demand. For purposes of this paragraph, the contract price shall be considered to be the stated contract price of $[ ], less any subsequent price reductions under the contract, plus (1) any price increases resulting from any terms of this contract for price redetermination or escalation, and (2) any other price increases that do not, in the aggregate, exceed $[*insert an amount not higher than 10 percent of the stated contract amount inserted in this paragraph*]. Any payments withheld under this paragraph shall be applied to reduce the unliquidated advance payments. If full liquidation has been made, payments under the contract shall resume.

(e) *Interest*. (1) The Contractor shall pay interest to the Government on the daily unliquidated advance payments at the daily rate in subparagraph (e)(3) of this clause. Interest shall be computed at the end of each calendar month for the actual number of days involved. For the purpose of computing the interest charge -

(i) Advance payments shall be considered as increasing the unliquidated balance as of the date of the advance payment check;

(ii) Repayments by Contractor check shall be considered as decreasing the unliquidated balance as of the date on which the check is received by the Government authority designated by the Contracting Officer; and

(iii) Liquidations by deductions from Government payments to the Contractor shall be considered as decreasing the unliquidated balance as of the date of the check for the reduced payment.

(2) Interest charges resulting from the monthly computation shall be deducted from payments, other than advance payments, due the Contractor. If the accrued interest exceeds the payment due, any excess interest shall be carried forward and deducted from subsequent payments. Interest carried forward shall not be compounded. Interest on advance payments shall cease to accrue upon satisfactory completion or termination of the contract for the convenience of the Government. The Contractor shall charge interest on advance payments to subcontractors in the manner described above and credit the interest to the Government. Interest need not be charged on advance payments to nonprofit educational or research subcontractors, for experimental, developmental, or research work.

(3) If interest is required under the contract, the Contracting Officer shall determine a daily interest rate based on the rate established by the Secretary of the Treasury under Pub. L. 92-41 (50 U.S.C. App., 1215(b)(2)). The Contracting Officer shall revise the daily interest rate during the contract period in keeping with any changes in the cited interest rate.

(4) If the full amount of interest charged under this paragraph has not been paid by deduction or otherwise upon completion or termination of this contract, the Contractor shall pay the remaining interest to the Government on demand.

(f) *Lien on property under contract*. (1) All advance payments under this contract, together with interest charges, shall be secured, when made, by a lien in favor of the Government, paramount to all other liens, on the supplies or other things covered by this contract and on all material and other property acquired for or allocated to the performance of this contract, except to the extent that the Government by virtue of any other terms of this contract, or otherwise, shall have valid title to the supplies, materials, or other property as against other creditors of the Contractor.

(2) The Contractor shall identify, by marking or segregation, all property that is subject to a lien in favor of the Government by virtue of any terms of this contract in such a way as to indicate that it is subject to a lien and that it has been acquired for or allocated to performing this contract. If, for any reason, the supplies, materials, or other property are not identified by marking or segregation, the Government shall be considered to have a lien to the extent of the Government's interest under this contract on any mass of property with which the supplies, materials, or other property are commingled. The Contractor shall maintain adequate accounting control over the property on its books and records.

(3) If, at any time during the progress of the work on the contract, it becomes necessary to deliver to a third person any items or materials on which the Government has a lien, the Contractor shall notify the third person of the lien and shall obtain from the third person a receipt in duplicate acknowledging the existence of the lien. The Contractor shall provide a copy of each receipt to the Contracting Officer.

(4) If, under the termination clause, the Contracting Officer authorizes the contractor to sell or retain termination inventory, the approval shall constitute a release of the Government's lien to the extent that -

(i) The termination inventory is sold or retained; and

(ii) The sale proceeds or retention credits are applied to reduce any outstanding advance payments.

(g) *Insurance*. (1) The Contractor shall maintain with responsible insurance carriers -

(i) Insurance on plant and equipment against fire and other hazards, to the extent that similar properties are usually insured by others operating plants and properties of similar character in the same general locality;

(ii) Adequate insurance against liability on account of damage to persons or property; and

(iii) Adequate insurance under all applicable workers' compensation laws.

(2) Until work under this contract has been completed and all advance payments made under the contract have been liquidated, the Contractor shall -

(i) Maintain this insurance;

(ii) Maintain adequate insurance on any materials, parts, assemblies, subassemblies, supplies, equipment, and other property acquired for or allocable to this contract and subject to the Government lien under paragraph (f) of this clause; and

(iii) Furnish any evidence with respect to its insurance that the administering office may require.

(h) *Default*. (1) If any of the following events occur, the Government may, by written notice to the Contractor, withhold further payments on this contract:

(i) Termination of this contract for a fault of the Contractor.

(ii) A finding by the administering office that the Contractor has failed to -

(A) Observe any of the conditions of the advance payment terms;

(B) Comply with any material term of this contract;

(C) Make progress or maintain a financial condition adequate for performance of this contract;

(D) Limit inventory allocated to this contract to reasonable requirements; or

(E) Avoid delinquency in payment of taxes or of the costs of performing this contract in the ordinary course of business.

(iii) The appointment of a trustee, receiver, or liquidator for all or a substantial part of the Contractor's property, or the institution of proceedings by or against the Contractor for bankruptcy, reorganization, arrangement, or liquidation.

(iv) The commission of an act of bankruptcy.

(2) If any of the events described in subparagraph (h)(1) of this clause continue for 30 days after the written notice to the Contractor, the Government may take any of the following additional actions:

(i) Charge interest, in the manner prescribed in paragraph (e) of this clause, on outstanding advance payments during the period of any event described in subparagraph (h)(1) of this clause.

(ii) Demand immediate repayment by the Contractor of the unliquidated balance of advance payments.

(iii) Take possession of and, with or without advertisement, sell at public or private sale all or any part of the property on which the Government has a lien under this contract and, after deducting any expenses incident to the sale, apply the net proceeds of the sale to reduce the unliquidated balance of advance payments or other Government claims against the Contractor.

(3) The Government may take any of the actions described in subparagraphs (h)(1) and (h)(2) of this clause it considers appropriate at its discretion and without limiting any other rights of the Government.

(i) *Prohibition against assignment*. Notwithstanding any other terms of this contract, the Contractor shall not assign this contract, any interest therein, or any claim under the contract to any party.

(j) *Information and access to records*. The Contractor shall furnish to the administering office (1) monthly or at other intervals as required, signed or certified balance sheets and profit and loss statements, and, (2) if requested, other information concerning the operation of the contractor's business. The Contractor shall provide the authorized Government representatives proper facilities for inspection of the Contractor's books, records, and accounts.

(k) *Other security*. The terms of this contract are considered to provide adequate security to the Government for advance payments; however, if the administering office considers the security inadequate, the Contractor shall furnish additional security satisfactory to the administering office, to the extent that the security is available.

(l) *Representations*. The Contractor represents the following:

(1) The balance sheet, the profit and loss statement, and any other supporting financial statements furnished to the administering office fairly reflect the financial condition of the Contractor at the date shown or the period covered, and there has been no subsequent materially adverse change in the financial condition of the Contractor.

(2) No litigation or proceedings are presently pending or threatened against the Contractor, except as shown in the financial statements.

(3) The Contractor has disclosed all contingent liabilities, except for liability resulting from the renegotiation of defense production contracts, in the financial statements furnished to the administering office.

(4) None of the terms in this clause conflict with the authority under which the Contractor is doing business or with the provision of any existing indenture or agreement of the Contractor.

(5) The Contractor has the power to enter into this contract and accept advance payments, and has taken all necessary action to authorize the acceptance under the terms of this contract.

(6) The assets of the Contractor are not subject to any lien or encumbrance of any character except for current taxes not delinquent, and except as shown in the financial statements furnished by the Contractor. There is no current assignment of claims under any contract affected by these advance payment provisions.

(7) All information furnished by the Contractor to the administering office in connection with each request for advance payments is true and correct.

(8) These representations shall be continuing and shall be considered to have been repeated by the submission of each invoice for advance payments.

(m) *Covenants*. To the extent the Government considers it necessary while any advance payments made under this contract remain outstanding, the Contractor, without the prior written consent of the administering office, shall not -

(1) Mortgage, pledge, or otherwise encumber or allow to be encumbered, any of the assets of the Contractor now owned or subsequently acquired, or permit any preexisting mortgages, liens, or other encumbrances to remain on or attach to any assets of the Contractor which are allocated to performing this contract and with respect to which the Government has a lien under this contract;

(2) Sell, assign, transfer, or otherwise dispose of accounts receivable, notes, or claims for money due or to become due;

(3) Declare or pay any dividends, except dividends payable in stock of the corporation, or make any other distribution on account of any shares of its capital stock, or purchase, redeem, or otherwise acquire for value any of its stock, except as required by sinking fund or redemption arrangements reported to the administering office incident to the establishment of these advance payment provisions;

(4) Sell, convey, or lease all or a substantial part of its assets;

(5) Acquire for value the stock or other securities of any corporation, municipality, or Governmental authority, except direct obligations of the United States;

(6) Make any advance or loan or incur any liability as guarantor, surety, or accommodation endorser for any party;

(7) Permit a writ of attachment or any similar process to be issued against its property without getting a release or bonding the property within 30 days after the entry of the writ of attachment or other process;

(8) Pay any remuneration in any form to its directors, officers, or key employees higher than rates provided in existing agreements of which notice has been given to the administering office, accrue excess remuneration without first obtaining an agreement subordinating it to all claims of the Government, or employ any person at a rate of compensation over $[ ] a year;

(9) Change substantially the management, ownership, or control of the corporation;

(10) Merge or consolidate with any other firm or corporation, change the type of business, or engage in any transaction outside the ordinary course of the Contractor's business as presently conducted;

(11) Deposit any of its funds except in a bank or trust company insured by the Federal Deposit Insurance Corporation or a credit union insured by the National Credit Union Administration;

(12) Create or incur indebtedness for advances, other than advances to be made under the terms of this contract, or for borrowings;

(13) Make or covenant for capital expenditures exceeding $[ ] in total;

(14) Permit its net current assets, computed in accordance with generally accepted accounting principles, to become less than $[ ] ; or

(15) Make any payments on account of the obligations listed below, except in the manner and to the extent provided in this contract:

[*List the pertinent obligations*]

(End of clause)

52.232-23 Assignment of Claims. (JAN 1986)

52.243-1 Changes - Fixed-Price. (AUG 1987) - Alternate V (APR 1984)

52.246-23 Limitation of Liability. (FEB 1997)

52.252-6 Authorized Deviations in Clauses. (APR 1984)

(a) The use in this solicitation or contract of any Federal Acquisition Regulation (48 CFR Chapter 1) clause with an authorized deviation is indicated by the addition of (DEVIATION) after the date of the clause.

(b) The use in this solicitation or contract of any NASA FAR Supplement (48 CFR 18) clause with an authorized deviation is indicated by the addition of (DEVIATION) after the name of the regulation.

(End of clause)

1852.204-76 Security Requirements for Unclassified Information Technology Resources. (MAY 2007)

(a) The Contractor shall be responsible for information and information technology (IT) security when -

(1) The Contractor or its subcontractors must obtain physical or electronic (i.e., authentication level 2 and above as defined in National Institute of Standards and Technology (NIST) Special Publication (SP) 800-63, Electronic Authentication Guideline) access to NASA's computer systems, networks, or IT infrastructure; or

(2) Information categorized as low, moderate, or high by the Federal Information Processing Standards (FIPS) 199, Standards for Security Categorization of Federal Information and Information Systems is stored, generated, processed, or exchanged by NASA or on behalf of NASA by a contractor or subcontractor, regardless of whether the information resides on a NASA or a contractor/subcontractor's information system.

(b) IT Security Requirements.

(1) Within 30 days after contract award, a Contractor shall submit to the Contracting Officer for NASA approval an IT Security Plan, Risk Assessment, and FIPS 199, Standards for Security Categorization of Federal Information and Information Systems, Assessment. These plans and assessments, including annual updates shall be incorporated into the contract as compliance documents.

(i) The IT system security plan shall be prepared consistent, in form and content, with NIST SP 800-18, Guide for Developing Security Plans for Federal Information Systems, and any additions/augmentations described in NASA Procedural Requirements (NPR) 2810, Security of Information Technology. The security plan shall identify and document appropriate IT security controls consistent with the sensitivity of the information and the requirements of Federal Information Processing Standards (FIPS) 200, Recommended Security Controls for Federal Information Systems. The plan shall be reviewed and updated in accordance with NIST SP 800-26, Security Self-Assessment Guide for Information Technology Systems, and FIPS 200, on a yearly basis.

(ii) The risk assessment shall be prepared consistent, in form and content, with NIST SP 800-30, Risk Management Guide for Information Technology Systems, and any additions/augmentations described in NPR 2810. The risk assessment shall be updated on a yearly basis.

(iii) The FIPS 199 assessment shall identify all information types as well as the "high water mark," as defined in FIPS 199, of the processed, stored, or transmitted information necessary to fulfill the contractual requirements.

(2) The Contractor shall produce contingency plans consistent, in form and content, with NIST SP 800-34, Contingency Planning Guide for Information Technology Systems, and any additions/augmentations described in NPR 2810. The Contractor shall perform yearly "Classroom Exercises." "Functional Exercises," shall be coordinated with the Center CIOs and be conducted once every three years, with the first conducted within the first two years of contract award. These exercises are defined and described in NIST SP 800-34.

(3) The Contractor shall ensure coordination of its incident response team with the NASA Incident Response Center (NASIRC) and the NASA Security Operations Center, ensuring that incidents are reported consistent with NIST SP 800-61, Computer Security Incident Reporting Guide, and the United States Computer Emergency Readiness Team's (US-CERT) Concept of Operations for reporting security incidents. Specifically, any confirmed incident of a system containing NASA data or controlling NASA assets shall be reported to NASIRC within one hour that results in unauthorized access, loss or modification of NASA data, or denial of service affecting the availability of NASA data.

(4) The Contractor shall ensure that its employees, in performance of the contract, receive annual IT security training in NASA IT Security policies, procedures, computer ethics, and best practices in accordance with NPR 2810 requirements. The Contractor may use web-based training available from NASA to meet this requirement.

(5) The Contractor shall provide NASA, including the NASA Office of Inspector General, access to the Contractor's and subcontractors' facilities, installations, operations, documentation, databases, and personnel used in performance of the contract. Access shall be provided to the extent required to carry out IT security inspection, investigation, and/or audits to safeguard against threats and hazards to the integrity, availability, and confidentiality of NASA information or to the function of computer systems operated on behalf of NASA, and to preserve evidence of computer crime. To facilitate mandatory reviews, the Contractor shall ensure appropriate compartmentalization of NASA information, stored and/or processed, either by information systems in direct support of the contract or that are incidental to the contract.

(6) The Contractor shall ensure that system administrators who perform tasks that have a material impact on IT

security and operations demonstrate knowledge appropriate to those tasks. Knowledge is demonstrated through the NASA System Administrator Security Certification Program. A system administrator is one who provides IT services (including network services, file storage, and/or web services) to someone other than themselves and takes or assumes the responsibility for the security and administrative controls of that service. Within 30 days after contract award, the Contractor shall provide to the Contracting Officer a list of all system administrator positions and personnel filling those positions, along with a schedule that ensures certification of all personnel within 90 days after contract award. Additionally, the Contractor should report all personnel changes which impact system administrator positions within 5 days of the personnel change and ensure these individuals obtain System Administrator certification within 90 days after the change.

(7) The Contractor shall ensure that NASA's Sensitive But Unclassified (SBU) information as defined in NPR 1600.1, NASA Security Program Procedural Requirements, which includes privacy information, is encrypted in storage and transmission.

(8) When the Contractor is located at a NASA Center or installation or is using NASA IP address space, the Contractor shall -

(i) Submit requests for non-NASA provided external Internet connections to the Contracting Officer for approval by the Network Security Configuration Control Board (NSCCB);

(ii) Comply with the NASA CIO metrics including patch management, operating systems and application configuration guidelines, vulnerability scanning, incident reporting, system administrator certification, and security training; and

(iii) Utilize the NASA Public Key Infrastructure (PKI) for all encrypted communication or non-repudiation requirements within NASA when secure email capability is required.

(c) Physical and Logical Access Requirements.

(1) Contractor personnel requiring access to IT systems operated by the Contractor for NASA or interconnected to a NASA network shall be screened at an appropriate level in accordance with NPR 2810 and Chapter 4, NPR 1600.1, NASA Security Program Procedural Requirements. NASA shall provide screening, appropriate to the highest risk level, of the IT systems and information accessed, using, as a minimum, National Agency Check with Inquiries (NACI). The Contractor shall submit the required forms to the NASA Center Chief of Security (CCS) within fourteen (14) days after contract award or assignment of an individual to a position requiring screening. The forms may be obtained from the CCS. At the option of NASA, interim access may be granted pending completion of the required investigation and final access determination. For Contractors who will reside on a NASA Center or installation, the security screening required for all required access (e.g., installation, facility, IT, information, etc.) is consolidated to ensure only one investigation is conducted based on the highest risk level. Contractors not residing on a NASA installation will be screened based on their IT access risk level determination only. See NPR 1600.1, Chapter 4.

(2) Guidance for selecting the appropriate level of screening is based on the risk of adverse impact to NASA missions. NASA defines three levels of risk for which screening is required (IT-1 has the highest level of risk).

(i) IT-1 - Individuals having privileged access or limited privileged access to systems whose misuse can cause very serious adverse impact to NASA missions. These systems include, for example, those that can transmit commands directly modifying the behavior of spacecraft, satellites or aircraft.

(ii) IT-2 - Individuals having privileged access or limited privileged access to systems whose misuse can cause serious adverse impact to NASA missions. These systems include, for example, those that can transmit commands directly modifying the behavior of payloads on spacecraft, satellites or aircraft; and those that contain the primary copy of "level 1" information whose cost to replace exceeds one million dollars.

(iii) IT-3 - Individuals having privileged access or limited privileged access to systems whose misuse can cause significant adverse impact to NASA missions. These systems include, for example, those that interconnect with a

NASA network in a way that exceeds access by the general public, such as bypassing firewalls; and systems operated by the Contractor for NASA whose function or information has substantial cost to replace, even if these systems are not interconnected with a NASA network.

(3) Screening for individuals shall employ forms appropriate for the level of risk as established in Chapter 4, NPR 1600.1.

(4) The Contractor may conduct its own screening of individuals requiring privileged access or limited privileged access provided the Contractor can demonstrate to the Contracting Officer that the procedures used by the Contractor are equivalent to NASA's personnel screening procedures for the risk level assigned for the IT position.

(5) Subject to approval of the Contracting Officer, the Contractor may forgo screening of Contractor personnel for those individuals who have proof of a -

(i) Current or recent national security clearances (within last three years);

(ii) Screening conducted by NASA within the last three years that meets or exceeds the screening requirements of the IT position; or

(iii) Screening conducted by the Contractor, within the last three years, that is equivalent to the NASA personnel screening procedures as approved by the Contracting Officer and concurred on by the CCS.

(d) The Contracting Officer may waive the requirements of paragraphs (b) and (c) (1) through (c) (3) upon request of the Contractor. The Contractor shall provide all relevant information requested by the Contracting Officer to support the waiver request.

(e) The Contractor shall contact the Contracting Officer for any documents, information, or forms necessary to comply with the requirements of this clause.

(f) At the completion of the contract, the contractor shall return all NASA information and IT resources provided to the contractor during the performance of the contract and certify that all NASA information has been purged from contractor-owned systems used in the performance of the contract.

(g) The Contractor shall insert this clause, including this paragraph (g), in all subcontracts:

(1) Have physical or electronic access to NASA's computer systems, networks, or IT infrastructure; or

(2) Use information systems to generate, store, process, or exchange data with NASA or on behalf of NASA, regardless of whether the data resides on a NASA or a contractor's information system.

(End of clause)

1852.215-84 Ombudsman. (OCT 2003)

(a) An ombudsman has been appointed to hear and facilitate the resolution of concerns from offerors, potential offerors, and contractors during the preaward and postaward phases of this acquisition. When requested, the ombudsman will maintain strict confidentiality as to the source of the concern. The existence of the ombudsman is not to diminish the authority of the contracting officer, the Source Evaluation Board, or the selection official. Further, the ombudsman does not participate in the evaluation of proposals, the source selection process, or the adjudication of formal contract disputes. Therefore, before consulting with an ombudsman, interested parties must first address their concerns, issues, disagreements, and/or recommendations to the contracting officer for resolution.

(b) If resolution cannot be made by the contracting officer, interested parties may contact the installation ombudsman, Rebecca S. Dubuisson, NASA Shared Services Center, rebecca.s.dubuisson@nasa.gov. Concerns, issues, disagreements, and recommendations which cannot be resolved at the installation may be referred to the NASA ombudsman, James A. Balinskas, the Director of the Contract Management Division, at 202-358-0445, facsimile

202-358-3083, e-mail james.a.balinskas@nasa.gov . Please do not contact the ombudsman to request copies of the solicitation, verify offer due date, or clarify technical requirements. Such inquiries shall be directed to the Contracting Officer or as specified elsewhere in this document.

(End of clause)

1852.219-76 NASA 8 Percent Goal. (JUL 1997)

(a) Definitions.

"Historically Black Colleges or University," as used in this clause, means an institution determined by the Secretary of Education to meet the requirements of 34 CFR Section 608.2. The term also includes any nonprofit research institution that was an integral part of such a college or university before November 14, 1986.

"Minority institutions," as used in this clause, means an institution of higher education meeting the requirements of section 1046(3) of the Higher Education Act of 1965 (20 U.S.C. 1135d-5(3)) which for the purposes of this clause includes a Hispanic-serving institution of higher education as defined in section 316(b)(1) of the Act (20 U.S.C. 1059c(b)(1)).

"Small disadvantaged business concern," as used in this clause, means a small business concern that (1) is at least 51 percent unconditionally owned by one or more individuals who are both socially and economically disadvantaged, or a publicly owned business having at least 51 percent of its stock unconditionally owned by one or more socially and economically disadvantaged individuals, and (2) has its management and daily business controlled by one or more such individuals. This term also means a small business concern that is at least 51 percent unconditionally owned by an economically disadvantaged Indian tribe or Native Hawaiian Organization, or a publicly owned business having at least 51 percent of its stock unconditionally owned by one or more of these entities, which has its management and daily business controlled by members of an economically disadvantaged Indian tribe or Native Hawaiian Organization, and which meets the requirements of 13 CFR 124.

"Women-owned small business concern," as used in this clause, means a small business concern (1) which is at least 51 percent owned by one or more women or, in the case of any publicly owned business, at least 51 percent of the stock of which is owned by one or more women, and (2) whose management and daily business operations are controlled by one or more women.

(b) The NASA Administrator is required by statute to establish annually a goal to make available to small disadvantaged business concerns, Historically Black Colleges and Universities, minority institutions, and women-owned small business concerns, at least 8 percent of NASA's procurement dollars under prime contracts or subcontracts awarded in support of authorized programs, including the space station by the time operational status is obtained.

(c) The contractor hereby agrees to assist NASA in achieving this goal by using its best efforts to award subcontracts to such entities to the fullest extent consistent with efficient contract performance.

(d) Contractors acting in good faith may rely on written representations by their subcontractors regarding their status as small disadvantaged business concerns, Historically Black Colleges and Universities, minority institutions, and women-owned small business concerns.

(End of clause)

1852.219-80 Limitation on Subcontracting - SBIR Phase I Program. (OCT 2006)

1852.219-83 Limitation of the Principal Investigator - SBIR Program. (OCT 2006)

The primary employment of the principal investigator (PI) shall be with the small business concern (SBC)/Contractor during the conduct of this contract. Primary employment means that more than one-half of the principal investigator's time is spent in the employ of the SBC/Contractor. This precludes full-time employment with another organization. Deviations from these requirements must be approved in advance and in writing by the

Contracting Officer and are not subject to a change in the firm-fixed price of the contract. The PI for this contract is [*insert name*].

(End of clause)

1852.219-85 Conditions for Final Payment - SBIR and STTR Contracts. (OCT 2006)

1852.232-70 NASA Modification of FAR 52.232-12. (MAR 1998)

(a) Basic Clause. (1) In paragraph (e), Maximum Payment, in the sentence that begins "When the sum of," change the word "When" to lower case and insert before it: "Unliquidated advance payments shall not exceed $[ ] at any time outstanding. In addition.…"

(2) In paragraph (m) (1), delete "in the form prescribed by the administering office" and substitute "and Standard Form 272, Federal Cash Transactions Report, and, if appropriate, Standard Form 272-A, Federal Cash Transactions Report Continuation."

(b) Alternate II (if incorporated in the contract). In paragraph (e), Maximum Payment, in the sentence that begins "When the sum of," change the word "When" to lower case and insert before it: "Unliquidated advance payments shall not exceed $[ ] at any time outstanding. In addition.…"

(c) Alternate V (if incorporated in the contract). (1) Substitute the following for paragraph (b) : "(b) Use of funds. The Contractor may use advance payment funds only to pay for properly allocable, allowable, and reasonable costs for direct materials, direct labor, indirect costs, or such other costs approved in writing by the administering contracting office. Payments are subject to any restrictions in other clauses of this contract. Determinations of whether costs are properly allocable, allowable, and reasonable shall be in accordance with generally accepted accounting principles, subject to any applicable subparts of Part 31 of the Federal Acquisition Regulation, other applicable regulations referenced in Part 31, or Subpart 1831.2."

(2) In paragraph (d), Maximum Payment, in the sentence that begins "When the sum of," change the word "When" to lower case and insert before it: "Unliquidated advance payments shall not exceed $[ ] at any time outstanding. In addition.…"

(3) In paragraph (j) (1), insert between "Statements," and "and" "together with Standard Form 272, Federal Cash Transactions Report, and, if appropriate, Standard Form 272-A, Federal Cash Transactions Report Continuation"

(4) If this is a Phase I contract awarded under the SBIR or STTR programs, delete paragraph (a) and substitute the following: "(a) Requirements for payment. Advance payments will be made under this contract upon receipt of invoices from the Contractor. Invoices should be clearly marked "Small Business Innovation Research Contract" or "Small Business Technology Transfer Contract," as appropriate, to expedite payment processing. One-third of the total contract price will be available to be advanced to the contractor immediately after award, another one-third will be advanced three months after award, and the final one-third will be paid upon acceptance by NASA of the Contractor's final report. By law, full payment must be made no later than 12 months after the date that contract requirements are completed. The Contractor shall flow down the terms of this clause to any subcontractor requiring advance payments."

(End of clause)

1852.235-70 Center for AeroSpace Information. (DEC 2006)

1852.237-72 Access to Sensitive Information. (JUN 2005)

(a) As used in this clause, ``sensitive information" refers to information that a contractor has developed at private expense, or that the Government has generated that qualifies for an exception to the Freedom of Information Act, which is not currently in the public domain, and which may embody trade secrets or commercial or financial information, and which may be sensitive or privileged.

(b) To assist NASA in accomplishing management activities and administrative functions, the Contractor shall provide the services specified elsewhere in this contract.

(c) If performing this contract entails access to sensitive information, as defined above, the Contractor agrees to--

(1) Utilize any sensitive information coming into its possession only for the purposes of performing the services specified in this contract, and not to improve its own competitive position in another procurement.

(2) Safeguard sensitive information coming into its possession from unauthorized use and disclosure.

(3) Allow access to sensitive information only to those employees that need it to perform services under this contract.

(4) Preclude access and disclosure of sensitive information to persons and entities outside of the Contractor's organization.

(5) Train employees who may require access to sensitive information about their obligations to utilize it only to perform the services specified in this contract and to safeguard it from unauthorized use and disclosure.

(6) Obtain a written affirmation from each employee that he/she has received and will comply with training on the authorized uses and mandatory protections of sensitive information needed in performing this contract.

(7) Administer a monitoring process to ensure that employees comply with all reasonable security procedures, report any breaches to the Contracting Officer, and implement any necessary corrective actions.

(d) The Contractor will comply with all procedures and obligations specified in its Organizational Conflicts of Interest Avoidance Plan, which this contract incorporates as a compliance document.

(e) The nature of the work on this contract may subject the Contractor and its employees to a variety of laws and regulations relating to ethics, conflicts of interest, corruption, and other criminal or civil matters relating to the award and administration of government contracts. Recognizing that this contract establishes a high standard of accountability and trust, the Government will carefully review the Contractor's performance in relation to the mandates and restrictions found in these laws and regulations. Unauthorized uses or disclosures of sensitive information may result in termination of this contract for default, or in debarment of the Contractor for serious misconduct affecting present responsibility as a government contractor.

(f) The Contractor shall include the substance of this clause, including this paragraph (f), suitably modified to reflect the relationship of the parties, in all subcontracts that may involve access to sensitive information

(End of clause)

1852.237-73 Release of Sensitive Information. (JUN 2005)

(a) As used in this clause, "Sensitive information" refers to information, not currently in the public domain, that the Contractor has developed at private expense, that may embody trade secrets or commercial or financial information, and that may be sensitive or privileged.

(b) In accomplishing management activities and administrative functions, NASA relies heavily on the support of various service providers. To support NASA activities and functions, these service providers, as well as their subcontractors and their individual employees, may need access to sensitive information submitted by the Contractor under this contract. By submitting this proposal or performing this contract, the Contractor agrees that NASA may release to its service providers, their subcontractors, and their individual employees, sensitive information submitted during the course of this procurement, subject to the enumerated protections mandated by the clause at 1852.237-72, Access to Sensitive Information.

(c) (1) The Contractor shall identify any sensitive information submitted in support of this proposal or in performing this contract. For purposes of identifying sensitive information, the Contractor may, in addition to any other notice or legend otherwise required, use a notice similar to the following:

Mark the title page with the following legend:

This proposal or document includes sensitive information that NASA shall not disclose outside the Agency and its service providers that support management activities and administrative functions. To gain access to this sensitive information, a service provider's contract must contain the clause at NFS 1852.237-72, Access to Sensitive Information. Consistent with this clause, the service provider shall not duplicate, use, or disclose the information in whole or in part for any purpose other than to perform the services specified in its contract. This restriction does not limit the Government's right to use this information if it is obtained from another source without restriction. The information subject to this restriction is contained in pages [*insert page numbers or other identification of pages*]. Mark each page of sensitive information the Contractor wishes to restrict with the following legend:

Use or disclosure of sensitive information contained on this page is subject to the restriction on the title page of this proposal or document.

(2) The Contracting Officer shall evaluate the facts supporting any claim that particular information is "sensitive." This evaluation shall consider the time and resources necessary to protect the information in accordance with the detailed safeguards mandated by the clause at 1852.237-72, Access to Sensitive Information. However, unless the Contracting Officer decides, with the advice of Center counsel, that reasonable grounds exist to challenge the Contractor's claim that particular information is sensitive, NASA and its service providers and their employees shall comply with all of the safeguards contained in paragraph (d) of this clause.

(d) To receive access to sensitive information needed to assist NASA in accomplishing management activities and administrative functions, the service provider must be operating under a contract that contains the clause at 1852.237-72, Access to Sensitive Information. This clause obligates the service provider to do the following:

(1) Comply with all specified procedures and obligations, including the Organizational Conflicts of Interest Avoidance Plan, which the contract has incorporated as a compliance document.

(2) Utilize any sensitive information coming into its possession only for the purpose of performing the services specified in its contract.

(3) Safeguard sensitive information coming into its possession from unauthorized use and disclosure.

(4) Allow access to sensitive information only to those employees that need it to perform services under its contract.

(5) Preclude access and disclosure of sensitive information to persons and entities outside of the service provider's organization.

(6) Train employees who may require access to sensitive information about their obligations to utilize it only to perform the services specified in its contract and to safeguard it from unauthorized use and disclosure.

(7) Obtain a written affirmation from each employee that he/she has received and will comply with training on the authorized uses and mandatory protections of sensitive information needed in performing this contract.

(8) Administer a monitoring process to ensure that employees comply with all reasonable security procedures, report any breaches to the Contracting Officer, and implement any necessary corrective actions.

(e) When the service provider will have primary responsibility for operating an information technology system for NASA that contains sensitive information, the service provider's contract shall include the clause at 1852.204-76, Security Requirements for Unclassified Information Technology Resources. The Security Requirements clause requires the service provider to implement an Information Technology Security Plan to protect information processed, stored, or transmitted from unauthorized access, alteration, disclosure, or use. Service provider personnel requiring privileged access or limited privileged access to these information technology systems are subject to screening using the standard National Agency Check (NAC) forms appropriate to the level of risk for adverse impact to NASA missions. The Contracting Officer may allow the service provider to conduct its own screening, provided the service provider employs substantially equivalent screening procedures.

(f) This clause does not affect NASA's responsibilities under the Freedom of Information Act.

(g) The Contractor shall insert this clause, including this paragraph (g), suitably modified to reflect the relationship of the parties, in all subcontracts that may require the furnishing of sensitive information.

(End of clause)

LIST OF ATTACHMENTS

LIST OF ATTACHMENTS

The following documents are attached hereto and made a part of this contract:

[*Insert a table that identifies each contract Attachment (contract documents, exhibits, etc.), the Date of the attachment, and the Number of Pages for each attachment.*]

(End of Clause)

Appendix D: SBIR Phase 2 Model Contract

SUPPLIES OR SERVICES AND PRICES/COSTS

1852.216-78 Firm Fixed Price. (DEC 1988)

The total firm fixed price of this contract is $[*Insert the appropriate amount*].

(End of clause)

SUPPLIES AND/OR SERVICES TO BE PROVIDED

The Contractor shall provide all resources (except as may be expressly stated in the contract as furnished by the Government) necessary to deliver and/or perform the items below in accordance with the Description/Specifications/Statement of Work incorporated [*insert attachment number and/or section identifier of the Spec/SOW*].

[*data item deliverable table*]

(End of clause)

DESCRIPTION/SPECIFICATIONS/STATEMENT OF WORK

SPECIFICATION/STATEMENT OF WORK

The Contractor shall provide the item or services specified in Section B in accordance with the following:

[*Insert the Title of the Specification and/or Statement of Work*]

(End of text)

INSPECTION AND ACCEPTANCE

52.246-7 Inspection of Research and Development - Fixed-Price. (AUG 1996)

52.246-16 Responsibility for Supplies. (APR 1984)

1852.246-72 Material Inspection and Receiving Report. (AUG 2003)

(a) At the time of each delivery to the Government under this contract, the Contractor shall furnish a Material Inspection and Receiving Report (DD Form 250 series) prepared in [*Insert number of copies, including original*] copies, an original and [ ] copies (Insert number of copies).

(b) The Contractor shall prepare the DD Form 250 in accordance with NASA FAR Supplement 1846.6. The Contractor shall enclose the copies of the DD Form 250 in the package or seal them in a waterproof envelope, which shall be securely attached to the exterior of the package in the most protected location.

(c) When more than one package is involved in a shipment, the Contractor shall list on the DD Form 250, as additional information, the quantity of packages and the package numbers. The Contractor shall forward the DD Form 250 with the lowest numbered package of the shipment and print the words "CONTAINS DD FORM 250" on the package.

(End of clause)

DELIVERIES OR PERFORMANCE

52.242-15 Stop-Work Order. (AUG 1989)

52.247-34 F.o.b. Destination. (NOV 1991)

PERIOD OF PERFORMANCE

The period of performance of this contract is [*Insert specific dates (i.e. "from___ to ___") or the negotiated period in terms of weeks, months, or years (ex: "12 months from the effective date of the contract").*]

(End of clause)

DELIVERY AND/OR COMPLETION SCHEDULE

The Contractor shall deliver and/or complete performance of the items required under this contract as follows:

[*Insert a table which details for each item, the item number, description, quantity, unit of measure, and delivery/completion date.*]

(End of clause)

ADDITIONAL INFORMATION ON REPORTS OF WORK - SBIR/STTR Phase II

(a) Interim Technical Progress Reports. (1) At the end of every third month of contract performance (quarterly), the Contractor shall submit an interim progress report of all work accomplished. The report shall be in narrative form, be brief, and informal. This report shall include --

(i) A quantitative description of work performed during the period;

(ii) An indication of any current problems which may impede performance or impact program schedule or cost, and proposed corrective action;

(iii) A discussion of the work to be performed during the next reporting period;

(iv) Description of any changes to the planned use of subcontractors since contract award; and

(v) Estimated percentage of physical completion of the contract.

This report shall be submitted via the NASA SBIR Electronic Contract Administration Handbook. Instructions for the electronic submission process are available to contractors on the NASA SBIR home page at http://sbir.nasa.gov.

(2) Interim Technical Progress Reports are to be submitted within (10) days following the period to be reported, except for the Final report which shall be submitted no later than the final day of the contract performance period.

(b) Final Report, Project Summary Document & Project Summary Chart. The Contractor shall submit a Final Report within twenty four (24) months from the effective date of this contract. The report shall be in narrative form documenting and summarizing the results of the entire contract work. The following instructions apply to the final report and are in addition to the requirements of the "Final Scientific and Technical Reports" clause of this contract.

(1) The Final Report shall include both a single-page project summary as the first page, identifying the purpose of the research, a brief description of the research carried out and the research findings or results, and a "Final Phase

2 Summary Chart." The project summaries are to be submitted without restriction for NASA publication. These documents should not contain any proprietary data and should be submitted without any restrictive markings. Instructions for the electronic submission of the project summary and a sample of the Summary Chart are posted on the NASA SBIR Electronic Contract Administration Handbook located in the NASA SBIR/STTR Forms Library.

(2) The project summary and the final summary chart shall be submitted with each copy of the final report and as a separate electronic submission via the NASA SBIR Electronic Contract Administration Handbook.

(3) The balance of the report should indicate in detail the project objectives, work carried out, results obtained, and assessment of technical feasibility. The potential applications of the project results in Phase III both for NASA purposes and for commercial purposes shall also be included. Rights to both interim and final report data (except for the project summary) shall be in accordance with clause 52.227-20, Rights in Data -- SBIR Program, of this contract. The Contractor shall mark all pages of reports (except the project summary described above) with the SBIR Rights Notice set forth in clause 52.227-20.

(c) The final report shall also serve as the last interim report.

(d) Report Documentation Page. The Contractor shall include a completed Report Documentation Page (Standard Form 298) as the final page of the each report submitted in paragraphs (a) and (b) of this clause.

(e) Reports Distribution. Reports shall be distributed electronically to the recipients designated below in accordance with instructions posted on the NASA SBIR Home Page at http://sbir.nasa.gov. In addition to the electronic submission of the final report, one paper copy (reproducible) plus one copy of the final report on a Compact Disc (CD) shall be sent to the contracting officer's representative (COTR). The paper copy and CD sent to NASA shall be marked for the attention of the COTR and addressed in accordance with the shipping instructions provided in the Delivery Schedule of this contract. New Technology reporting should be handled in accordance with the New Technology Reporting clause of this contract.

	Interim	Final
Procurement Contract Administrator	1*	1*
Center SBIR Program Manager	0	1*
COTR	1*	3**
NASA Center for Aerospace Information (CASI)	0	2***

*Electronic copy via NASA's SBIR Electronic Handbook
**Electronic copy, plus one paper copy (reproducible) plus one CD. All graphics must be included.
***One paper copy (reproducible) plus one CD. All graphics must be included. NOTE: Only unclassified reports shall be submitted to the CASI.

(End of clause)

CONTRACT ADMINISTRATION DATA

1852.227-11 Patent Rights - Retention by the Contractor (Short Form).

1852.227-72 Designation of New Technology Representative and Patent Representative. (JUL 1997)

(a) For purposes of administration of the clause of this contract entitled "New Technology" or "Patent Rights - Retention by the Contractor (Short Form)," whichever is included, the following named representatives are hereby designated by the Contracting Officer to administer such clause:

Title

[ ]
Office Code
[ ]
Address (including zip code)
[ ]
New Technology Representative
[ ]
Patent Representative
[ ]

(b) Reports of reportable items, and disclosure of subject inventions, interim reports, final reports, utilization reports, and other reports required by the clause, as well as any correspondence with respect to such matters, should be directed to the New Technology Representative unless transmitted in response to correspondence or request from the Patent Representative. Inquires or requests regarding disposition of rights, election of rights, or related matters should be directed to the Patent Representative. This clause shall be included in any subcontract hereunder requiring a "New Technology" clause or "Patent Rights - Retention by the Contractor (Short Form)" clause, unless otherwise authorized or directed by the Contracting Officer. The respective responsibilities and authorities of the above-named representatives are set forth in 1827.305-370 of the NASA FAR Supplement.

(End of clause)

1852.245-70 Contractor Requests for Government-Provided Property. (DEVIATION) (SEP 2007)

(a) The Contractor shall provide all property required for the performance of this contract. The Contractor shall not acquire or construct items of property to which the Government will have title under the provisions of this contract without the Contracting Officer's written authorization. Property which will be acquired as a deliverable end item as material or as a component for incorporation into a deliverable end item is exempt from this requirement.

(b)(1) In the event the Contractor is unable to provide the property necessary for performance, and the Contractor requests provision of property by the Government, the Contractor's request shall--

(i) Justify the need for the property;

(ii) Provide the reasons why contractor-owned property cannot be used;

(iii) Describe the property in sufficient detail to enable the Government to screen its inventories for available property or to otherwise acquire property, including applicable manufacturer, model, part, catalog, National Stock Number or other pertinent identifiers;

(iv) Combine requests for quantities of items with identical descriptions and estimated values when the estimated values do not exceed $100,000 per unit; and

(v) Include only a single unit when the acquisition or construction value equals or exceeds $100,000.

(2) Contracting Officer authorization is required for items the Contractor intends to manufacture as well as those it intends to purchase.

(3) The Contractor shall submit requests to the Contracting Officer no less than 30 days in advance of the date the Contractor would, should it receive authorization, acquire or begin

fabrication of the item.

(c) The Contractor shall maintain copies of Contracting Officer authorizations, appropriately cross-referenced to the individual property record, within its property management system.

(d) Property furnished from Government excess sources is provided as-is, where-is. The Government makes no warranty regarding its applicability for performance of the contract or its ability to operate. Failure of property obtained from Government excess sources under this clause is insufficient reason for submission of requests for equitable adjustments discussed in the clause at 52.245-1, Government Property.

(End of clause)

SECTION G CONTRACT SPECIFIC ADDITIONAL CLAUSE ONE

INVOICES

Contractor shall submit one (1) copy of each invoice electronically through the Electronic Handbook; no other copies or actions are required. All invoices submitted by the SBC shall be marked with the contract number and invoice number. Hard copies of reports or invoices are not required. Failure to comply with requirements stipulated herein will delay payment.

Payment of invoices will be based upon acceptance and approval of each deliverable by the COTR and CO. Payment may be withheld if the required deliverables have not been properly submitted or accepted by the COTR. All reports and invoices shall be submitted by uploading one (1) copy into the Electronic Handbook (https://sbir.gsfc.nasa.gov/sbir/contract-admin/). The only exception to this requirement is that a copy of the New Technology Report and/or New Technology Summary Report shall be uploaded into the Electronic Handbook AND a copy shall be submitted using the eNTRe reporting system http://invention.nasa.gov/ .

(End of clause)

SECTION G CONTRACT SPECIFIC ADDITIONAL CLAUSE TWO

PHASE II - E OPTION

On active Phase II awards, NASA may execute the option to fund a limited number of Phase II awardees for "Phase II Enhancement" (Phase II-E) to encourage transition of SBIR/STTR projects into NASA programs and projects. The objective of the Phase II-E Option is to serve as an incentive to Phase III awards through providing cost share extension of the R&D efforts to the current Phase II contract. to meet the product/process/software requirements of a NASA program/project or third party investor to accelerate and/or enhance the infusion/commercial potential of the Phase II project, moving it into Phase III. Under this option, NASA will match with SBIR/STTR funds up to $150,000 of non-SBIR/non-STTR investment from a NASA project, NASA contractor, or third party commercial investor to extend an eXisting Phase II project for up to 4 months to perform additional research. The total cumulative award for the Phase II contract plus the Phase II-E match will not exceed $750,000.00 of SBIR/STTR funding. The Non-SBIR contribution is not limited since it is regulated under the guidelines for Phase III award.

(End of clause)

SPECIAL CONTRACT REQUIREMENTS

1852.223-72 Safety and Health (Short Form). (APR 2002)

1852.223-75 Major Breach of Safety or Security. (FEB 2002)

1852.225-70 Export Licenses. (FEB 2000)

(a) The Contractor shall comply with all U.S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this contract. In the absence of available license exemptions/exceptions, the Contractor shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of hardware, technical data, and software, or for the provision of technical assistance.

(b) The Contractor shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of this contract, including instances where the work is to be performed on-site at [*insert name of NASA installation*], where the foreign person will have access to export-controlled technical data or software.

(c) The Contractor shall be responsible for all regulatory record keeping requirements associated with the use of licenses and license exemptions/exceptions.

(d) The Contractor shall be responsible for ensuring that the provisions of this clause apply to its subcontractors.

(End of clause)

1852.232-77 Limitation of Funds (Fixed- Price Contract). (MAR 1989)

(a) Of the total price of items [ ] through [ ], the sum of $[ ] is presently available for payment and allotted to this contract. It is anticipated that from time to time additional funds will be allocated to the contract in accordance with the following schedule, until the total price of said items is allotted:

SCHEDULE FOR ALLOTMENT OF FUNDS

Date	Amounts
[ ]	[ ]

(b) The Contractor agrees to perform or have performed work on the items specified in paragraph (a) of this clause up to the point at which, if this contract is terminated pursuant to the Termination for Convenience of the Government clause of this contract, the total amount payable by the Government (including amounts payable for subcontracts and settlement costs) pursuant to paragraphs (f) and (g) of that clause would, in the exercise of reasonable judgment by the Contractor, approximate the total amount at the time allotted to the contract. The Contractor is not obligated to continue performance of the work beyond that point. The Government is not obligated in any event to pay or reimburse the Contractor more than the amount from time to time allotted to the contract, anything to the contrary in the Termination for Convenience of the Government clause notwithstanding.

(c) (1) It is contemplated that funds presently allotted to this contract will cover the work to be performed until [ ].

(2) If funds allotted are considered by the Contractor to be inadequate to cover the work to be performed until that date, or an agreed date substituted for it, the Contractor shall notify the Contracting Officer in writing when within the next 60 days the work will reach a point at which, if the contract is terminated pursuant to the Termination for Convenience of the Government clause of this contract, the total amount payable by the Government (including amounts payable

for subcontracts and settlement costs) pursuant to paragraphs (f) and (g) of that clause will approximate 75 percent of the total amount then allotted to the contract.

(3) (i) The notice shall state the estimate when the point referred to in paragraph (c) (2) of this clause will be reached and the estimated amount of additional funds required to continue performance to the date specified in paragraph (c) (1) of this clause, or an agreed date substituted for it.

(ii) The Contractor shall, 60 days in advance of the date specified in paragraph (c) (1) of this clause, or an agreed date substituted for it, advise the Contracting Officer in writing as to the estimated amount of additional funds required for the timely performance of the contract for a further period as may be specified in the contract or otherwise agreed to by the parties.

(4) If, after the notification referred to in paragraph (c) (3) (ii) of this clause, additional funds are not allotted by the date specified in paragraph (c) (1) of this clause, or an agreed date substituted for it, the Contracting Officer shall, upon the Contractor's written request, terminate this contract on that date or on the date set forth in the request, whichever is later, pursuant to the Termination for Convenience of the Government clause.

(d) When additional funds are allotted from time to time for continued performance of the work under this contract, the parties shall agree on the applicable period of contract performance to be covered by these funds. The provisions of paragraphs (b) and (c) of this clause shall apply to these additional allotted funds and the substituted date pertaining to them, and the contract shall be modified accordingly.

(e) If, solely by reason of the Government's failure to allot additional funds in amounts sufficient for the timely performance of this contract, the Contractor incurs additional costs or is delayed in the performance of the work under this contract, and if additional funds are allotted, an equitable adjustment shall be made in the price or prices (including appropriate target, billing, and ceiling prices where applicable) of the items to be delivered, or in the time of delivery, or both.

(f) The Government may at any time before termination, and, with the consent of the Contractor, after notice of termination, allot additional funds for this contract.

(g) The provisions of this clause with respect to termination shall in no way be deemed to limit the rights of the Government under the default clause of this contract. The provisions of this Limitation of Funds clause are limited to the work on and allotment of funds for the items set forth in paragraph (a) of this clause. This clause shall become inoperative upon the allotment of funds for the total price of said work except for rights and obligations then existing under this clause.

(h) Nothing in this clause shall affect the right of the Government to terminate this contract pursuant to the Termination for Convenience of the Government clause of this contract.

(End of clause)

1852.235-71 Key Personnel and Facilities. (MAR 1989)

(a) The personnel and/or facilities listed below (or specified in the contract Schedule) are considered essential to the work being performed under this contract. Before removing, replacing, or diverting any of the listed or specified personnel or facilities, the Contractor shall (1) notify the Contracting Officer reasonably in advance and (2) submit justification (including proposed substitutions) in sufficient detail to permit evaluation of the impact on this contract.

(b) The Contractor shall make no diversion without the Contracting Officer's written consent; provided, that the Contracting Officer may ratify in writing the proposed change, and that ratification shall constitute the Contracting Officer's consent required by this clause.

(c) The list of personnel and/or facilities (shown below or as specified in the contract Schedule) may, with the consent of the contracting parties, be amended from time to time during the course of the contract to add or delete personnel and/or facilities.

[*List here the personnel and/or facilities considered essential, unless they are specified in the contract Schedule.*]

(End of clause)

1852.235-73 Final Scientific and Technical Reports. (DEC 2006) -- Alternate III (JAN 2005)

1852.235-74 Additional Reports of Work - Research and Development. (FEB 2003)

In addition to the final report required under this contract, the Contractor shall submit the following report(s) to the Contracting Officer:

(a) Quarterly progress reports. The Contractor shall submit separate quarterly reports of all work accomplished during each three-month period of contract performance. In addition to factual data, these reports should include a separate analysis section interpreting the results obtained, recommending further action, and relating occurrences to the ultimate objectives of the contract. Sufficient diagrams, sketches, curves, photographs, and drawings should be included to convey the intended meaning.

(b) Submission dates. Quarterly reports shall be submitted within 10 days following the period to be reported. No quarterly report need be submitted for the final three months of contract effort since that period will be covered in the final report. The final report shall be submitted within ____days after the completion of the effort under the contract.

(End of clause)

1852.244-70 Geographic Participation in the Aerospace Program. (APR 1985)

SECTION 508 COMPLIANCE

(a) The Workforce Investment Act of 1998 amended section 508 of the Rehabilitation Act of 1973 to require that :
(1) When developing, procuring, maintaining or using Electronic and Information Technology (EIT), agencies must ensure that employees with disabilities have access to and use of information and data that is comparable to that for other employees; and
(2) Members of the public with disabilities seeking information or services from an agency have access to and use of information and data that is comparable to that for members of the public without disabilities.
(b) Section 508 standards should be taken into consideration in the design of prototypes. Failure to meet Section 508 standards will impact the Government's ability to make future purchases of the technology developed under this contract. Information regarding Section 508 standards can be obtained at http://www.access-board.gov/508.htm.

(End of clause)

CONTRACT CLAUSES

52.202-1 Definitions. (JUL 2004)

52.203-3 Gratuities. (APR 1984)

52.203-5 Covenant Against Contingent Fees. (APR 1984)

52.203-6 Restrictions on Subcontractor Sales to the Government. (SEP 2006)

52.203-7 Anti-Kickback Procedures. (JUL 1995)

52.203-8 Cancellation, Rescission, and Recovery of Funds for Illegal or Improper Activity. (JAN 1997)

52.203-10 Price or Fee Adjustment for Illegal or Improper Activity. (JAN 1997)

52.203-12 Limitation on Payments to Influence Certain Federal Transactions. (SEP 2007)

52.204-4 Printed or Copied Double-Sided on Recycled Paper. (AUG 2000)

52.204-7 Central Contractor Registration. (APR 2008)

52.209-6 Protecting the Government's Interest When Subcontracting with Contractors Debarred, Suspended, or Proposed for Debarment. (SEP 2006)

52.211-5 Material Requirements. (AUG 2000)

52.215-2 Audit and Records - Negotiation. (JUN 1999)

52.215-8 Order of Precedence - Uniform Contract Format. (OCT 1997)

52.215-17 Waiver of Facilities Capital Cost of Money. (OCT 1997)

52.217-2 Cancellation Under Multi-year Contracts. (OCT 1997)

52.217-9 Option to Extend the Term of the Contract. (MAR 2000)

(a) The Government may extend the term of this contract by written notice to the Contractor within [*insert the period of time within which the Contracting Officer may exercise the option*]; provided that the Government gives the Contractor a preliminary written notice of its intent to extend at least [ ]days (*60 days unless a different number of days is inserted)* before the contract expires. The preliminary notice does not commit the Government to an extension.

(b) If the Government exercises this option, the extended contract shall be considered to include this option clause.

(c) The total duration of this contract, including the exercise of any options under this clause, shall not exceed [ ](months)(years).

(End of clause)

52.219-6 Notice of Total Small Business Set-Aside. (JUN 2003)

52.219-8 Utilization of Small Business Concerns. (MAY 2004)

52.219-28 Post-Award Small Business Program Rerepresentation. (APR 2009)

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

Long-term contract means a contract of more than five years in duration, including options. However, the term does not include contracts that exceed five years in duration because the period of performance has been extended for a cumulative period not to exceed six months under the clause at 52.217-8, Option to Extend Services, or other appropriate authority.

Small business concern means a concern, including its affiliates, that is independently owned and operated, not dominant in the field of operation in which it is bidding on Government contracts, and qualified as a small business under the criteria in 13 CFR part 121 and the size standard in paragraph (c) of this clause.

(b) If the Contractor represented that it was a small business concern prior to award of this contract, the Contractor shall rerepresent its size status according to paragraph (e) of this clause or, if applicable, paragraph (g) of this clause, upon the occurrence of any of the following:

(1) Within 30 days after execution of a novation agreement or within 30 days after modification of the contract to include this clause, if the novation agreement was executed prior to inclusion of this clause in the contract.

(2) Within 30 days after a merger or acquisition that does not require a novation or within 30 days after modification of the contract to include this clause, if the merger or acquisition occurred prior to inclusion of this clause in the contract.

(3) For long-term contracts -

(i) Within 60 to 120 days prior to the end of the fifth year of the contract; and

(ii) Within 60 to 120 days prior to the exercise date specified in the contract for any option thereafter.

(c) The Contractor shall rerepresent its size status in accordance with the size standard in effect at the time of this rerepresentation that corresponds to the North American Industry Classification System (NAICS) code assigned to this contract. The small business size standard corresponding to this NAICS code can be found at *http://www.sba.gov/ services/contractingopportunities/ sizestandardstopics/*.

(d) The small business size standard for a Contractor providing a product which it does not manufacture itself, for a contract other than a construction or service contract, is 500 employees.

(e) Except as provided in paragraph (g) of this clause, the Contractor shall make the rerepresentation required by paragraph (b) of this clause by validating or updating all its representations in the Online Representations and Certifications Application and its data in the Central Contractor Registration, as necessary, to ensure they reflect current status. The Contractor shall notify the contracting office by e-mail, or otherwise in writing, that the data have been validated or updated, and provide the date of the validation or update.

(f) If the Contractor represented that it was other than a small business concern prior to award of this contract, the Contractor may, but is not required to, take the actions required by paragraphs (e) or (g) of this clause.

(g) If the Contractor does not have representations and certifications in ORCA, or does not have a representation in ORCA for the NAICS code applicable to this contract, the Contractor is required to complete the following rerepresentation and submit it to the contracting office, along with the contract number and the date on which the rerepresentation was completed:

The Contractor represents that it ___ is, ___ is not a small business concern under NAICS Code _____ assigned to contract number _____. (*Contractor to sign and date and insert authorized signer's name and title).*

(End of clause)

52.222-3 Convict Labor. (JUN 2003)

52.222-19 Child Labor - Cooperation with Authorities and Remedies. (FEB 2008)

52.222-20 Walsh-Healey Public Contracts Act. (DEC 1996)

52.222-21 Prohibition of Segregated Facilities. (FEB 1999)

52.222-26 Equal Opportunity. (MAR 2007)

52.222-35 Equal Opportunity for Special Disabled Veterans, Veterans of the Vietnam Era, and Other Eligible Veterans. (SEP 2006)

52.222-36 Affirmative Action for Workers with Disabilities. (JUN 1998)

52.222-37 Employment Reports on Special Disabled Veterans, Veterans of the Vietnam Era, and Other Eligible Veterans. (SEP 2006)

52.222-50 Combating Trafficking in Persons. (FEB 2009)

52.223-3 Hazardous Material Identification and Material Safety Data. (JAN 1997) - Alternate I (JUL 1995)

52.223-5 Pollution Prevention and Right-to-Know Information. (AUG 2003)

52.223-6 Drug-Free Workplace. (MAY 2001)

52.223-14 Toxic Chemical Release Reporting. (AUG 2003)

52.223-15 Energy Efficiency in Energy-Consuming Products. (DEC 2007)

52.225-1 Buy American Act - Supplies. (FEB 2009)

52.225-13 Restrictions on Certain Foreign Purchases. (JUN 2008)

52.227-1 Authorization and Consent. (DEC 2007) -- Alternate I (APR 1984)

52.227-2 Notice and Assistance Regarding Patent and Copyright Infringement. (DEC 2007)

52.227-11 Patent Rights--Ownership by the Contractor. (DEC 2007)

(a) As used in this clause--

"Invention" means any invention or discovery that is or may be patentable or otherwise protectable under title 35 of the U.S. Code, or any variety of plant that is or may be protectable under the Plant Variety Protection Act (7 U.S.C. 2321, et seq.)

"Made" means--

(1) When used in relation to any invention other than a plant variety, the conception or first actual reduction to practice of the invention; or

(2) When used in relation to a plant variety, that the Contractor has at least tentatively determined that the variety has been reproduced with recognized characteristics.

"Nonprofit organization" means a university or other institution of higher education or an organization of the type described in section 501(c)(3) of the Internal Revenue Code of 1954 (26 U.S.C. 501(c)) and exempt from taxation under section 501(a) of the Internal Revenue Code (26 U.S.C. 501(a)), or any nonprofit scientific or educational organization qualified under a State nonprofit organization statute.

"Practical application" means to manufacture, in the case of a composition of product; to practice, in the case of a process or method; or to operate, in the case of a machine or system; and, in each case, under such conditions as to establish that the invention is being utilized and that its benefits are, to the extent permitted by law or Government regulations, available to the public on reasonable terms.

"Subject invention" means any invention of the Contractor made in the performance of work under this contract.

(b) Contractor's rights. (1) Ownership. The Contractor may retain ownership of each subject invention throughout the world in accordance with the provisions of this clause.

(2) License. (i) The Contractor shall retain a nonexclusive royalty-free license throughout the world in each subject invention to which the Government obtains title, unless the Contractor fails to disclose the invention within the times specified in paragraph (c) of this clause. The Contractor's license extends to any domestic subsidiaries and affiliates within the corporate structure of which the Contractor is a part, and includes the right to grant sublicenses to the extent the Contractor was legally obligated to do so at contract award. The license is transferable only with the written approval of the agency, except when transferred to the successor of that part of the Contractor's business to which the invention pertains.

(ii) The Contractor's license may be revoked or modified by the agency to the extent necessary to achieve expeditious practical application of the subject invention in a particular country in accordance with the procedures in FAR 27.302(i)(2) and 27.304-1(f).

(c) Contractor's obligations. (1) The Contractor shall disclose in writing each subject invention to the Contracting Officer within 2 months after the inventor discloses it in writing to Contractor personnel responsible for patent matters. The disclosure shall identify the inventor(s) and this contract under which the subject invention was made. It shall be sufficiently complete in technical detail to convey a clear understanding of the subject invention. The disclosure shall also identify any publication, on sale (i.e., sale or offer for sale), or public use of the subject invention, or whether a manuscript describing the subject invention has been submitted for publication and, if so, whether it has been accepted for publication. In addition, after disclosure to the agency, the Contractor shall promptly notify the Contracting Officer of the acceptance of any manuscript describing the subject invention for publication and any on sale or public use.

(2) The Contractor shall elect in writing whether or not to retain ownership of any subject invention by notifying the Contracting Officer within 2 years of disclosure to the agency. However, in any case where publication, on sale, or public use has initiated the 1-year statutory period during

which valid patent protection can be obtained in the United States, the period for election of title may be shortened by the agency to a date that is no more than 60 days prior to the end of the statutory period.

(3) The Contractor shall file either a provisional or a nonprovisional patent application or a Plant Variety Protection Application on an elected subject invention within 1 year after election. However, in any case where a publication, on sale, or public use has initiated the 1-year statutory period during which valid patent protection can be obtained in the United States, the Contractor shall file the application prior to the end of that statutory period. If the Contractor files a provisional application, it shall file a nonprovisional application within 10 months of the filing of the provisional application. The Contractor shall file patent applications in additional countries or international patent offices within either 10 months of the first filed patent application (whether provisional or nonprovisional) or 6 months from the date permission is granted by the Commissioner of Patents to file foreign patent applications where such filing has been prohibited by a Secrecy Order.

(4) The Contractor may request extensions of time for disclosure, election, or filing under paragraphs (c)(1), (c)(2), and (c)(3) of this clause.

(d) Government's rights--(1) Ownership. The Contractor shall assign to the agency, on written request, title to any subject invention--

(i) If the Contractor fails to disclose or elect ownership to the subject invention within the times specified in paragraph (c) of this clause, or elects not to retain ownership; provided, that the agency may request title only within 60 days after learning of the Contractor's failure to disclose or elect within the specified times.

(ii) In those countries in which the Contractor fails to file patent applications within the times specified in paragraph (c) of this clause; provided, however, that if the Contractor has filed a patent application in a country after the times specified in paragraph (c) of this clause, but prior to its receipt of the written request of the agency, the Contractor shall continue to retain ownership in that country.

(iii) In any country in which the Contractor decides not to continue the prosecution of any application for, to pay the maintenance fees on, or defend in reexamination or opposition proceeding on, a patent on a subject invention.

(2) License. If the Contractor retains ownership of any subject invention, the Government shall have a nonexclusive, nontransferable, irrevocable, paid-up license to practice, or have practiced for or on its behalf, the subject invention throughout the world.

(e) Contractor action to protect the Government's interest. (1) The Contractor shall execute or have executed and promptly deliver to the agency all instruments necessary to--

(i) Establish or confirm the rights the Government has throughout the world in those subject inventions in which the Contractor elects to retain ownership; and

(ii) Assign title to the agency when requested under paragraph (d) of this clause and to enable the Government to obtain patent protection and plant variety protection for that subject invention in any country.

(2) The Contractor shall require, by written agreement, its employees, other than clerical and non-

technical employees, to disclose promptly in writing to personnel identified as responsible for the administration of patent matters and in the Contractor's format, each subject invention in order that the Contractor can comply with the disclosure provisions of paragraph (c) of this clause, and to execute all papers necessary to file patent applications on subject inventions and to establish the Government's rights in the subject inventions. The disclosure format should require, as a minimum, the information required by paragraph (c)(1) of this clause. The Contractor shall instruct such employees, through employee agreements or other suitable educational programs, as to the importance of reporting inventions in sufficient time to permit the filing of patent applications prior to U.S. or foreign statutory bars.

(3) The Contractor shall notify the Contracting Officer of any decisions not to file a nonprovisional patent application, continue the prosecution of a patent application, pay maintenance fees, or defend in a reexamination or opposition proceeding on a patent, in any country, not less than 30 days before the expiration of the response or filing period required by the relevant patent office.

(4) The Contractor shall include, within the specification of any United States nonprovisional patent or plant variety protection application and any patent or plant variety protection certificate issuing thereon covering a subject invention, the following statement, "This invention was made with Government support under (identify the contract) awarded by (identify the agency). The Government has certain rights in the invention."

(f) Reporting on utilization of subject inventions. The Contractor shall submit, on request, periodic reports no more frequently than annually on the utilization of a subject invention or on efforts at obtaining utilization of the subject invention that are being made by the Contractor or its licensees or assignees. The reports shall include information regarding the status of development, date of first commercial sale or use, gross royalties received by the Contractor, and other data and information as the agency may reasonably specify. The Contractor also shall provide additional reports as may be requested by the agency in connection with any march-in proceeding undertaken by the agency in accordance with paragraph (h) of this clause. The Contractor also shall mark any utilization report as confidential/proprietary to help prevent inadvertent release outside the Government. As required by 35 U.S.C. 202(c)(5), the agency will not disclose that information to persons outside the Government without the Contractor's permission.

(g) Preference for United States industry. Notwithstanding any other provision of this clause, neither the Contractor nor any assignee shall grant to any person the exclusive right to use or sell any subject invention in the United States unless the person agrees that any products embodying the subject invention or produced through the use of the subject invention will be manufactured substantially in the United States. However, in individual cases, the requirement for an agreement may be waived by the agency upon a showing by the Contractor or its assignee that reasonable but unsuccessful efforts have been made to grant licenses on similar terms to potential licensees that would be likely to manufacture substantially in the United States, or that under the circumstances domestic manufacture is not commercially feasible.

(h) March-in rights. The Contractor acknowledges that, with respect to any subject invention in which it has retained ownership, the agency has the right to require licensing pursuant to 35 U.S.C. 203 and 210(c), and in accordance with the procedures in 37 CFR 401.6 and any supplemental regulations of the agency in effect on the date of contract award.

(i) Special provisions for contracts with nonprofit organizations. If the Contractor is a nonprofit organization, it shall--

(1) Not assign rights to a subject invention in the United States without the written approval of the agency, except where an assignment is made to an organization that has as one of its primary functions the management of inventions, provided, that the assignee shall be subject to the same

provisions as the Contractor;

(2) Share royalties collected on a subject invention with the inventor, including Federal employee co-inventors (but through their agency if the agency deems it appropriate) when the subject invention is assigned in accordance with 35 U.S.C. 202(e) and 37 CFR 401.10;

(3) Use the balance of any royalties or income earned by the Contractor with respect to subject inventions, after payment of expenses (including payments to inventors) incidental to the administration of subject inventions for the support of scientific research or education; and

(4) Make efforts that are reasonable under the circumstances to attract licensees of subject inventions that are small business concerns, and give a preference to a small business concern when licensing a subject invention if the Contractor determines that the small business concern has a plan or proposal for marketing the invention which, if executed, is equally as likely to bring the invention to practical application as any plans or proposals from applicants that are not small business concerns; provided, that the Contractor is also satisfied that the small business concern has the capability and resources to carry out its plan or proposal. The decision whether to give a preference in any specific case will be at the discretion of the Contractor.

(5) Allow the Secretary of Commerce to review the Contractor's licensing program and decisions regarding small business applicants, and negotiate changes to its licensing policies, procedures, or practices with the Secretary of Commerce when the Secretary's review discloses that the Contractor could take reasonable steps to more effectively implement the requirements of paragraph (i)(4) of this clause.

(j) Communications. [*Complete according to agency instructions.*]

(k) Subcontracts. (1) The Contractor shall include the substance of this clause, including this paragraph (k), in all subcontracts for experimental, developmental, or research work to be performed by a small business concern or nonprofit organization.

(2) The Contractor shall include in all other subcontracts for experimental, developmental, or research work the substance of the patent rights clause required by FAR Subpart 27.3.

(3) At all tiers, the patent rights clause must be modified to identify the parties as follows: references to the Government are not changed, and the subcontractor has all rights and obligations of the Contractor in the clause. The Contractor shall not, as part of the consideration for awarding the subcontract, obtain rights in the subcontractor's subject inventions.

(4) In subcontracts, at any tier, the agency, the subcontractor, and the Contractor agree that the mutual obligations of the parties created by this clause constitute a contract between the subcontractor and the agency with respect to the matters covered by the clause; provided, however, that nothing in this paragraph is intended to confer any jurisdiction under the Contract Disputes Act in connection with proceedings under paragraph (h) of this clause.

(End of clause)

52.227-16 Additional Data Requirements. (JUN 1987)

52.227-20 Rights in Data--SBIR Program. (DEC 2007)

52.229-3 Federal, State, and Local Taxes. (APR 2003)

52.232-2 Payments under Fixed-Price Research and Development Contracts. (APR 1984)

52.232-8 Discounts for Prompt Payment. (FEB 2002)

52.232-11 Extras. (APR 1984)

52.232-17 Interest. (OCT 2008)

52.232-23 Assignment of Claims. (JAN 1986)

52.232-25 Prompt payment. (OCT 2008)

52.232-34 Payment by Electronic Funds Transfer - Other than Central Contractor Registration. (MAY 1999)

(a) *Method of payment*. (1) All payments by the Government under this contract shall be made by electronic funds transfer (EFT) except as provided in paragraph (a)(2) of this clause. As used in this clause, the term EFT refers to the funds transfer and may also include the payment information transfer.

(2) In the event the Government is unable to release one or more payments by EFT, the Contractor agrees to either -

(i) Accept payment by check or some other mutually agreeable method of payment; or

(ii) Request the Government to extend payment due dates until such time as the Government makes payment by EFT (but see paragraph (d) of this clause).

(b) *Mandatory submission of Contractor's EFT information*. (1) The Contractor is required to provide the Government with the information required to make payment by EFT (see paragraph (j) of this clause). The Contractor shall provide this information directly to the office designated in this contract to receive that information (hereafter: designated office) by [*the Contracting Officer shall insert date, days after award, days before first request, the date specified for receipt of offers if the provision at 52.232-38 is utilized, or concurrent with first request as prescribed by the head of the agency; if not prescribed, insert no later than 15 days prior to submission of the first request for payment*]. If not otherwise specified in this contract, the payment office is the designated office for receipt of the Contractor's EFT information. If more than one designated office is named for the contract, the Contractor shall provide a separate notice to each office. In the event that the EFT information changes, the Contractor shall be responsible for providing the updated information to the designated office(s).

(2) If the Contractor provides EFT information applicable to multiple contracts, the Contractor shall specifically state the applicability of this EFT information in terms acceptable to the designated office. However, EFT information supplied to a designated office shall be applicable only to contracts that identify that designated office as the office to receive EFT information for that contract.

(c) *Mechanisms for EFT payment*. The Government may make payment by EFT through either the Automated Clearing House (ACH) network, subject to the rules of the National Automated Clearing House Association, or the Fedwire Transfer System. The rules governing Federal payments through the ACH are contained in 31 CFR part 210.

(d) *Suspension of payment*. (1) The Government is not required to make any payment under this contract until after receipt, by the designated office, of the correct EFT payment information from the Contractor.

Until receipt of the correct EFT information, any invoice or contract financing request shall be deemed not to be a proper invoice for the purpose of prompt payment under this contract. The prompt payment terms of the contract regarding notice of an improper invoice and delays in accrual of interest penalties apply.

(2) If the EFT information changes after submission of correct EFT information, the Government shall begin using the changed EFT information no later than 30 days after its receipt by the designated office to the extent payment is made by EFT. However, the Contractor may request that no further payments be made until the updated EFT information is implemented by the payment office. If such suspension would result in a late payment under the prompt payment terms of this contract, the Contractor's request for suspension shall extend the due date for payment by the number of days of the suspension.

(e) *Liability for uncompleted or erroneous transfers*. (1) If an uncompleted or erroneous transfer occurs because the Government used the Contractor's EFT information incorrectly, the Government remains responsible for -

(i) Making a correct payment;

(ii) Paying any prompt payment penalty due; and

(iii) Recovering any erroneously directed funds.

(2) If an uncompleted or erroneous transfer occurs because the Contractor's EFT information was incorrect, or was revised within 30 days of Government release of the EFT payment transaction instruction to the Federal Reserve System, and -

(i) If the funds are no longer under the control of the payment office, the Government is deemed to have made payment and the Contractor is responsible for recovery of any erroneously directed funds; or

(ii) If the funds remain under the control of the payment office, the Government shall not make payment and the provisions of paragraph (d) shall apply.

(f) *EFT and prompt payment*. A payment shall be deemed to have been made in a timely manner in accordance with the prompt payment terms of this contract if, in the EFT payment transaction instruction released to the Federal Reserve System, the date specified for settlement of the payment is on or before the prompt payment due date, provided the specified payment date is a valid date under the rules of the Federal Reserve System.

(g) *EFT and assignment of claims*. If the Contractor assigns the proceeds of this contract as provided for in the assignment of claims terms of this contract, the Contractor shall require as a condition of any such assignment, that the assignee shall provide the EFT information required by paragraph (j) of this clause to the designated office, and shall be paid by EFT in accordance with the terms of this clause. In all respects, the requirements of this clause shall apply to the assignee as if it were the Contractor. EFT information that shows the ultimate recipient of the transfer to be other than the Contractor, in the absence of a proper assignment of claims acceptable to the Government, is incorrect EFT information within the meaning of paragraph (d) of this clause.

(h) *Liability for change of EFT information by financial agent.* The Government is not liable for errors resulting from changes to EFT information provided by the Contractor's financial agent.

(i) *Payment information*. The payment or disbursing office shall forward to the Contractor available payment information that is suitable for transmission as of the date of lease of the EFT instruction to the Federal Reserve System. The Government may request the Contractor to designate a desired format and method(s) for delivery of payment information from a list of formats and methods the payment office is capable of executing. However, the Government does not guarantee that any particular format or method of delivery is available at any particular payment office and retains the latitude to use the format and delivery method most convenient to the Government. If the Government makes payment by check in accordance with paragraph (a) of this clause, the Government shall mail the payment information to the remittance address in the contract.

(j) *EFT information*. The Contractor shall provide the following information to the designated office. The Contractor may supply this data for this or multiple contracts (see paragraph (b) of this clause). The Contractor shall designate a single financial agent per contract capable of receiving and processing the EFT information using the EFT methods described in paragraph (c) of this clause.

(1) The contract number (or other procurement identification number).

(2) The Contractor's name and remittance address, as stated in the contract(s).

(3) The signature (manual or electronic, as appropriate), title, and telephone number of the Contractor official authorized to provide this information.

(4) The name, address, and 9-digit Routing Transit Number of the Contractor's financial agent.

(5) The Contractor's account number and the type of account (checking, saving, or lockbox).

(6) If applicable, the Fedwire Transfer System telegraphic abbreviation of the Contractor's financial agent.

(7) If applicable, the Contractor shall also provide the name, address, telegraphic abbreviation, and 9-digit Routing Transit Number of the correspondent financial institution receiving the wire transfer payment if the Contractor's financial agent is not directly on-line to the Fedwire Transfer System; and, therefore, not the receiver of the wire transfer payment.

(End of clause)

52.233-1 Disputes. (JUL 2002)

52.233-3 Protest after Award. (AUG 1996)

52.233-4 Applicable Law for Breach of Contract Claim. (OCT 2004)

52.242-13 Bankruptcy. (JUL 1995)

52.243-1 Changes - Fixed-Price. (AUG 1987) - Alternate V (APR 1984)

52.244-6 Subcontracts for Commercial Items. (MAR 2009)

52.245-1 Government Property. (JUN 2007)

52.245-9 Use and Charges. (JUN 2007)

52.246-23 Limitation of Liability. (FEB 1997)

52.246-25 Limitation of Liability - Services. (FEB 1997)

52.247-64 Preference for Privately Owned U.S.-Flag Commercial Vessels. (FEB 2006)

52.249-2 Termination for Convenience of the Government (Fixed-Price). (MAY 2004)

52.249-9 Default (Fixed-Price Research and Development). (APR 1984)

52.252-2 Clauses Incorporated by Reference. (FEB 1998)

This contract incorporates one or more clauses by reference, with the same force and effect as if they were given in full text. Upon request, the Contracting Officer will make their full text available. Also, the full text of a clause may be accessed electronically at this/these address(es): Federal Acquisition Regulation (FAR) clauses:

http://www.acqnet.gov/far/

NASA FAR Supplement (NFS) clauses:

http://www.hq.nasa.gov/office/procurement/regs/nfstoc.htm

(End of clause)

52.252-6 Authorized Deviations in Clauses. (APR 1984)

(a) The use in this solicitation or contract of any Federal Acquisition Regulation (48 CFR Chapter 1) clause with an authorized deviation is indicated by the addition of (DEVIATION) after the date of the clause.

(b) The use in this solicitation or contract of any NASA FAR Supplement (48 CFR 18) clause with an authorized deviation is indicated by the addition of (DEVIATION) after the name of the regulation.

(End of clause)

52.253-1 Computer Generated Forms. (JAN 1991)

1852.204-76 Security Requirements for Unclassified Information Technology Resources. (MAY 2007)

(a) The Contractor shall be responsible for information and information technology (IT) security when -

(1) The Contractor or its subcontractors must obtain physical or electronic (i.e., authentication level 2 and above as defined in National Institute of Standards and Technology (NIST) Special Publication (SP) 800-63, Electronic Authentication Guideline) access to NASA's computer systems, networks, or IT infrastructure; or

(2) Information categorized as low, moderate, or high by the Federal Information Processing Standards (FIPS) 199, Standards for Security Categorization of Federal Information and Information Systems is stored, generated, processed, or exchanged by NASA or on behalf of NASA by a contractor or subcontractor, regardless of whether the information resides on a NASA or a contractor/subcontractor's information system.

(b) IT Security Requirements.

(1) Within 30 days after contract award, a Contractor shall submit to the Contracting Officer for NASA approval an IT Security Plan, Risk Assessment, and FIPS 199, Standards for Security Categorization of Federal Information and Information Systems, Assessment. These plans and assessments, including annual updates shall be incorporated into the contract as compliance documents.

(i) The IT system security plan shall be prepared consistent, in form and content, with NIST SP 800-18, Guide for Developing Security Plans for Federal Information Systems, and any additions/augmentations described in NASA Procedural Requirements (NPR) 2810, Security of Information Technology. The security plan shall identify and document appropriate IT security controls consistent with the sensitivity of the information and the requirements of Federal Information Processing Standards (FIPS) 200, Recommended Security Controls for Federal Information Systems. The plan shall be reviewed and updated in accordance with NIST SP 800-26, Security Self-Assessment Guide for Information Technology Systems, and FIPS 200, on a yearly basis.

(ii) The risk assessment shall be prepared consistent, in form and content, with NIST SP 800-30, Risk Management Guide for Information Technology Systems, and any additions/augmentations described in NPR 2810. The risk assessment shall be updated on a yearly basis.

(iii) The FIPS 199 assessment shall identify all information types as well as the "high water mark," as defined in FIPS 199, of the processed, stored, or transmitted information necessary to fulfill the contractual requirements.

(2) The Contractor shall produce contingency plans consistent, in form and content, with NIST SP 800-34, Contingency Planning Guide for Information Technology Systems, and any additions/augmentations described in NPR 2810. The Contractor shall perform yearly "Classroom Exercises." "Functional Exercises," shall be coordinated with the Center CIOs and be conducted once every three years, with the first conducted within the first two years of contract award. These exercises are defined and described in NIST SP 800-34.

(3) The Contractor shall ensure coordination of its incident response team with the NASA Incident Response Center (NASIRC) and the NASA Security Operations Center, ensuring that incidents are reported consistent with NIST SP 800-61, Computer Security Incident Reporting Guide, and the United States Computer Emergency Readiness Team's (US-CERT) Concept of Operations for reporting security incidents. Specifically, any confirmed incident of a system containing NASA data or controlling NASA assets shall be reported to NASIRC within one hour that results in unauthorized access, loss or modification of NASA data, or denial of service affecting the availability of NASA data.

(4) The Contractor shall ensure that its employees, in performance of the contract, receive annual IT security training in NASA IT Security policies, procedures, computer ethics, and best practices in accordance with NPR 2810 requirements. The Contractor may use web-based training available from NASA to meet this requirement.

(5) The Contractor shall provide NASA, including the NASA Office of Inspector General, access to the Contractor's and subcontractors' facilities, installations, operations, documentation, databases, and personnel used in performance of the contract. Access shall be provided to the extent required to carry out IT security inspection, investigation, and/or audits to safeguard against

threats and hazards to the integrity, availability, and confidentiality of NASA information or to the function of computer systems operated on behalf of NASA, and to preserve evidence of computer crime. To facilitate mandatory reviews, the Contractor shall ensure appropriate compartmentalization of NASA information, stored and/or processed, either by information systems in direct support of the contract or that are incidental to the contract.

(6) The Contractor shall ensure that system administrators who perform tasks that have a material impact on IT security and operations demonstrate knowledge appropriate to those tasks. Knowledge is demonstrated through the NASA System Administrator Security Certification Program. A system administrator is one who provides IT services (including network services, file storage, and/or web services) to someone other than themselves and takes or assumes the responsibility for the security and administrative controls of that service. Within 30 days after contract award, the Contractor shall provide to the Contracting Officer a list of all system administrator positions and personnel filling those positions, along with a schedule that ensures certification of all personnel within 90 days after contract award. Additionally, the Contractor should report all personnel changes which impact system administrator positions within 5 days of the personnel change and ensure these individuals obtain System Administrator certification within 90 days after the change.

(7) The Contractor shall ensure that NASA's Sensitive But Unclassified (SBU) information as defined in NPR 1600.1, NASA Security Program Procedural Requirements, which includes privacy information, is encrypted in storage and transmission.

(8) When the Contractor is located at a NASA Center or installation or is using NASA IP address space, the Contractor shall -

(i) Submit requests for non-NASA provided external Internet connections to the Contracting Officer for approval by the Network Security Configuration Control Board (NSCCB);

(ii) Comply with the NASA CIO metrics including patch management, operating systems and application configuration guidelines, vulnerability scanning, incident reporting, system administrator certification, and security training; and

(iii) Utilize the NASA Public Key Infrastructure (PKI) for all encrypted communication or non-repudiation requirements within NASA when secure email capability is required.

(c) Physical and Logical Access Requirements.

(1) Contractor personnel requiring access to IT systems operated by the Contractor for NASA or interconnected to a NASA network shall be screened at an appropriate level in accordance with NPR 2810 and Chapter 4, NPR 1600.1, NASA Security Program Procedural Requirements. NASA shall provide screening, appropriate to the highest risk level, of the IT systems and information accessed, using, as a minimum, National Agency Check with Inquiries (NACI). The Contractor shall submit the required forms to the NASA Center Chief of Security (CCS) within fourteen (14) days after contract award or assignment of an individual to a position requiring screening. The forms may be obtained from the CCS. At the option of NASA, interim access may be granted pending completion of the required investigation and final access determination. For Contractors who will reside on a NASA Center or installation, the security screening required for all required access (e.g., installation, facility, IT, information, etc.) is consolidated to ensure only one investigation is conducted based on the highest risk level. Contractors not residing on a NASA installation will be screened based on their IT access risk level determination only. See NPR 1600.1, Chapter 4.

(2) Guidance for selecting the appropriate level of screening is based on the risk of adverse impact to NASA missions. NASA defines three levels of risk for which screening is required (IT-1 has the highest level of risk).

(i) IT-1 - Individuals having privileged access or limited privileged access to systems whose misuse can cause very serious adverse impact to NASA missions. These systems include, for example, those that can transmit commands directly modifying the behavior of spacecraft, satellites or aircraft.

(ii) IT-2 - Individuals having privileged access or limited privileged access to systems whose misuse can cause serious adverse impact to NASA missions. These systems include, for example, those that can transmit commands directly modifying the behavior of payloads on spacecraft, satellites or aircraft; and those that contain the primary copy of "level 1" information whose cost to replace exceeds one million dollars.

(iii) IT-3 - Individuals having privileged access or limited privileged access to systems whose misuse can cause significant adverse impact to NASA missions. These systems include, for example, those that interconnect with a NASA network in a way that exceeds access by the general public, such as bypassing firewalls; and systems operated by the Contractor for NASA whose function or information has substantial cost to replace, even if these systems are not interconnected with a NASA network.

(3) Screening for individuals shall employ forms appropriate for the level of risk as established in Chapter 4, NPR 1600.1.

(4) The Contractor may conduct its own screening of individuals requiring privileged access or limited privileged access provided the Contractor can demonstrate to the Contracting Officer that the procedures used by the Contractor are equivalent to NASA's personnel screening procedures for the risk level assigned for the IT position.

(5) Subject to approval of the Contracting Officer, the Contractor may forgo screening of Contractor personnel for those individuals who have proof of a -

(i) Current or recent national security clearances (within last three years);

(ii) Screening conducted by NASA within the last three years that meets or exceeds the screening requirements of the IT position; or

(iii) Screening conducted by the Contractor, within the last three years, that is equivalent to the NASA personnel screening procedures as approved by the Contracting Officer and concurred on by the CCS.

(d) The Contracting Officer may waive the requirements of paragraphs (b) and (c) (1) through (c) (3) upon request of the Contractor. The Contractor shall provide all relevant information requested by the Contracting Officer to support the waiver request.

(e) The Contractor shall contact the Contracting Officer for any documents, information, or forms necessary to comply with the requirements of this clause.

(f) At the completion of the contract, the contractor shall return all NASA information and IT resources provided to the contractor during the performance of the contract and certify that all NASA information has been purged from contractor-owned systems used in the performance of the contract.

(g) The Contractor shall insert this clause, including this paragraph (g), in all subcontracts:

(1) Have physical or electronic access to NASA's computer systems, networks, or IT infrastructure; or

(2) Use information systems to generate, store, process, or exchange data with NASA or on behalf of NASA, regardless of whether the data resides on a NASA or a contractor's information system.

(End of clause)

1852.215-84 Ombudsman. (OCT 2003)

(a) An ombudsman has been appointed to hear and facilitate the resolution of concerns from offerors, potential offerors, and contractors during the preaward and postaward phases of this acquisition. When requested, the ombudsman will maintain strict confidentiality as to the source of the concern. The existence of the ombudsman is not to diminish the authority of the contracting officer, the Source Evaluation Board, or the selection official. Further, the ombudsman does not participate in the evaluation of proposals, the source selection process, or the adjudication of formal contract disputes. Therefore, before consulting with an ombudsman, interested parties must first address their concerns, issues, disagreements, and/or recommendations to the contracting officer for resolution.

(b) If resolution cannot be made by the contracting officer, interested parties may contact the installation ombudsman, Rebecca S. Dubuisson, NASA Shared Services Center, rebecca.s.dubuisson@nasa.gov. Concerns, issues, disagreements, and recommendations which cannot be resolved at the installation may be referred to the NASA ombudsman, James A. Balinskas, the Director of the Contract Management Division, at 202-358-0445, facsimile 202-358-3083, e-mail james.a.balinskas@nasa.gov . Please do not contact the ombudsman to request copies of the solicitation, verify offer due date, or clarify technical requirements. Such inquiries shall be directed to the Contracting Officer or as specified elsewhere in this document.

(End of clause)

1852.219-76 NASA 8 Percent Goal. (JUL 1997)

(a) Definitions.

"Historically Black Colleges or University," as used in this clause, means an institution determined by the Secretary of Education to meet the requirements of 34 CFR Section 608.2. The term also includes any nonprofit research institution that was an integral part of such a college or university before November 14, 1986.

"Minority institutions," as used in this clause, means an institution of higher education meeting the requirements of section 1046(3) of the Higher Education Act of 1965 (20 U.S.C. 1135d-5(3)) which for the purposes of this clause includes a Hispanic-serving institution of higher education as defined in section 316(b)(1) of the Act (20 U.S.C. 1059c(b)(1)).

"Small disadvantaged business concern," as used in this clause, means a small business concern that (1) is at least 51 percent unconditionally owned by one or more individuals who are both socially and economically disadvantaged, or a publicly owned business having at least 51 percent of its stock unconditionally owned by one or more socially and economically disadvantaged individuals, and (2) has its management and daily business controlled by one or more such individuals. This term also means a small business concern that is at least 51 percent unconditionally owned by an economically disadvantaged Indian tribe or Native Hawaiian Organization, or a publicly owned business having at least 51 percent of its stock unconditionally owned by one or more of these entities, which has its management and daily business controlled by members of an economically disadvantaged Indian tribe or Native Hawaiian Organization, and which meets the requirements of 13 CFR 124.

"Women-owned small business concern," as used in this clause, means a small business concern (1) which is at least 51 percent owned by one or more women or, in the case of any publicly owned business, at least 51 percent of the stock of which is owned by one or more women, and (2) whose management and daily business operations are controlled by one or more women.

(b) The NASA Administrator is required by statute to establish annually a goal to make available to small disadvantaged business concerns, Historically Black Colleges and Universities, minority institutions, and women-owned small business concerns, at least 8 percent of NASA's procurement dollars under prime contracts or subcontracts awarded in support of authorized programs, including the space station by the time operational status is obtained.

(c) The contractor hereby agrees to assist NASA in achieving this goal by using its best efforts to award subcontracts to such entities to the fullest extent consistent with efficient contract performance.

(d) Contractors acting in good faith may rely on written representations by their subcontractors regarding their status as small disadvantaged business concerns, Historically Black Colleges and Universities, minority institutions, and women-owned small business concerns.

(End of clause)

1852.219-81 Limitation on Subcontracting - SBIR Phase II Program. (OCT 2006)

1852.219-83 Limitation of the Principal Investigator - SBIR Program. (OCT 2006)

The primary employment of the principal investigator (PI) shall be with the small business concern (SBC)/Contractor during the conduct of this contract. Primary employment means that more than one-half of the principal investigator's time is spent in the employ of the SBC/Contractor. This precludes full-time employment with another organization. Deviations from these requirements must be approved in advance and in writing by the Contracting Officer and are not subject to a change in the firm-fixed price of the contract. The PI for this contract is [*insert name*].

(End of clause)

1852.219-85 Conditions for Final Payment - SBIR and STTR Contracts. (OCT 2006)

1852.235-70 Center for AeroSpace Information. (DEC 2006)

1852.237-72 Access to Sensitive Information. (JUN 2005)

(a) As used in this clause, ``sensitive information'' refers to information that a contractor has developed at private expense, or that the Government has generated that qualifies for an exception to the Freedom of Information Act, which is not currently in the public domain, and which may embody trade secrets or commercial or financial information, and which may be sensitive or privileged.

(b) To assist NASA in accomplishing management activities and administrative functions, the Contractor shall provide the services specified elsewhere in this contract.

(c) If performing this contract entails access to sensitive information, as defined above, the Contractor agrees to--

(1) Utilize any sensitive information coming into its possession only for the purposes of performing the services specified in this contract, and not to improve its own competitive position in another procurement.

(2) Safeguard sensitive information coming into its possession from unauthorized use and disclosure.

(3) Allow access to sensitive information only to those employees that need it to perform services under this contract.

(4) Preclude access and disclosure of sensitive information to persons and entities outside of the Contractor's organization.

(5) Train employees who may require access to sensitive information about their obligations to utilize it only to perform the services specified in this contract and to safeguard it from unauthorized use and disclosure.

(6) Obtain a written affirmation from each employee that he/she has received and will comply with training on the authorized uses and mandatory protections of sensitive information needed in performing this contract.

(7) Administer a monitoring process to ensure that employees comply with all reasonable security procedures, report any breaches to the Contracting Officer, and implement any necessary corrective actions.

(d) The Contractor will comply with all procedures and obligations specified in its Organizational Conflicts of Interest Avoidance Plan, which this contract incorporates as a compliance document.

(e) The nature of the work on this contract may subject the Contractor and its employees to a variety of laws and regulations relating to ethics, conflicts of interest, corruption, and other criminal or civil matters relating to the award and administration of government contracts. Recognizing that this contract establishes a high standard of accountability and trust, the Government will carefully review the Contractor's performance in relation to the mandates and restrictions found in these laws and regulations. Unauthorized uses or disclosures of sensitive information may result in termination of this contract for default, or in debarment of the Contractor for serious misconduct affecting present responsibility as a government contractor.

(f) The Contractor shall include the substance of this clause, including this paragraph (f), suitably modified to reflect the relationship of the parties, in all subcontracts that may involve access to sensitive information

(End of clause)

1852.237-73 Release of Sensitive Information. (JUN 2005)

(a) As used in this clause, "Sensitive information" refers to information, not currently in the public domain, that the Contractor has developed at private expense, that may embody trade secrets or commercial or financial information, and that may be sensitive or privileged.

(b) In accomplishing management activities and administrative functions, NASA relies heavily on the support of various service providers. To support NASA activities and functions, these service providers, as well as their subcontractors and their individual employees, may need access to sensitive information submitted by the Contractor under this contract. By submitting this proposal or performing this contract, the Contractor agrees that NASA may release to its service providers, their subcontractors, and their individual employees, sensitive information submitted during the course of this procurement, subject to the enumerated protections mandated by the clause at 1852.237-72, Access to Sensitive Information.

(c) (1) The Contractor shall identify any sensitive information submitted in support of this proposal or in performing this contract. For purposes of identifying sensitive information, the Contractor may, in addition to any other notice or legend otherwise required, use a notice similar to the following:

Mark the title page with the following legend:

This proposal or document includes sensitive information that NASA shall not disclose outside the Agency and its service providers that support management activities and administrative functions. To gain access to this sensitive information, a service provider's contract must contain the clause at NFS 1852.237-72, Access to Sensitive Information. Consistent with this clause, the service provider shall not duplicate, use, or disclose the information in whole or in part for any purpose other than to perform the services specified in its contract. This restriction does not limit the Government's right to use this information if it is obtained from another source without restriction. The information subject to this restriction is contained in pages [*insert page numbers or other identification of pages*]. Mark each page of sensitive information the Contractor wishes to restrict with the following legend:

Use or disclosure of sensitive information contained on this page is subject to the restriction on the title page of this proposal or document.

(2) The Contracting Officer shall evaluate the facts supporting any claim that particular information is "sensitive." This evaluation shall consider the time and resources necessary to protect the information in accordance with the detailed safeguards mandated by the clause at 1852.237-72, Access to Sensitive Information. However, unless the Contracting Officer decides, with the advice of Center counsel, that reasonable grounds exist to challenge the Contractor's claim that particular information is sensitive, NASA and its service providers and their employees shall comply with all of the safeguards contained in paragraph (d) of this clause.

(d) To receive access to sensitive information needed to assist NASA in accomplishing management activities and administrative functions, the service provider must be operating under a contract that contains the clause at 1852.237-72, Access to Sensitive Information. This clause obligates the service provider to do the following:

(1) Comply with all specified procedures and obligations, including the Organizational Conflicts of Interest Avoidance Plan, which the contract has incorporated as a compliance document.

(2) Utilize any sensitive information coming into its possession only for the purpose of performing the services specified in its contract.

(3) Safeguard sensitive information coming into its possession from unauthorized use and disclosure.

(4) Allow access to sensitive information only to those employees that need it to perform services under its contract.

(5) Preclude access and disclosure of sensitive information to persons and entities outside of the service provider's organization.

(6) Train employees who may require access to sensitive information about their obligations to utilize it only to perform the services specified in its contract and to safeguard it from unauthorized use and disclosure.

(7) Obtain a written affirmation from each employee that he/she has received and will comply with training on the authorized uses and mandatory protections of sensitive information needed in performing this contract.

(8) Administer a monitoring process to ensure that employees comply with all reasonable security procedures, report any breaches to the Contracting Officer, and implement any necessary corrective actions.

(e) When the service provider will have primary responsibility for operating an information technology system for NASA that contains sensitive information, the service provider's contract shall include the clause at 1852.204-76, Security Requirements for Unclassified Information Technology Resources. The Security Requirements clause requires the service provider to implement an Information Technology Security Plan to protect information processed, stored, or transmitted from unauthorized access, alteration, disclosure, or use. Service provider personnel requiring privileged access or limited privileged access to these information technology systems are subject to screening using the standard National Agency Check (NAC) forms appropriate to the level of risk for adverse impact to NASA missions. The Contracting Officer may allow the service provider to conduct its own screening, provided the service provider employs substantially equivalent screening procedures.

(f) This clause does not affect NASA's responsibilities under the Freedom of Information Act.

(g) The Contractor shall insert this clause, including this paragraph (g), suitably modified to reflect the relationship of the parties, in all subcontracts that may require the furnishing of sensitive information.

(End of clause)

LIST OF ATTACHMENTS

Appendix E: STTR Phase 1 Model Contract

SUPPLIES OR SERVICES AND PRICES/COSTS

52.213-4 Terms and Conditions - Simplified Acquisitions (Other Than Commercial Items). (MAR 2009)

(a) The Contractor shall comply with the following Federal Acquisition Regulation (FAR) clauses that are incorporated by reference:

(1) The clauses listed below implement provisions of law or Executive order:

(i) 52.222-3, Convict Labor (June 2003) (E.O. 11755).

(ii) 52.222-21, Prohibition of Segregated Facilities (Feb 1999) (E.O. 11246).

(iii) 52.222-26, Equal Opportunity (MAR 2007) (E.O. 11246).

(iv) 52.222-50, Combating Trafficking in Persons (FEB 2009) (22 U.S.C. 7104(g)).

(v) 52.225-13, Restrictions on Certain Foreign Purchases (FEB 2006) (E.o.s, proclamations, and statutes administered by the Office of Foreign Assets Control of the Department of the Treasury).

(vi) 52.233-3, Protest After Award (AUG 1996) (31 U.S.C. 3553).

(vii) 52.233-4, Applicable Law for Breach of Contract Claim (OCT 2004) (Pub. L. 108-77, 108-78).

(2) Listed below are additional clauses that apply:

(i) 52.232-1, Payments (APR 1984).

(ii) 52.232-8, Discounts for Prompt Payment (Feb 2002).

(iii) 52.232-11, Extras (APR 1984).

(iv) 52.232-25, Prompt Payment (OCT 2008).

(v) 52.233-1, Disputes (JUL 2002).

(vi) 52.244-6, Subcontracts for Commercial Items. (MAR 2009)

(vii) 52.253-1, Computer Generated Forms (JAN 1991).

(b) The Contractor shall comply with the following FAR clauses, incorporated by reference, unless the circumstances do not apply:

(1) The clauses listed below implement provisions of law or Executive order:

(i) 52.222-19, Child Labor--Cooperation with Authorities and Remedies (FEB 2008) (E.O. 13126). (Applies to contracts for supplies exceeding the micro-purchase threshold.)

(ii) 52.222-20, Walsh-Healey Public Contracts Act (Dec 1996) (41 U.S.C. 35-45) (Applies to supply contracts over $10,000 in the United States, Puerto Rico, or the U.S. Virgin Islands).

(iii) 52.222-35, Equal Opportunity for Special Disabled Veterans, Veterans of the Vietnam Era, and Other Eligible Veterans (SEP 2006) (38 U.S.C. 4212) (Applies to contracts of $100,000 or more).

(iv) 52.222-36, Affirmative Action for Workers with Disabilities (June 1998) (29 U.S.C. 793). (Applies to contracts over $10,000, unless the work is to be performed outside the United States by employees recruited outside the United States.) (For purposes of this clause, United States includes the 50 States, the District of Columbia, Puerto Rico, the Northern Mariana Islands, American Samoa, Guam, the U.S. Virgin Islands, and Wake Island.)

(v) 52.222-37, Employment Reports on Special Disabled Veterans, Veterans of the Vietnam Era, and Other Eligible Veterans (SEP 2006) (38 U.S.C. 4212) (Applies to contracts of $100,000 or more).

(vi) 52.222-41, Service Contract Act of 1965 (Nov 2007) (41 U.S.C. 351), *et seq*.) (Applies to service contracts over $2,500 that are subject to the Service Contract Act and will be performed in the United States, District of Columbia, Puerto Rico, the Northern Mariana Islands, American Samoa, Guam, the U.S. Virgin Islands, Johnston Island, Wake Island, or the outer continental shelf lands.)

(vii) 52.223-5, Pollution Prevention and Right-to-Know Information (Aug 2003) (E.O. 13148) (Applies to services performed on Federal facilities).

(viii) 52.223-15, Energy Efficiency in Energy-Consuming Products (DEC 2007) (42 U.S.C. 8259b) (Unless exempt pursuant to 23.204, applies to contracts when energy-consuming products listed in the ENERGY STAR Program or Federal Energy Management Program (FEMP) will be--

(A) Delivered;

(B) Acquired by the Contractor for use in performing services at a Federally-controlled facility;

(C) Furnished by the Contractor for use by the Government; or

(D) Specified in the design of a building or work, or incorporated during its construction, renovation, or maintenance.)

(ix) 52.225-1, Buy American Act--Supplies (FEB 2009) (41 U.S.C. 10a-10d) (Applies to contracts for supplies, and to contracts for services involving the furnishing of supplies, for use in the United States or its outlying areas, if the value of the supply contract or supply portion of a service contract exceeds the micro-purchase threshold and the acquisition--

(A) Is set aside for small business concerns; or

(B) Cannot be set aside for small business concerns (see 19.502-2), and does not exceed $25,000).

(x) 52.232-34, Payment by Electronic Funds Transfer - Other than Central Contractor Registration (May 1999). (Applies when the payment will be made by EFT and the payment office does not use the CCR database as its source of EFT information.)

(xi) 52.247-64, Preference for Privately Owned U.S.-Flag Commercial Vessels (FEB 2006) (46 U.S.C. Appx 1241). (Applies to supplies transported by ocean vessels (except for the types of subcontracts listed at 47.504(d).)

(2) Listed below are additional clauses that may apply:

(i) 52.209-6, Protecting the Government's Interest When Subcontracting with Contractors Debarred, Suspended, or Proposed for Debarment (SEP 2006) (Applies to contracts over $30,000).

(ii) 52.211-17, Delivery of Excess Quantities (Sept 1989) (Applies to fixed-price supplies).

(iii) 52.226-6, Promoting Excess Food Donation to Nonprofit Organizations. (MAR 2009) (Pub. L. 110-247) (Applies to contracts greater than $25,000 that provide for the provision, the service, or the sale of food in the United States.)

(iv) 52.247-29, F.o.b. Origin (FEB 2006) (Applies to supplies if delivery is f.o.b. origin).

(v) 52.247-34, F.o.b. Destination (Nov 1991) (Applies to supplies if delivery is f.o.b. destination).

(c) *FAR 52.252-2, Clauses Incorporated by Reference (Feb 1998*). This contract incorporates one or more clauses by reference, with the same force and effect as if they were given in full text. Upon request, the Contracting Officer will make their full text available. Also, the full text of a clause may be accessed electronically at this/these address(es):

http://www.acqnet.gov/far/

NASA FAR Supplement (NFS) clauses:

http://www.hq.nasa.gov/office/procurement/regs/nfstoc.htm

(d) *Inspection/Acceptance*. The Contractor shall tender for acceptance only those items that conform to the requirements of this contract. The Government reserves the right to inspect or test any supplies or services that have been tendered for acceptance. The Government may require repair or replacement of nonconforming supplies or reperformance of nonconforming services at no increase in contract price. The Government must exercise its postacceptance rights -

(1) Within a reasonable period of time after the defect was discovered or should have been discovered; and

(2) Before any substantial change occurs in the condition of the item, unless the change is due to the defect in the item.

(e) *Excusable delays*. The Contractor shall be liable for default unless nonperformance is caused by an occurrence beyond the reasonable control of the Contractor and without its fault or negligence, such as acts of God or the public enemy, acts of the Government in either its sovereign or contractual capacity, fires, floods, epidemics, quarantine restrictions, strikes, unusually severe weather, and delays of common carriers. The Contractor shall notify the Contracting Officer in writing as soon as it is reasonably possible after the commencement of any excusable delay, setting forth the full particulars in connection therewith, shall remedy such occurrence with all reasonable dispatch, and shall promptly give written notice to the Contracting Officer of the cessation of such occurrence.

(f) *Termination for the Government's convenience*. The Government reserves the right to terminate this contract, or any part hereof, for its sole convenience. In the event of such termination, the Contractor shall immediately stop all work hereunder and shall immediately cause any and all of its suppliers and subcontractors to cease work. Subject to the terms of this contract, the Contractor shall be paid a percentage of the contract price reflecting the percentage of the work performed prior to the notice of termination, plus reasonable charges that the Contractor can demonstrate to the satisfaction of the Government, using its standard record keeping system, have resulted from the termination. The Contractor shall not be required to comply with the cost accounting standards or contract cost principles for this purpose. This paragraph does not give the Government any right to audit the Contractor's records. The Contractor shall not be paid for any work performed or costs incurred that reasonably could have been avoided.

(g) *Termination for cause*. The Government may terminate this contract, or any part hereof, for cause in the event of any default by the Contractor, or if the Contractor fails to comply with any contract terms and conditions, or fails to provide the Government, upon request, with adequate assurances of future performance. In the event of termination for cause, the Government shall not be liable to the Contractor for any amount for supplies or services not accepted, and the Contractor shall be liable to the Government for any and all rights and remedies provided by law. If it is determined that the Government improperly terminated this contract for default, such termination shall be deemed a termination for convenience.

(h) *Warranty*. The Contractor warrants and implies that the items delivered hereunder are merchantable and fit for use for the particular purpose described in this contract.

(End of clause)

1852.216-78 Firm Fixed Price. (DEC 1988)

The total firm fixed price of this contract is $[*Insert the appropriate amount*].

(End of clause)

SUPPLIES AND/OR SERVICES TO BE PROVIDED

The Contractor shall provide all resources (except as may be expressly stated in the contract as furnished by the Government) necessary to deliver and/or perform the items below in accordance with the Description/Specifications/Statement of Work incorporated [*insert attachment number and/or section identifier of the Spec/SOW*].

(End of clause)

DESCRIPTION/SPECIFICATIONS/STATEMENT OF WORK

SPECIFICATION/STATEMENT OF WORK

The Contractor shall provide the item or services specified in Section B in accordance with the following:

[*Insert the Title of the Specification and/or Statement of Work*]

(End of text)

INSPECTION AND ACCEPTANCE

52.246-9 Inspection of Research and Development (Short Form). (APR 1984)

52.246-16 Responsibility for Supplies. (APR 1984)

DELIVERIES OR PERFORMANCE

52.242-15 Stop-Work Order. (AUG 1989)

PERIOD OF PERFORMANCE

The period of performance of this contract is [*Insert specific dates (i.e. "from___ to ___") or the negotiated period in terms of weeks, months, or years (ex: "12 months from the effective date of the contract").*]

(End of clause)

DELIVERY AND/OR COMPLETION SCHEDULE

The Contractor shall deliver and/or complete performance of the items required under this contract as follows:

[*Insert a table which details for each item, the item number, description, quantity, unit of measure, and delivery/completion date.*]

(End of clause)

ADDITIONAL REPORTS OF WORK - SBIR/STTR Phase I

(a**)** Interim Technical Progress Reports.
(1) The Contractor shall submit an interim progress report of all work accomplished. The report shall be in narrative form, be brief, and informal. This report shall include:
(i) A quantitative description of work performed during the period;
(ii) An indication of any current problems which may impede performance or impact program schedule or cost, and proposed corrective action;
(iii) A discussion of the work to be performed during the next reporting period;
(iv) A description of any changes to the planned use of subcontractors since contract award: and
(v) Estimated percentage of physical completion of the contract.
This report shall be submitted via the NASA SBIR Contract Administration Electronic Handbook.
Instructions for the electronic submission process are available to contractors on the NASA SBIR Home Page at: http://sbir.gsfc.nasa,gov/SBIR/SBIR.html
(2) Interim Technical Progress Reports are to be submitted within ten (10) days following the period to be reported, except for the Final Report which shall be submitted no later than the final day of the contract performance period.
(b) **Final Report & Project Summary Document.** The Contractor shall submit a Final Report within six (6) months from the effective date of this contract. The report shall be in narrative form documenting and summarizing the results of the entire contract work. The following instructions apply to the final report and are in addition to the requirements of the "Final Scientific and Technical Reports" clause of this contract (NFS 1852.235-73).
(1) **The Final Report shall include a single-page project summary as the first page,** identifying the purpose of the research, a brief description of the research carried out, the research findings or results (including the degree to which the Phase I objectives were achieved), and whether the results justify Phase II continuation. The project summary is to be submitted without restriction for NASA publication. This document should not contain any proprietary data and should be submitted without any restrictive markings. Instructions for the electronic submission of the project summary are posted on the NASA SBIR Electronic Contract Administration Handbook located in the NASA SBIR/STTR Forms Library.
(2) **The project summary shall be submitted with each copy of the final report and as a separate electronic submission via the NASA SBIR Electronic Contract Administration Handbook.**
(3) The balance of the report should indicate in detail the project objectives, work carried out, results obtained, and assessment of technical merit and feasibility. The potential applications of the project results **for a potential Phase 3** effort both for NASA purposes and for commercial purposes shall also be included. Rights to both interim and final report data (except for the project summary) shall be in accordance with clause 52.227-20, Rights in Data -- SBIR Program, of this contract. The Contractor shall mark all pages of reports (except the project summary) with the SBIR Rights notice set forth in clause 52.227-20.

(c) **The final report shall serve as the last interim report.**

NOTE: Only unclassified reports shall be submitted to the CASI

CONTRACT ADMINISTRATION DATA

1852.227-11 Patent Rights - Retention by the Contractor (Short Form).

1852.227-72 Designation of New Technology Representative and Patent Representative. (JUL 1997)

(a) For purposes of administration of the clause of this contract entitled "New Technology" or "Patent Rights - Retention by the Contractor (Short Form)," whichever is included, the following named representatives are hereby designated by the Contracting Officer to administer such clause:

Title
[ ]
Office Code
[ ]
Address (including zip code)
[ ]
New Technology Representative
[ ]
Patent Representative
[ ]

(b) Reports of reportable items, and disclosure of subject inventions, interim reports, final reports, utilization reports, and other reports required by the clause, as well as any correspondence with respect to such matters, should be directed to the New Technology Representative unless transmitted in response to correspondence or request from the Patent Representative. Inquires or requests regarding disposition of rights, election of rights, or related matters should be directed to the Patent Representative. This clause shall be included in any subcontract hereunder requiring a "New Technology" clause or "Patent Rights - Retention by the Contractor (Short Form)" clause, unless otherwise authorized or directed by the Contracting Officer. The respective responsibilities and authorities of the above-named representatives are set forth in 1827.305-370 of the NASA FAR Supplement.

(End of clause)

SECTION G CONTRACT SPECIFIC ADDITIONAL CLAUSE ONE

INVOICES AND PAYMENTS

Contractor shall submit one (1) copy of each invoice electronically through the Electronic Handbook; no other copies or actions are required. All invoices submitted by the SBC shall be marked with the contract number and invoice number. Hard copies of reports or invoices are not required. Failure to comply with requirements stipulated herein will delay payment.

Payment of invoices will be based upon acceptance and approval of each deliverable by the COTR and CO. Payment may be withheld if the required deliverables have not been properly submitted or accepted by the COTR. All reports and invoices shall be submitted by uploading one (1) copy into the Electronic Handbook (https://sbir.gsfc.nasa.gov/sbir/contract-admin/). The only exception to this requirement is that a copy of the New Technology Report and/or New Technology Summary Report shall be uploaded into the Electronic Handbook AND a copy shall be submitted using the eNTRe reporting system http://invention.nasa.gov/.

(End of clause)

SECTION G CONTRACT SPECIFIC ADDITIONAL CLAUSE TWO

REQUEST FOR PROPOSAL FOR PHASE II FOLLOW-ON CONTRACT

(a) This Phase I contract serves as a request for proposal for an SBIR Phase II follow-on contract except: (i) when NASA notifies the contractor that the area or topic of research is no longer suitably high enough within the Agency's research priorities; or (ii) when NASA notifies the contractor that the Phase I research results are not worthy of continuation. Submission of a Phase II proposal is strictly voluntary and NASA assumes no responsibility for proposal preparation costs. Phase II proposals are due at the end of the Phase I contract. NOTE THAT PHASE II PROPOSALS MUST BE RECEIVED BY THE GOVERNMENT NO LATER THAN 5:00 pm EDT ON THE LAST DAY OF THE PHASE I CONTRACT PERIOD [(Insert the end date of the Phase I contract)]. LATE PROPOSALS MAY BE ELIMINATED FROM FURTHER CONSIDERATION FOR PHASE II AWARDS.
All information necessary to submit a SBIR Phase II proposal is available at:
http://sbir.gsfc.nasa.gov/SBIR/SBIR.html.

(End of clause)

SPECIAL CONTRACT REQUIREMENTS

1852.223-72 Safety and Health (Short Form). (APR 2002)

1852.225-70 Export Licenses. (FEB 2000)

(a) The Contractor shall comply with all U.S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this contract. In the absence of available license exemptions/exceptions, the Contractor shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of hardware, technical data, and software, or for the provision of technical assistance.

(b) The Contractor shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of this contract, including instances where the work is to be performed on-site at [*insert name of NASA installation*], where the foreign person will have access to export-controlled technical data or software.

(c) The Contractor shall be responsible for all regulatory record keeping requirements associated with the use of licenses and license exemptions/exceptions.

(d) The Contractor shall be responsible for ensuring that the provisions of this clause apply to its subcontractors.

(End of clause)

1852.235-71 Key Personnel and Facilities. (MAR 1989)

(a) The personnel and/or facilities listed below (or specified in the contract Schedule) are considered essential to the work being performed under this contract. Before removing, replacing, or diverting any of the listed or specified personnel or facilities, the Contractor shall (1) notify the Contracting Officer reasonably in advance and (2) submit justification (including proposed substitutions) in sufficient detail to permit evaluation of the impact on this contract.

(b) The Contractor shall make no diversion without the Contracting Officer's written consent; provided, that the Contracting Officer may ratify in writing the proposed change, and that ratification shall constitute the Contracting Officer's consent required by this clause.

(c) The list of personnel and/or facilities (shown below or as specified in the contract Schedule) may, with the consent of the contracting parties, be amended from time to time during the course of the contract to add or delete personnel and/or facilities.

[*List here the personnel and/or facilities considered essential, unless they are specified in the contract Schedule.*]

(End of clause)

1852.235-73 Final Scientific and Technical Reports. (DEC 2006) -- Alternate III (JAN 2005)

1852.235-74 Additional Reports of Work - Research and Development. (FEB 2003)

In addition to the final report required under this contract, the Contractor shall submit the following report(s) to the Contracting Officer:

(a) Quarterly progress reports. The Contractor shall submit separate quarterly reports of all work accomplished during each three-month period of contract performance. In addition to factual data, these reports should include a separate analysis section interpreting the results obtained, recommending further action, and relating occurrences to the ultimate objectives of the contract. Sufficient diagrams, sketches, curves, photographs, and drawings should be included to convey the intended meaning.

(b) Submission dates. Quarterly reports shall be submitted within 10 days the following the period to be reported. No quarterly report need be submitted for the final three months of contract effort since that period will be covered in the final report. The final report shall be submitted within ____days after the completion of the effort under the contract.

(End of clause)

NEW TECHNOLOGY REPORTING - SBIR/STTR PROGRAM

Federal Acquisition Regulation clause 52.227-11, "Patent Rights Retention by the Contractor (Short Form)", as modified by NASA FAR Supplement 1852.227-11, requires that contractors provide NASA:

(a) A disclosure of each subject invention, within two months after the inventor discloses it to contractor personnel responsible for patent matters.

"Subject invention," means any invention, discovery, improvement, or innovation of the contractor that is or may be patentable or otherwise protectable under Title 35 of the United States Code, made in the performance of any work under any NASA contract. Subject inventions include, but are not limited to, new processes, machines, manufactures, and compositions of matter, and improvements to, or new applications of, existing processes, machines, manufactures, and compositions of matter. Subject Inventions also include new computer programs, and improvements to, or new applications of, existing computer programs, whether or not copyrightable or otherwise protectable under Title 17 of the United States Code.

NASA prefers that the contractor use either the electronic or paper version of NASA Form 1679, "Disclosure of Invention and New Technology (Including Software)" to disclose subject inventions. Both the electronic and paper versions of NASA Form 1679 may be accessed at the electronic New Technology Reporting Web site http://invention.nasa.gov. Alternate formats may be used if the information provided is equivalent to that found on the NASA Form 1679.

(b) The Contractor must also provide:

(1) "Interim New Technology Summary Reports", due 12 months from the effective date of the contract, with additional reports due annually thereafter, listing subject inventions during that period, and certifying that all subject inventions have been disclosed, or that there were no such subject inventions.

(2) "Final New Technology Summary Report", due within 3 months after completion of the contracted work, listing all subject inventions and certifying that all subject inventions have been disclosed (or that there were no such subject inventions). A listing of all subcontracts at any tier containing a patent rights clause or certification that there were no such subcontracts should be included with the report as well. Note: Final payment will not be made until the Final New Technology Summary Report has been received and accepted, so Contractors are advised to submit this report with the other final deliverables to avoid delay in receiving payment.

Contractors should use the "New Technology Summary Report" form for both interim and final summary reports. NASA Summary Forms may be accessed at the electronic New Technology Reporting Web site http://invention.nasa.gov. Alternate formats may be used if the information provided is equivalent to that found on the NASA Summary Form.

All disclosures and interim/final reports as well as any correspondence with respect to such matters should be submitted to the Center's New Technology Representative at the address listed in the following paragraph.

Company New Technology Representative Designation: Upon contract award, the Contractor shall send the name, address, telephone number and email address of the Contractor's New Technology Representative responsible for submitting the New Technology Reports (include the contract number with this submission), to the NASA New Technology Representative at the following address:
[*Insert address of Center New Technology Representative*]

All inquiries or requests regarding disposition of rights, election of rights, or related matters should be directed to the Center's Patent Representative at the following address:
[*Insert address for the Center Patent Representative*]

(End of clause)

SECTION 508 COMPLIANCE

(a) The Workforce Investment Act of 1998 amended section 508 of the Rehabilitation Act of 1973 to require that :
(1) When developing, procuring, maintaining or using Electronic and Information Technology (EIT), agencies must ensure that employees with disabilities have access to and use of information and data that is comparable to that for other employees; and
(2) Members of the public with disabilities seeking information or services from an agency have access to and use of information and data that is comparable to that for members of the public without disabilities.
(b) Section 508 standards should be taken into consideration in the design of prototypes. Failure to meet Section 508 standards will impact the Government's ability to make future purchases of the technology developed under this contract. Information regarding Section 508 standards can be obtained at http://www.access-board.gov/508.htm.

(End of clause)

CONTRACT CLAUSES

52.202-1 Definitions. (JUL 2004)

52.203-5 Covenant Against Contingent Fees. (APR 1984)

52.203-7 Anti-Kickback Procedures. (JUL 1995)

52.204-7 Central Contractor Registration. (APR 2008)

52.219-6 Notice of Total Small Business Set-Aside. (JUN 2003)

52.223-14 Toxic Chemical Release Reporting. (AUG 2003)

52.227-1 Authorization and Consent. (DEC 2007) -- Alternate I (APR 1984)

52.227-2 Notice and Assistance Regarding Patent and Copyright Infringement. (DEC 2007)

52.227-11 Patent Rights--Ownership by the Contractor. (DEC 2007)

(a) As used in this clause--

"Invention" means any invention or discovery that is or may be patentable or otherwise protectable under title 35 of the U.S. Code, or any variety of plant that is or may be protectable under the Plant Variety Protection Act (7 U.S.C. 2321, et seq.)

"Made" means--

(1) When used in relation to any invention other than a plant variety, the conception or first actual reduction to practice of the invention; or

(2) When used in relation to a plant variety, that the Contractor has at least tentatively determined that the variety has been reproduced with recognized characteristics.

"Nonprofit organization" means a university or other institution of higher education or an organization of the type described in section 501(c)(3) of the Internal Revenue Code of 1954 (26 U.S.C. 501(c)) and exempt from taxation under section 501(a) of the Internal Revenue Code (26 U.S.C. 501(a)), or any nonprofit scientific or educational organization qualified under a State nonprofit organization statute.

"Practical application" means to manufacture, in the case of a composition of product; to practice, in the case of a process or method; or to operate, in the case of a machine or system; and, in each case, under such conditions as to establish that the invention is being utilized and that its benefits are, to the extent permitted by law or Government regulations, available to the public on reasonable terms.

"Subject invention" means any invention of the Contractor made in the performance of work under this contract.

(b) Contractor's rights. (1) Ownership. The Contractor may retain ownership of each subject invention throughout the world in accordance with the provisions of this clause.

(2) License. (i) The Contractor shall retain a nonexclusive royalty-free license throughout the world in each subject invention to which the Government obtains title, unless the Contractor fails to disclose the invention within the

times specified in paragraph (c) of this clause. The Contractor's license extends to any domestic subsidiaries and affiliates within the corporate structure of which the Contractor is a part, and includes the right to grant sublicenses to the extent the Contractor was legally obligated to do so at contract award. The license is transferable only with the written approval of the agency, except when transferred to the successor of that part of the Contractor's business to which the invention pertains.

(ii) The Contractor's license may be revoked or modified by the agency to the extent necessary to achieve expeditious practical application of the subject invention in a particular country in accordance with the procedures in FAR 27.302(i)(2) and 27.304-1(f).

(c) Contractor's obligations. (1) The Contractor shall disclose in writing each subject invention to the Contracting Officer within 2 months after the inventor discloses it in writing to Contractor personnel responsible for patent matters. The disclosure shall identify the inventor(s) and this contract under which the subject invention was made. It shall be sufficiently complete in technical detail to convey a clear understanding of the subject invention. The disclosure shall also identify any publication, on sale (i.e., sale or offer for sale), or public use of the subject invention, or whether a manuscript describing the subject invention has been submitted for publication and, if so, whether it has been accepted for publication. In addition, after disclosure to the agency, the Contractor shall promptly notify the Contracting Officer of the acceptance of any manuscript describing the subject invention for publication and any on sale or public use.

(2) The Contractor shall elect in writing whether or not to retain ownership of any subject invention by notifying the Contracting Officer within 2 years of disclosure to the agency. However, in any case where publication, on sale, or public use has initiated the 1-year statutory period during which valid patent protection can be obtained in the United States, the period for election of title may be shortened by the agency to a date that is no more than 60 days prior to the end of the statutory period.

(3) The Contractor shall file either a provisional or a nonprovisional patent application or a Plant Variety Protection Application on an elected subject invention within 1 year after election. However, in any case where a publication, on sale, or public use has initiated the 1-year statutory period during which valid patent protection can be obtained in the United States, the Contractor shall file the application prior to the end of that statutory period. If the Contractor files a provisional application, it shall file a nonprovisional application within 10 months of the filing of the provisional application. The Contractor shall file patent applications in additional countries or international patent offices within either 10 months of the first filed patent application (whether provisional or nonprovisional) or 6 months from the date permission is granted by the Commissioner of Patents to file foreign patent applications where such filing has been prohibited by a Secrecy Order.

(4) The Contractor may request extensions of time for disclosure, election, or filing under paragraphs (c)(1), (c)(2), and (c)(3) of this clause.

(d) Government's rights--(1) Ownership. The Contractor shall assign to the agency, on written request, title to any subject invention--

(i) If the Contractor fails to disclose or elect ownership to the subject invention within the times specified in paragraph (c) of this clause, or elects not to retain ownership; provided, that the agency may request title only within 60 days after learning of the Contractor's failure to disclose or elect within the specified times.

(ii) In those countries in which the Contractor fails to file patent applications within the times specified in paragraph (c) of this clause; provided, however, that if the Contractor has filed a patent application in a country after the times specified in paragraph (c) of this clause, but prior to its receipt of the written request of the agency, the Contractor shall continue to retain ownership in that country.

(iii) In any country in which the Contractor decides not to continue the prosecution of any application for, to pay the maintenance fees on, or defend in reexamination or opposition proceeding on, a patent on a subject invention.

(2) License. If the Contractor retains ownership of any subject invention, the Government shall have a nonexclusive, nontransferable, irrevocable, paid-up license to practice, or have practiced for or on its behalf, the subject invention throughout the world.

(e) Contractor action to protect the Government's interest. (1) The Contractor shall execute or have executed and promptly deliver to the agency all instruments necessary to--

(i) Establish or confirm the rights the Government has throughout the world in those subject inventions in which the Contractor elects to retain ownership; and

(ii) Assign title to the agency when requested under paragraph (d) of this clause and to enable the Government to obtain patent protection and plant variety protection for that subject invention in any country.

(2) The Contractor shall require, by written agreement, its employees, other than clerical and nontechnical employees, to disclose promptly in writing to personnel identified as responsible for the administration of patent matters and in the Contractor's format, each subject invention in order that the Contractor can comply with the disclosure provisions of paragraph (c) of this clause, and to execute all papers necessary to file patent applications on subject inventions and to establish the Government's rights in the subject inventions. The disclosure format should require, as a minimum, the information required by paragraph (c)(1) of this clause. The Contractor shall instruct such employees, through employee agreements or other suitable educational programs, as to the importance of reporting inventions in sufficient time to permit the filing of patent applications prior to U.S. or foreign statutory bars.

(3) The Contractor shall notify the Contracting Officer of any decisions not to file a nonprovisional patent application, continue the prosecution of a patent application, pay maintenance fees, or defend in a reexamination or opposition proceeding on a patent, in any country, not less than 30 days before the expiration of the response or filing period required by the relevant patent office.

(4) The Contractor shall include, within the specification of any United States nonprovisional patent or plant variety protection application and any patent or plant variety protection certificate issuing thereon covering a subject invention, the following statement, "This invention was made with Government support under (identify the contract) awarded by (identify the agency). The Government has certain rights in the invention."

(f) Reporting on utilization of subject inventions. The Contractor shall submit, on request, periodic reports no more frequently than annually on the utilization of a subject invention or on efforts at obtaining utilization of the subject invention that are being made by the Contractor or its licensees or assignees. The reports shall include information regarding the status of development, date of first commercial sale or use, gross royalties received by the Contractor, and other data and information as the agency may reasonably specify. The Contractor also shall provide additional reports as may be requested by the agency in connection with any march-in proceeding undertaken by the agency in accordance with paragraph (h) of this clause. The Contractor also shall mark any utilization report as confidential/proprietary to help prevent inadvertent release outside the Government. As required by 35 U.S.C. 202(c)(5), the agency will not disclose that information to persons outside the Government without the Contractor's permission.

(g) Preference for United States industry. Notwithstanding any other provision of this clause, neither the Contractor nor any assignee shall grant to any person the exclusive right to use or sell any subject invention in the United States unless the person agrees that any products embodying the subject invention or produced through the use of the subject invention will be manufactured substantially in the United States. However, in individual cases, the requirement for an agreement may be waived by the agency upon a showing by the Contractor or its assignee that reasonable but unsuccessful efforts have been made to grant licenses on similar terms to potential licensees that would be likely to manufacture substantially in the United States, or that under the circumstances domestic manufacture is not commercially feasible.

(h) March-in rights. The Contractor acknowledges that, with respect to any subject invention in which it has retained ownership, the agency has the right to require licensing pursuant to 35 U.S.C. 203 and 210(c), and in accordance with the procedures in 37 CFR 401.6 and any supplemental regulations of the agency in effect on the date of contract award.

(i) Special provisions for contracts with nonprofit organizations. If the Contractor is a nonprofit organization, it shall--

(1) Not assign rights to a subject invention in the United States without the written approval of the agency, except where an assignment is made to an organization that has as one of its primary functions the management of inventions, provided, that the assignee shall be subject to the same provisions as the Contractor;

(2) Share royalties collected on a subject invention with the inventor, including Federal employee co-inventors (but through their agency if the agency deems it appropriate) when the subject invention is assigned in accordance with 35 U.S.C. 202(e) and 37 CFR 401.10;

(3) Use the balance of any royalties or income earned by the Contractor with respect to subject inventions, after payment of expenses (including payments to inventors) incidental to the administration of subject inventions for the support of scientific research or education; and

(4) Make efforts that are reasonable under the circumstances to attract licensees of subject inventions that are small business concerns, and give a preference to a small business concern when licensing a subject invention if the Contractor determines that the small business concern has a plan or proposal for marketing the invention which, if executed, is equally as likely to bring the invention to practical application as any plans or proposals from applicants that are not small business concerns; provided, that the Contractor is also satisfied that the small business concern has the capability and resources to carry out its plan or proposal. The decision whether to give a preference in any specific case will be at the discretion of the Contractor.

(5) Allow the Secretary of Commerce to review the Contractor's licensing program and decisions regarding small business applicants, and negotiate changes to its licensing policies, procedures, or practices with the Secretary of Commerce when the Secretary's review discloses that the Contractor could take reasonable steps to more effectively implement the requirements of paragraph (i)(4) of this clause.

(j) Communications. [*Complete according to agency instructions.*]

(k) Subcontracts. (1) The Contractor shall include the substance of this clause, including this paragraph (k), in all subcontracts for experimental, developmental, or research work to be performed by a small business concern or nonprofit organization.

(2) The Contractor shall include in all other subcontracts for experimental, developmental, or research work the substance of the patent rights clause required by FAR Subpart 27.3.

(3) At all tiers, the patent rights clause must be modified to identify the parties as follows: references to the Government are not changed, and the subcontractor has all rights and obligations of the Contractor in the clause. The Contractor shall not, as part of the consideration for awarding the subcontract, obtain rights in the subcontractor's subject inventions.

(4) In subcontracts, at any tier, the agency, the subcontractor, and the Contractor agree that the mutual obligations of the parties created by this clause constitute a contract between the subcontractor and the agency with respect to the matters covered by the clause; provided, however, that nothing in this paragraph is intended to confer any jurisdic-

tion under the Contract Disputes Act in connection with proceedings under paragraph (h) of this clause.

(End of clause)

52.227-16 Additional Data Requirements. (JUN 1987)

52.227-20 Rights in Data--SBIR Program. (DEC 2007)

52.232-2 Payments under Fixed-Price Research and Development Contracts. (APR 1984)

52.232-12 Advance Payments. (MAY 2001) - Alternate IV (APR 1984)

(a) *Requirements for payment*. Advance payments will be made under this contract (1) upon submission of properly certified invoices or vouchers by the Contractor, and approval by the administering office, [*insert the name of the office designated under agency procedures*], or (2) under a letter of credit. The amount of the invoice or voucher submitted plus all advance payments previously approved shall not exceed $[ ]. If a letter of credit is used, the Contractor shall withdraw cash only when needed for disbursements acceptable under this contract and report cash disbursements and balances as required by the administering office. The Contractor shall apply terms similar to this clause to any advance payments to subcontractors.

(b) Special account. Until (1) the Contractor has liquidated all advance payments made under the contract and related interest charges and (2) the administering office has approved in writing the release of any funds due and payable to the Contractor, all advance payments and other payments under this contract shall be made by check payable to the Contractor marked for deposit only in the Contractor's special account with the [*insert the name of the financial institution*]. None of the funds in the special account shall be mingled with other funds of the Contractor. Withdrawals from the special account may be made only by check of the Contractor countersigned by the Contracting Officer or a Government countersigning agent designated in writing by the Contracting Officer.

(c) *Use of funds*. The Contractor may withdraw funds from the special account only to pay for properly allocable, allowable, and reasonable costs for direct materials, direct labor, and indirect costs. Other withdrawals require approval in writing by the administering office. Determinations of whether costs are properly allocable, allowable, and reasonable shall be in accordance with generally accepted accounting principles, subject to any applicable subparts of Part 31 of the Federal Acquisition Regulation.

(d) *Repayment to the Government.* At any time, the Contractor may repay all or any part of the funds advanced by the Government. Whenever requested in writing to do so by the administering office, the Contractor shall repay to the Government any part of unliquidated advance payments considered by the administering office to exceed the Contractor's current requirements or the amount specified in paragraph (a) above. If the Contractor fails to repay the amount requested by the administering office, all or any part of the unliquidated advance payments may be withdrawn from the special account by check signed by only the countersigning agent and applied to reduction of the unliquidated advance payments under this contract.

(e) *Maximum payment*. When the sum of all unliquidated advance payments, unpaid interest charges, and other payments exceed [ ] percent of the contract price, the Government shall withhold further payments to the Contractor. On completion or termination of the contract, the Government shall deduct from the amount due to the Contractor all unliquidated advance payments and all interest charges payable. If previous payments to the Contractor exceed the amount due, the excess amount shall be paid to the Government on demand. For purposes of this paragraph, the contract price shall be considered to be the stated contract price of $ [ ], less any subsequent price reductions under the contract, plus (1) any price increases resulting from any terms of this contract for price redetermination or escalation, and (2) any other price increases that do not, in the aggregate, exceed $ [*insert an amount not higher than 10 percent of the stated contract amount inserted in this paragraph*]. Any payments withheld under this paragraph shall be applied to reduce the unliquidated advance payments. If full liquidation has been made, payments under the contract shall resume.

(f) *Interest*. (1) No interest shall be charged to the prime Contractor for advance payments except for interest charged during a period of default. The terms of this paragraph concerning interest charges for advance payments shall not apply to the prime Contractor. The Contractor shall pay interest to the Government on the daily unliquidated advance payments at the daily rate specified in subparagraph (f)(3) below. Interest shall be computed at the end of each calendar month for the actual number of days involved. For the purpose of computing the interest charge -

(i) Advance payments shall be considered as increasing the unliquidated balance as of the date of the advance payment check;

(ii) Repayments by Contractor check shall be considered as decreasing the unliquidated balance as of the date on which the check is received by the Government authority designated by the Contracting Officer; and

(iii) Liquidations by deductions from Government payments to the Contractor shall be considered as decreasing the unliquidated balance as of the date of the check for the reduced payment.

(2) Interest charges resulting from the monthly computation shall be deducted from payments, other than advance payments, due the Contractor. If the accrued interest exceeds the payment due, any excess interest shall be carried forward and deducted from subsequent payments. Interest carried forward shall not be compounded. Interest on advance payments shall cease to accrue upon satisfactory completion or termination of the contract for the convenience of the Government. The Contractor shall charge interest on advance payments to subcontractors in the manner described above and credit the interest to the Government. Interest need not be charged on advance payments to nonprofit educational or research subcontractors for experimental, developmental, or research work.

(3) If interest is required under the contract, the Contracting Officer shall determine a daily interest rate based on the higher of (i) the published prime rate of the financial institution (depository) in which the special account is established or (ii) the rate established by the Secretary of the Treasury under Pub. L. 92-41 (50 U.S.C. App. 1215(b)(2)). The Contracting Officer shall revise the daily interest rate during the contract period in keeping with any changes in the cited interest rates.

(4) If the full amount of interest charged under this paragraph has not been paid by deduction or otherwise upon completion or termination of this contract, the Contractor shall pay the remaining interest to the Government on demand.

(g) Financial institution agreement. Before an advance payment is made under this contract, the Contractor shall transmit to the administering office, in the form prescribed by the administering office, an agreement in triplicate from the financial institution in which the special account is established, clearly setting forth the special character of the account and the responsibilities of the financial institution under the account. The Contractor shall select a financial institution that is a member bank of the Federal Reserve System, an insured bank within the meaning of the Federal Deposit Insurance Corporation Act (12 U.S.C. 1811), or a credit union insured by the National Credit Union Administration.

(h) *Lien on special account*. The Government shall have a lien upon any balance in the special account paramount to all other liens. The Government lien shall secure the repayment of any advance payments made under this contract and any related interest charges.

(i) *Lien on property under contract*. (1) All advance payments under this contract, together with interest charges, shall be secured, when made, by a lien in favor of the Government, paramount to all other liens, on the supplies or other things covered by this contract and on material and other property acquired for or allocated to the performance of this contract, except to the extent that the Government by virtue of any other terms of this contract, or otherwise, shall have valid title to the supplies, materials, or other property as against other creditors of the Contractor.

(2) The Contractor shall identify, by marking or segregation, all property that is subject to a lien in favor of the Government by virtue of any terms of this contract in such a way as to indicate that it is subject to a lien and that it has been acquired for or allocated to performing this contract. If, for any reason, the supplies, materials, or other property are not identified by marking or segregation, the Government shall be considered to have a lien to the extent of the Government's interest under this contract on any mass of property with which the supplies, materials, or other property are commingled. The Contractor shall maintain adequate accounting control over the property on its books and records.

(3) If, at any time during the progress of the work on the contract, it becomes necessary to deliver to a third person any items or materials on which the Government has a lien, the Contractor shall notify the third person of the lien and shall obtain from the third person a receipt in duplicate acknowledging the existence of the lien. The Contractor shall provide a copy of each receipt to the Contracting Officer.

(4) If, under the termination clause, the Contracting Officer authorizes the Contractor to sell or retain termination inventory, the approval shall constitute a release of the Government's lien to the extent that -

(i) The termination inventory is sold or retained; and

(ii) The sale proceeds or retention credits are applied to reduce any outstanding advance payments.

(j) *Insurance*. (1) The Contractor shall maintain with responsible insurance carriers -

(i) Insurance on plant and equipment against fire and other hazards, to the extent that similar properties are usually insured by others operating plants and properties of similar character in the same general locality;

(ii) Adequate insurance against liability on account of damage to persons or property; and

(iii) Adequate insurance under all applicable workers' compensation laws.

(2) Until work under this contract has been completed and all advance payments made under the contract have been liquidated, the Contractor shall -

(i) Maintain this insurance;

(ii) Maintain adequate insurance on any materials, parts, assemblies, subassemblies, supplies, equipment, and other property acquired for or allocable to this contract and subject to the Government lien under paragraph (i) of this clause; and

(iii) Furnish any evidence with respect to its insurance that the administering office may require.

(k) *Default*. (1) If any of the following events occurs, the Government may, by written notice to the Contractor, withhold further withdrawals from the special account and further payments on this contract:

(i) Termination of this contract for a fault of the Contractor.

(ii) A finding by the administering office that the Contractor has failed to -

(A) Observe any of the conditions of the advance payment terms;

(B) Comply with any material term of this contract;

(C) Make progress or maintain a financial condition adequate for performance of this contract;

(D) Limit inventory allocated to this contract to reasonable requirements; or

(E) Avoid delinquency in payment of taxes or of the costs of performing this contract in the ordinary course of business.

(iii) The appointment of a trustee, receiver, or liquidator for all or a substantial part of the Contractor's property, or the institution of proceedings by or against the Contractor for bankruptcy, reorganization, arrangement, or liquidation.

(iv) The service of any writ of attachment, levy of execution, or commencement of garnishment proceedings concerning the special account.

(v) The commission of an act of bankruptcy.

(2) If any of the events described in subparagraph (1) above continue for 30 days after the written notice to the Contractor, the Government may take any of the following additional actions:

(i) Withdraw by checks payable to the Treasurer of the United States, signed only by the countersigning agency, all or any part of the balance in the special account and apply the amounts to reduce outstanding advance payments and any other claims of the Government against the Contractor.

(ii) Charge interest, in the manner prescribed in paragraph (f) above, on outstanding advance payments during the period of any event described in subparagraph (k)(1) above.

(iii) Demand immediate repayment by the Contractor of the unliquidated balance of advance payments.

(iv) Take possession of and, with or without advertisement, sell at public or private sale all or any part of the property on which the Government has a lien under this contract and, after deducting any expenses incident to the sale, apply the net proceeds of the sale to reduce the unliquidated balance of advance payments or other Government claims against the Contractor.

(3) The Government may take any of the actions described in subparagraphs (k)(1) and (2) of this clause it considers appropriate at its discretion and without limiting any other rights of the Government.

(l) *Prohibition against assignment*. Notwithstanding any other terms of this contract, the Contractor shall not assign this contract, any interest therein, or any claim under the contract to any party.

(m) *Information and access to records*. The Contractor shall furnish to the administering office (1) monthly or at other intervals as required, signed or certified balance sheets and profit and loss statements together with a report on the operation of the special account in the form prescribed by the administering office; and (2) if requested, other information concerning the operation of the Contractor's business. The Contractor shall provide the authorized Government representatives proper facilities for inspection of the Contractor's books, records, and accounts.

(n) *Other security*. The terms of this contract are considered to provide adequate security to the Government for advance payments; however, if the administering office considers the security inadequate, the Contractor shall furnish additional security satisfactory to the administering office, to the extent that the security is available.

(o) *Representations*. The Contractor represents the following:

(1) The balance sheet, the profit and loss statement, and any other supporting financial statements furnished to the administering office fairly reflect the financial condition of the Contractor at the date shown or the period covered, and there has been no subsequent materially adverse change in the financial condition of the Contractor.

(2) No litigation or proceedings are presently pending or threatened against the Contractor, except as shown in the financial statements.

(3) The Contractor has disclosed all contingent liabilities, except for liability resulting from the renegotiation of defense production contracts, in the financial statements furnished to the administering office.

(4) None of the terms in this clause conflict with the authority under which the Contractor is doing business or with the provision of any existing indenture or agreement of the Contractor.

(5) The Contractor has the power to enter into this contract and accept advance payments, and has taken all necessary action to authorize the acceptance under the terms of this contract.

(6) The assets of the Contractor are not subject to any lien or encumbrance of any character except for current taxes not delinquent, and except as shown in the financial statements furnished by the Contractor. There is no current assignment of claims under any contract affected by these advance payment provisions.

(7) All information furnished by the Contractor to the administering office in connection with each request for advance payments is true and correct.

(8) These representations shall be continuing and shall be considered to have been repeated by the submission of each invoice for advance payments.

(p) *Covenants*. To the extent the Government considers it necessary while any advance payments made under this contract remain outstanding, the Contractor, without the prior written consent of the administering office, shall not -

(1) Mortgage, pledge, or otherwise encumber or allow to be encumbered, any of the assets of the Contractor now owned or subsequently acquired, or permit any preexisting mortgages, liens, or other encumbrances to remain on or attach to any assets of the Contractor which are allocated to performing this contract and with respect to which the Government has a lien under this contract;

(2) Sell, assign, transfer, or otherwise dispose of accounts receivable, notes, or claims for money due or to become due;

(3) Declare or pay any dividends, except dividends payable in stock of the corporation, or make any other distribution on account of any shares of its capital stock, or purchase, redeem, or otherwise acquire for value any of its stock, except as required by sinking fund or redemption arrangements reported to the administering office incident to the establishment of these advance payment provisions;

(4) Sell, convey, or lease all or a substantial part of its assets;

(5) Acquire for value the stock or other securities of any corporation, municipality, or governmental authority, except direct obligations of the United States;

(6) Make any advance or loan or incur any liability as guarantor, surety, or accommodation endorser for any party;

(7) Permit a writ of attachment or any similar process to be issued against its property without getting a release or bonding the property within 30 days after the entry of the writ of attachment or other process;

(8) Pay any remuneration in any form to its directors, officers, or key employees higher than rates provided in existing agreements of which notice has been given to the administering office; accrue excess remuneration without first obtaining an agreement subordinating it to all claims of the Government; or employ any person at a rate of compensation over $ [ ] a year;

(9) Change substantially the management, ownership, or control of the corporation;

(10) Merge or consolidate with any other firm or corporation, change the type of business, or engage in any transaction outside the ordinary course of the Contractor's business as presently conducted;

(11) Deposit any of its funds except in a bank or trust company insured by the Federal Deposit Insurance Corporation or a credit union insured by the National Credit Union Administration;

(12) Create or incur indebtedness for advances, other than advances to be made under the terms of this contract, or for borrowings;

(13) Make or covenant for capital expenditures exceeding $ [ ] in total;

(14) Permit its net current assets, computed in accordance with generally accepted accounting principles, to become less than $[ ]; or

(15) Make any payments on account of the obligations listed below, except in the manner and to the extent provided in this contract:

[*List the pertinent obligations*]

(End of clause)

52.232-12 Advance Payments. (MAY 2001) - Alternate V (MAY 2001)

ADVANCE PAYMENTS WITHOUT SPECIAL BANK ACCOUNT (MAY 1999)

(a) *Requirements for payment.* Advance payments will be made under this contract (1) upon submission of properly certified invoices or vouchers by the contractor, and approval by the administering office, [*insert the name of the office designated under agency procedures*], or (2) under a letter of credit. The amount of the invoice or voucher submitted plus all advance payments previously approved shall not exceed $[ ]. If a letter of credit is used, the Contractor shall withdraw cash only when needed for disbursements acceptable under this contract and report cash disbursements and balances as required by the administering office. The Contractor shall apply terms similar to this clause to any advance payments to subcontractors.

(b) *Use of funds.* The Contractor may use advance payment funds only to pay for properly allocable, allowable, and reasonable costs for direct materials, direct labor, and indirect costs. Determinations of whether costs are properly allocable, allowable, and reasonable shall be in accordance with generally accepted accounting principles, subject to any applicable subparts of Part 31 of the Federal Acquisition Regulation.

(c) *Repayment to the Government.* At any time, the Contractor may repay all or any part of the funds advanced by the Government. Whenever requested in writing to do so by the administering office, the Contractor shall repay to the Government any part of unliquidated advance payments considered by the administering office to exceed the Contractor's current requirements or the amount specified in paragraph (a) of this clause.

(d) Maximum payment. When the sum of all unliquidated advance payments, unpaid interest charges, and other payments exceed [ ] percent of the contract price, the Government shall withhold further payments to the Contractor.

On completion or termination of the contract, the Government shall deduct from the amount due to the Contractor all unliquidated advance payments and all interest charges payable. If previous payments to the Contractor exceed the amount due, the excess amount shall be paid to the Government on demand. For purposes of this paragraph, the contract price shall be considered to be the stated contract price of $[ ], less any subsequent price reductions under the contract, plus (1) any price increases resulting from any terms of this contract for price redetermination or escalation, and (2) any other price increases that do not, in the aggregate, exceed $[*insert an amount not higher than 10 percent of the stated contract amount inserted in this paragraph*]. Any payments withheld under this paragraph shall be applied to reduce the unliquidated advance payments. If full liquidation has been made, payments under the contract shall resume.

(e) *Interest*. (1) The Contractor shall pay interest to the Government on the daily unliquidated advance payments at the daily rate in subparagraph (e)(3) of this clause. Interest shall be computed at the end of each calendar month for the actual number of days involved. For the purpose of computing the interest charge -

(i) Advance payments shall be considered as increasing the unliquidated balance as of the date of the advance payment check;

(ii) Repayments by Contractor check shall be considered as decreasing the unliquidated balance as of the date on which the check is received by the Government authority designated by the Contracting Officer; and

(iii) Liquidations by deductions from Government payments to the Contractor shall be considered as decreasing the unliquidated balance as of the date of the check for the reduced payment.

(2) Interest charges resulting from the monthly computation shall be deducted from payments, other than advance payments, due the Contractor. If the accrued interest exceeds the payment due, any excess interest shall be carried forward and deducted from subsequent payments. Interest carried forward shall not be compounded. Interest on advance payments shall cease to accrue upon satisfactory completion or termination of the contract for the convenience of the Government. The Contractor shall charge interest on advance payments to subcontractors in the manner described above and credit the interest to the Government. Interest need not be charged on advance payments to nonprofit educational or research subcontractors, for experimental, developmental, or research work.

(3) If interest is required under the contract, the Contracting Officer shall determine a daily interest rate based on the rate established by the Secretary of the Treasury under Pub. L. 92-41 (50 U.S.C. App., 1215(b)(2)). The Contracting Officer shall revise the daily interest rate during the contract period in keeping with any changes in the cited interest rate.

(4) If the full amount of interest charged under this paragraph has not been paid by deduction or otherwise upon completion or termination of this contract, the Contractor shall pay the remaining interest to the Government on demand.

(f) *Lien on property under contract*. (1) All advance payments under this contract, together with interest charges, shall be secured, when made, by a lien in favor of the Government, paramount to all other liens, on the supplies or other things covered by this contract and on all material and other property acquired for or allocated to the performance of this contract, except to the extent that the Government by virtue of any other terms of this contract, or otherwise, shall have valid title to the supplies, materials, or other property as against other creditors of the Contractor.

(2) The Contractor shall identify, by marking or segregation, all property that is subject to a lien in favor of the Government by virtue of any terms of this contract in such a way as to indicate that it is subject to a lien and that it has been acquired for or allocated to performing this contract. If, for any reason, the supplies, materials, or other property are not identified by marking or segregation, the Government shall be considered to have a lien to the extent of the Government's interest under this contract on any mass of property with which the supplies, materials,

or other property are commingled. The Contractor shall maintain adequate accounting control over the property on its books and records.

(3) If, at any time during the progress of the work on the contract, it becomes necessary to deliver to a third person any items or materials on which the Government has a lien, the Contractor shall notify the third person of the lien and shall obtain from the third person a receipt in duplicate acknowledging the existence of the lien. The Contractor shall provide a copy of each receipt to the Contracting Officer.

(4) If, under the termination clause, the Contracting Officer authorizes the contractor to sell or retain termination inventory, the approval shall constitute a release of the Government's lien to the extent that -

(i) The termination inventory is sold or retained; and

(ii) The sale proceeds or retention credits are applied to reduce any outstanding advance payments.

(g) *Insurance*. (1) The Contractor shall maintain with responsible insurance carriers -

(i) Insurance on plant and equipment against fire and other hazards, to the extent that similar properties are usually insured by others operating plants and properties of similar character in the same general locality;

(ii) Adequate insurance against liability on account of damage to persons or property; and

(iii) Adequate insurance under all applicable workers' compensation laws.

(2) Until work under this contract has been completed and all advance payments made under the contract have been liquidated, the Contractor shall -

(i) Maintain this insurance;

(ii) Maintain adequate insurance on any materials, parts, assemblies, subassemblies, supplies, equipment, and other property acquired for or allocable to this contract and subject to the Government lien under paragraph (f) of this clause; and

(iii) Furnish any evidence with respect to its insurance that the administering office may require.

(h) *Default*. (1) If any of the following events occur, the Government may, by written notice to the Contractor, withhold further payments on this contract:

(i) Termination of this contract for a fault of the Contractor.

(ii) A finding by the administering office that the Contractor has failed to -

(A) Observe any of the conditions of the advance payment terms;

(B) Comply with any material term of this contract;

(C) Make progress or maintain a financial condition adequate for performance of this contract;

(D) Limit inventory allocated to this contract to reasonable requirements; or

(E) Avoid delinquency in payment of taxes or of the costs of performing this contract in the ordinary course of business.

(iii) The appointment of a trustee, receiver, or liquidator for all or a substantial part of the Contractor's property, or the institution of proceedings by or against the Contractor for bankruptcy, reorganization, arrangement, or liquidation.

(iv) The commission of an act of bankruptcy.

(2) If any of the events described in subparagraph (h)(1) of this clause continue for 30 days after the written notice to the Contractor, the Government may take any of the following additional actions:

(i) Charge interest, in the manner prescribed in paragraph (e) of this clause, on outstanding advance payments during the period of any event described in subparagraph (h)(1) of this clause.

(ii) Demand immediate repayment by the Contractor of the unliquidated balance of advance payments.

(iii) Take possession of and, with or without advertisement, sell at public or private sale all or any part of the property on which the Government has a lien under this contract and, after deducting any expenses incident to the sale, apply the net proceeds of the sale to reduce the unliquidated balance of advance payments or other Government claims against the Contractor.

(3) The Government may take any of the actions described in subparagraphs (h)(1) and (h)(2) of this clause it considers appropriate at its discretion and without limiting any other rights of the Government.

(i) *Prohibition against assignment*. Notwithstanding any other terms of this contract, the Contractor shall not assign this contract, any interest therein, or any claim under the contract to any party.

(j) *Information and access to records*. The Contractor shall furnish to the administering office (1) monthly or at other intervals as required, signed or certified balance sheets and profit and loss statements, and, (2) if requested, other information concerning the operation of the contractor's business. The Contractor shall provide the authorized Government representatives proper facilities for inspection of the Contractor's books, records, and accounts.

(k) *Other security*. The terms of this contract are considered to provide adequate security to the Government for advance payments; however, if the administering office considers the security inadequate, the Contractor shall furnish additional security satisfactory to the administering office, to the extent that the security is available.

(l) *Representations*. The Contractor represents the following:

(1) The balance sheet, the profit and loss statement, and any other supporting financial statements furnished to the administering office fairly reflect the financial condition of the Contractor at the date shown or the period covered, and there has been no subsequent materially adverse change in the financial condition of the Contractor.

(2) No litigation or proceedings are presently pending or threatened against the Contractor, except as shown in the financial statements.

(3) The Contractor has disclosed all contingent liabilities, except for liability resulting from the renegotiation of defense production contracts, in the financial statements furnished to the administering office.

(4) None of the terms in this clause conflict with the authority under which the Contractor is doing business or with the provision of any existing indenture or agreement of the Contractor.

(5) The Contractor has the power to enter into this contract and accept advance payments, and has taken all necessary action to authorize the acceptance under the terms of this contract.

(6) The assets of the Contractor are not subject to any lien or encumbrance of any character except for current taxes not delinquent, and except as shown in the financial statements furnished by the Contractor. There is no current assignment of claims under any contract affected by these advance payment provisions.

(7) All information furnished by the Contractor to the administering office in connection with each request for advance payments is true and correct.

(8) These representations shall be continuing and shall be considered to have been repeated by the submission of each invoice for advance payments.

(m) *Covenants*. To the extent the Government considers it necessary while any advance payments made under this contract remain outstanding, the Contractor, without the prior written consent of the administering office, shall not -

(1) Mortgage, pledge, or otherwise encumber or allow to be encumbered, any of the assets of the Contractor now owned or subsequently acquired, or permit any preexisting mortgages, liens, or other encumbrances to remain on or attach to any assets of the Contractor which are allocated to performing this contract and with respect to which the Government has a lien under this contract;

(2) Sell, assign, transfer, or otherwise dispose of accounts receivable, notes, or claims for money due or to become due;

(3) Declare or pay any dividends, except dividends payable in stock of the corporation, or make any other distribution on account of any shares of its capital stock, or purchase, redeem, or otherwise acquire for value any of its stock, except as required by sinking fund or redemption arrangements reported to the administering office incident to the establishment of these advance payment provisions;

(4) Sell, convey, or lease all or a substantial part of its assets;

(5) Acquire for value the stock or other securities of any corporation, municipality, or Governmental authority, except direct obligations of the United States;

(6) Make any advance or loan or incur any liability as guarantor, surety, or accommodation endorser for any party;

(7) Permit a writ of attachment or any similar process to be issued against its property without getting a release or bonding the property within 30 days after the entry of the writ of attachment or other process;

(8) Pay any remuneration in any form to its directors, officers, or key employees higher than rates provided in existing agreements of which notice has been given to the administering office, accrue excess remuneration without first obtaining an agreement subordinating it to all claims of the Government, or employ any person at a rate of compensation over $[ ] a year;

(9) Change substantially the management, ownership, or control of the corporation;

(10) Merge or consolidate with any other firm or corporation, change the type of business, or engage in any transaction outside the ordinary course of the Contractor's business as presently conducted;

(11) Deposit any of its funds except in a bank or trust company insured by the Federal Deposit Insurance Corporation or a credit union insured by the National Credit Union Administration;

(12) Create or incur indebtedness for advances, other than advances to be made under the terms of this contract, or for borrowings;

(13) Make or covenant for capital expenditures exceeding $[ ] in total;

(14) Permit its net current assets, computed in accordance with generally accepted accounting principles, to become less than $[ ] ; or

(15) Make any payments on account of the obligations listed below, except in the manner and to the extent provided in this contract:

[*List the pertinent obligations*]

(End of clause)

52.232-23 Assignment of Claims. (JAN 1986)

52.243-1 Changes - Fixed-Price. (AUG 1987) - Alternate V (APR 1984)

52.246-23 Limitation of Liability. (FEB 1997)

52.252-6 Authorized Deviations in Clauses. (APR 1984)

(a) The use in this solicitation or contract of any Federal Acquisition Regulation (48 CFR Chapter 1) clause with an authorized deviation is indicated by the addition of (DEVIATION) after the date of the clause.

(b) The use in this solicitation or contract of any NASA FAR Supplement (48 CFR 18) clause with an authorized deviation is indicated by the addition of (DEVIATION) after the name of the regulation.

(End of clause)

1852.204-76 Security Requirements for Unclassified Information Technology Resources. (MAY 2007)

(a) The Contractor shall be responsible for information and information technology (IT) security when -

(1) The Contractor or its subcontractors must obtain physical or electronic (i.e., authentication level 2 and above as defined in National Institute of Standards and Technology (NIST) Special Publication (SP) 800-63, Electronic Authentication Guideline) access to NASA's computer systems, networks, or IT infrastructure; or

(2) Information categorized as low, moderate, or high by the Federal Information Processing Standards (FIPS) 199, Standards for Security Categorization of Federal Information and Information Systems is stored, generated, processed, or exchanged by NASA or on behalf of NASA by a contractor or subcontractor, regardless of whether the information resides on a NASA or a contractor/subcontractor's information system.

(b) IT Security Requirements.

(1) Within 30 days after contract award, a Contractor shall submit to the Contracting Officer for NASA approval an IT Security Plan, Risk Assessment, and FIPS 199, Standards for Security Categorization of Federal Information and Information Systems, Assessment. These plans and assessments, including annual updates shall be incorporated into the contract as compliance documents.

(i) The IT system security plan shall be prepared consistent, in form and content, with NIST SP 800-18, Guide for Developing Security Plans for Federal Information Systems, and any additions/augmentations described in NASA Procedural Requirements (NPR) 2810, Security of Information Technology. The security plan shall identify and document appropriate IT security controls consistent with the sensitivity of the information and the requirements of Federal Information Processing Standards (FIPS) 200, Recommended Security Controls for Federal Information Systems. The plan shall be reviewed and updated in accordance with NIST SP 800-26, Security Self-Assessment Guide for Information Technology Systems, and FIPS 200, on a yearly basis.

(ii) The risk assessment shall be prepared consistent, in form and content, with NIST SP 800-30, Risk Management Guide for Information Technology Systems, and any additions/augmentations described in NPR 2810. The risk assessment shall be updated on a yearly basis.

(iii) The FIPS 199 assessment shall identify all information types as well as the "high water mark," as defined in FIPS 199, of the processed, stored, or transmitted information necessary to fulfill the contractual requirements.

(2) The Contractor shall produce contingency plans consistent, in form and content, with NIST SP 800-34, Contingency Planning Guide for Information Technology Systems, and any additions/augmentations described in NPR 2810. The Contractor shall perform yearly "Classroom Exercises." "Functional Exercises," shall be coordinated with the Center CIOs and be conducted once every three years, with the first conducted within the first two years of contract award. These exercises are defined and described in NIST SP 800-34.

(3) The Contractor shall ensure coordination of its incident response team with the NASA Incident Response Center (NASIRC) and the NASA Security Operations Center, ensuring that incidents are reported consistent with NIST SP 800-61, Computer Security Incident Reporting Guide, and the United States Computer Emergency Readiness Team's (US-CERT) Concept of Operations for reporting security incidents. Specifically, any confirmed incident of a system containing NASA data or controlling NASA assets shall be reported to NASIRC within one hour that results in unauthorized access, loss or modification of NASA data, or denial of service affecting the availability of NASA data.

(4) The Contractor shall ensure that its employees, in performance of the contract, receive annual IT security training in NASA IT Security policies, procedures, computer ethics, and best practices in accordance with NPR 2810 requirements. The Contractor may use web-based training available from NASA to meet this requirement.

(5) The Contractor shall provide NASA, including the NASA Office of Inspector General, access to the Contractor's and subcontractors' facilities, installations, operations, documentation, databases, and personnel used in performance of the contract. Access shall be provided to the extent required to carry out IT security inspection, investigation, and/or audits to safeguard against threats and hazards to the integrity, availability, and confidentiality of NASA information or to the function of computer systems operated on behalf of NASA, and to preserve evidence of computer crime. To facilitate mandatory reviews, the Contractor shall ensure appropriate compartmentalization of NASA information, stored and/or processed, either by information systems in direct support of the contract or that are incidental to the contract.

(6) The Contractor shall ensure that system administrators who perform tasks that have a material impact on IT security and operations demonstrate knowledge appropriate to those tasks. Knowledge is demonstrated through the NASA System Administrator Security Certification Program. A system administrator is one who provides IT services (including network services, file storage, and/or web services) to someone other than themselves and takes or assumes the responsibility for the security and administrative controls of that service. Within 30 days after contract award, the Contractor shall provide to the Contracting Officer a list of all system administrator positions and personnel filling those positions, along with a schedule that ensures certification of all personnel within 90 days after contract award. Additionally, the Contractor should report all personnel changes which impact system administrator positions within 5 days of the personnel change and ensure these individuals obtain System Administrator certification within 90 days after the change.

(7) The Contractor shall ensure that NASA's Sensitive But Unclassified (SBU) information as defined in NPR 1600.1, NASA Security Program Procedural Requirements, which includes privacy information, is encrypted in

storage and transmission.

(8) When the Contractor is located at a NASA Center or installation or is using NASA IP address space, the Contractor shall -

(i) Submit requests for non-NASA provided external Internet connections to the Contracting Officer for approval by the Network Security Configuration Control Board (NSCCB);

(ii) Comply with the NASA CIO metrics including patch management, operating systems and application configuration guidelines, vulnerability scanning, incident reporting, system administrator certification, and security training; and

(iii) Utilize the NASA Public Key Infrastructure (PKI) for all encrypted communication or non-repudiation requirements within NASA when secure email capability is required.

(c) Physical and Logical Access Requirements.

(1) Contractor personnel requiring access to IT systems operated by the Contractor for NASA or interconnected to a NASA network shall be screened at an appropriate level in accordance with NPR 2810 and Chapter 4, NPR 1600.1, NASA Security Program Procedural Requirements. NASA shall provide screening, appropriate to the highest risk level, of the IT systems and information accessed, using, as a minimum, National Agency Check with Inquiries (NACI). The Contractor shall submit the required forms to the NASA Center Chief of Security (CCS) within fourteen (14) days after contract award or assignment of an individual to a position requiring screening. The forms may be obtained from the CCS. At the option of NASA, interim access may be granted pending completion of the required investigation and final access determination. For Contractors who will reside on a NASA Center or installation, the security screening required for all required access (e.g., installation, facility, IT, information, etc.) is consolidated to ensure only one investigation is conducted based on the highest risk level. Contractors not residing on a NASA installation will be screened based on their IT access risk level determination only. See NPR 1600.1, Chapter 4.

(2) Guidance for selecting the appropriate level of screening is based on the risk of adverse impact to NASA missions. NASA defines three levels of risk for which screening is required (IT-1 has the highest level of risk).

(i) IT-1 - Individuals having privileged access or limited privileged access to systems whose misuse can cause very serious adverse impact to NASA missions. These systems include, for example, those that can transmit commands directly modifying the behavior of spacecraft, satellites or aircraft.

(ii) IT-2 - Individuals having privileged access or limited privileged access to systems whose misuse can cause serious adverse impact to NASA missions. These systems include, for example, those that can transmit commands directly modifying the behavior of payloads on spacecraft, satellites or aircraft; and those that contain the primary copy of "level 1" information whose cost to replace exceeds one million dollars.

(iii) IT-3 - Individuals having privileged access or limited privileged access to systems whose misuse can cause significant adverse impact to NASA missions. These systems include, for example, those that interconnect with a NASA network in a way that exceeds access by the general public, such as bypassing firewalls; and systems operated by the Contractor for NASA whose function or information has substantial cost to replace, even if these systems are not interconnected with a NASA network.

(3) Screening for individuals shall employ forms appropriate for the level of risk as established in Chapter 4, NPR 1600.1.

(4) The Contractor may conduct its own screening of individuals requiring privileged access or limited privileged

access provided the Contractor can demonstrate to the Contracting Officer that the procedures used by the Contractor are equivalent to NASA's personnel screening procedures for the risk level assigned for the IT position.

(5) Subject to approval of the Contracting Officer, the Contractor may forgo screening of Contractor personnel for those individuals who have proof of a -

(i) Current or recent national security clearances (within last three years);

(ii) Screening conducted by NASA within the last three years that meets or exceeds the screening requirements of the IT position; or

(iii) Screening conducted by the Contractor, within the last three years, that is equivalent to the NASA personnel screening procedures as approved by the Contracting Officer and concurred on by the CCS.

(d) The Contracting Officer may waive the requirements of paragraphs (b) and (c) (1) through (c) (3) upon request of the Contractor. The Contractor shall provide all relevant information requested by the Contracting Officer to support the waiver request.

(e) The Contractor shall contact the Contracting Officer for any documents, information, or forms necessary to comply with the requirements of this clause.

(f) At the completion of the contract, the contractor shall return all NASA information and IT resources provided to the contractor during the performance of the contract and certify that all NASA information has been purged from contractor-owned systems used in the performance of the contract.

(g) The Contractor shall insert this clause, including this paragraph (g), in all subcontracts:

(1) Have physical or electronic access to NASA's computer systems, networks, or IT infrastructure; or

(2) Use information systems to generate, store, process, or exchange data with NASA or on behalf of NASA, regardless of whether the data resides on a NASA or a contractor's information system.

(End of clause)

1852.215-84 Ombudsman. (OCT 2003)

(a) An ombudsman has been appointed to hear and facilitate the resolution of concerns from offerors, potential offerors, and contractors during the preaward and postaward phases of this acquisition. When requested, the ombudsman will maintain strict confidentiality as to the source of the concern. The existence of the ombudsman is not to diminish the authority of the contracting officer, the Source Evaluation Board, or the selection official. Further, the ombudsman does not participate in the evaluation of proposals, the source selection process, or the adjudication of formal contract disputes. Therefore, before consulting with an ombudsman, interested parties must first address their concerns, issues, disagreements, and/or recommendations to the contracting officer for resolution.

(b) If resolution cannot be made by the contracting officer, interested parties may contact the installation ombudsman, Rebecca S. Dubuisson, NASA Shared Services Center, rebecca.s.dubuisson@nasa.gov. Concerns, issues, disagreements, and recommendations which cannot be resolved at the installation may be referred to the NASA ombudsman, James A. Balinskas, the Director of the Contract Management Division, at 202-358-0445, facsimile 202-358-3083, e-mail james.a.balinskas@nasa.gov . Please do not contact the ombudsman to request copies of the solicitation, verify offer due date, or clarify technical requirements. Such inquiries shall be directed to the Contracting Officer or as specified elsewhere in this document.

(End of clause)

1852.219-76 NASA 8 Percent Goal. (JUL 1997)

(a) Definitions.

"Historically Black Colleges or University," as used in this clause, means an institution determined by the Secretary of Education to meet the requirements of 34 CFR Section 608.2. The term also includes any nonprofit research institution that was an integral part of such a college or university before November 14, 1986.

"Minority institutions," as used in this clause, means an institution of higher education meeting the requirements of section 1046(3) of the Higher Education Act of 1965 (20 U.S.C. 1135d-5(3)) which for the purposes of this clause includes a Hispanic-serving institution of higher education as defined in section 316(b)(1) of the Act (20 U.S.C. 1059c(b)(1)).

"Small disadvantaged business concern," as used in this clause, means a small business concern that (1) is at least 51 percent unconditionally owned by one or more individuals who are both socially and economically disadvantaged, or a publicly owned business having at least 51 percent of its stock unconditionally owned by one or more socially and economically disadvantaged individuals, and (2) has its management and daily business controlled by one or more such individuals. This term also means a small business concern that is at least 51 percent unconditionally owned by an economically disadvantaged Indian tribe or Native Hawaiian Organization, or a publicly owned business having at least 51 percent of its stock unconditionally owned by one or more of these entities, which has its management and daily business controlled by members of an economically disadvantaged Indian tribe or Native Hawaiian Organization, and which meets the requirements of 13 CFR 124.

"Women-owned small business concern," as used in this clause, means a small business concern (1) which is at least 51 percent owned by one or more women or, in the case of any publicly owned business, at least 51 percent of the stock of which is owned by one or more women, and (2) whose management and daily business operations are controlled by one or more women.

(b) The NASA Administrator is required by statute to establish annually a goal to make available to small disadvantaged business concerns, Historically Black Colleges and Universities, minority institutions, and women-owned small business concerns, at least 8 percent of NASA's procurement dollars under prime contracts or subcontracts awarded in support of authorized programs, including the space station by the time operational status is obtained.

(c) The contractor hereby agrees to assist NASA in achieving this goal by using its best efforts to award subcontracts to such entities to the fullest extent consistent with efficient contract performance.

(d) Contractors acting in good faith may rely on written representations by their subcontractors regarding their status as small disadvantaged business concerns, Historically Black Colleges and Universities, minority institutions, and women-owned small business concerns.

(End of clause)

1852.219-80 Limitation on Subcontracting - SBIR Phase I Program. (OCT 2006)

1852.219-83 Limitation of the Principal Investigator - SBIR Program. (OCT 2006)

The primary employment of the principal investigator (PI) shall be with the small business concern (SBC)/Contractor during the conduct of this contract. Primary employment means that more than one-half of the principal investigator's time is spent in the employ of the SBC/Contractor. This precludes full-time employment with another organization. Deviations from these requirements must be approved in advance and in writing by the

Contracting Officer and are not subject to a change in the firm-fixed price of the contract. The PI for this contract is [*insert name*].

(End of clause)

1852.219-85 Conditions for Final Payment - SBIR and STTR Contracts. (OCT 2006)

1852.232-70 NASA Modification of FAR 52.232-12. (MAR 1998)

(a) Basic Clause. (1) In paragraph (e), Maximum Payment, in the sentence that begins "When the sum of," change the word "When" to lower case and insert before it: "Unliquidated advance payments shall not exceed $[ ] at any time outstanding. In addition.…"

(2) In paragraph (m) (1), delete "in the form prescribed by the administering office" and substitute "and Standard Form 272, Federal Cash Transactions Report, and, if appropriate, Standard Form 272-A, Federal Cash Transactions Report Continuation."

(b) Alternate II (if incorporated in the contract). In paragraph (e), Maximum Payment, in the sentence that begins "When the sum of," change the word "When" to lower case and insert before it: "Unliquidated advance payments shall not exceed $[ ] at any time outstanding. In addition.…"

(c) Alternate V (if incorporated in the contract). (1) Substitute the following for paragraph (b) : "(b) Use of funds. The Contractor may use advance payment funds only to pay for properly allocable, allowable, and reasonable costs for direct materials, direct labor, indirect costs, or such other costs approved in writing by the administering contracting office. Payments are subject to any restrictions in other clauses of this contract. Determinations of whether costs are properly allocable, allowable, and reasonable shall be in accordance with generally accepted accounting principles, subject to any applicable subparts of Part 31 of the Federal Acquisition Regulation, other applicable regulations referenced in Part 31, or Subpart 1831.2."

(2) In paragraph (d), Maximum Payment, in the sentence that begins "When the sum of," change the word "When" to lower case and insert before it: "Unliquidated advance payments shall not exceed $[ ] at any time outstanding. In addition.…"

(3) In paragraph (j) (1), insert between "Statements," and "and" "together with Standard Form 272, Federal Cash Transactions Report, and, if appropriate, Standard Form 272-A, Federal Cash Transactions Report Continuation"

(4) If this is a Phase I contract awarded under the SBIR or STTR programs, delete paragraph (a) and substitute the following: "(a) Requirements for payment. Advance payments will be made under this contract upon receipt of invoices from the Contractor. Invoices should be clearly marked "Small Business Innovation Research Contract" or "Small Business Technology Transfer Contract," as appropriate, to expedite payment processing. One-third of the total contract price will be available to be advanced to the contractor immediately after award, another one-third will be advanced three months after award, and the final one-third will be paid upon acceptance by NASA of the Contractor's final report. By law, full payment must be made no later than 12 months after the date that contract requirements are completed. The Contractor shall flow down the terms of this clause to any subcontractor requiring advance payments."

(End of clause)

1852.235-70 Center for AeroSpace Information. (DEC 2006)

1852.237-72 Access to Sensitive Information. (JUN 2005)

(a) As used in this clause, ``sensitive information" refers to information that a contractor has developed at private expense, or that the Government has generated that qualifies for an exception to the Freedom of Information Act, which is not currently in the public domain, and which may embody trade secrets or commercial or financial information, and which may be sensitive or privileged.

(b) To assist NASA in accomplishing management activities and administrative functions, the Contractor shall provide the services specified elsewhere in this contract.

(c) If performing this contract entails access to sensitive information, as defined above, the Contractor agrees to--

(1) Utilize any sensitive information coming into its possession only for the purposes of performing the services specified in this contract, and not to improve its own competitive position in another procurement.

(2) Safeguard sensitive information coming into its possession from unauthorized use and disclosure.

(3) Allow access to sensitive information only to those employees that need it to perform services under this contract.

(4) Preclude access and disclosure of sensitive information to persons and entities outside of the Contractor's organization.

(5) Train employees who may require access to sensitive information about their obligations to utilize it only to perform the services specified in this contract and to safeguard it from unauthorized use and disclosure.

(6) Obtain a written affirmation from each employee that he/she has received and will comply with training on the authorized uses and mandatory protections of sensitive information needed in performing this contract.

(7) Administer a monitoring process to ensure that employees comply with all reasonable security procedures, report any breaches to the Contracting Officer, and implement any necessary corrective actions.

(d) The Contractor will comply with all procedures and obligations specified in its Organizational Conflicts of Interest Avoidance Plan, which this contract incorporates as a compliance document.

(e) The nature of the work on this contract may subject the Contractor and its employees to a variety of laws and regulations relating to ethics, conflicts of interest, corruption, and other criminal or civil matters relating to the award and administration of government contracts. Recognizing that this contract establishes a high standard of accountability and trust, the Government will carefully review the Contractor's performance in relation to the mandates and restrictions found in these laws and regulations. Unauthorized uses or disclosures of sensitive information may result in termination of this contract for default, or in debarment of the Contractor for serious misconduct affecting present responsibility as a government contractor.

(f) The Contractor shall include the substance of this clause, including this paragraph (f), suitably modified to reflect the relationship of the parties, in all subcontracts that may involve access to sensitive information

(End of clause)

1852.237-73 Release of Sensitive Information. (JUN 2005)

(a) As used in this clause, "Sensitive information" refers to information, not currently in the public domain, that the Contractor has developed at private expense, that may embody trade secrets or commercial or financial information, and that may be sensitive or privileged.

(b) In accomplishing management activities and administrative functions, NASA relies heavily on the support of various service providers. To support NASA activities and functions, these service providers, as well as their subcontractors and their individual employees, may need access to sensitive information submitted by the Contractor under this contract. By submitting this proposal or performing this contract, the Contractor agrees that NASA may release to its service providers, their subcontractors, and their individual employees, sensitive information submitted during the course of this procurement, subject to the enumerated protections mandated by the clause at 1852.237-72, Access to Sensitive Information.

(c) (1) The Contractor shall identify any sensitive information submitted in support of this proposal or in performing this contract. For purposes of identifying sensitive information, the Contractor may, in addition to any other notice or legend otherwise required, use a notice similar to the following:

Mark the title page with the following legend:

This proposal or document includes sensitive information that NASA shall not disclose outside the Agency and its service providers that support management activities and administrative functions. To gain access to this sensitive information, a service provider's contract must contain the clause at NFS 1852.237-72, Access to Sensitive Information. Consistent with this clause, the service provider shall not duplicate, use, or disclose the information in whole or in part for any purpose other than to perform the services specified in its contract. This restriction does not limit the Government's right to use this information if it is obtained from another source without restriction. The information subject to this restriction is contained in pages [*insert page numbers or other identification of pages*]. Mark each page of sensitive information the Contractor wishes to restrict with the following legend:

Use or disclosure of sensitive information contained on this page is subject to the restriction on the title page of this proposal or document.

(2) The Contracting Officer shall evaluate the facts supporting any claim that particular information is "sensitive." This evaluation shall consider the time and resources necessary to protect the information in accordance with the detailed safeguards mandated by the clause at 1852.237-72, Access to Sensitive Information. However, unless the Contracting Officer decides, with the advice of Center counsel, that reasonable grounds exist to challenge the Contractor's claim that particular information is sensitive, NASA and its service providers and their employees shall comply with all of the safeguards contained in paragraph (d) of this clause.

(d) To receive access to sensitive information needed to assist NASA in accomplishing management activities and administrative functions, the service provider must be operating under a contract that contains the clause at 1852.237-72, Access to Sensitive Information. This clause obligates the service provider to do the following:

(1) Comply with all specified procedures and obligations, including the Organizational Conflicts of Interest Avoidance Plan, which the contract has incorporated as a compliance document.

(2) Utilize any sensitive information coming into its possession only for the purpose of performing the services specified in its contract.

(3) Safeguard sensitive information coming into its possession from unauthorized use and disclosure.

(4) Allow access to sensitive information only to those employees that need it to perform services under its contract.

(5) Preclude access and disclosure of sensitive information to persons and entities outside of the service provider's organization.

(6) Train employees who may require access to sensitive information about their obligations to utilize it only to perform the services specified in its contract and to safeguard it from unauthorized use and disclosure.

(7) Obtain a written affirmation from each employee that he/she has received and will comply with training on the authorized uses and mandatory protections of sensitive information needed in performing this contract.

(8) Administer a monitoring process to ensure that employees comply with all reasonable security procedures, report any breaches to the Contracting Officer, and implement any necessary corrective actions.

(e) When the service provider will have primary responsibility for operating an information technology system for NASA that contains sensitive information, the service provider's contract shall include the clause at 1852.204-76, Security Requirements for Unclassified Information Technology Resources. The Security Requirements clause requires the service provider to implement an Information Technology Security Plan to protect information processed, stored, or transmitted from unauthorized access, alteration, disclosure, or use. Service provider personnel requiring privileged access or limited privileged access to these information technology systems are subject to screening using the standard National Agency Check (NAC) forms appropriate to the level of risk for adverse impact to NASA missions. The Contracting Officer may allow the service provider to conduct its own screening, provided the service provider employs substantially equivalent screening procedures.

(f) This clause does not affect NASA's responsibilities under the Freedom of Information Act.

(g) The Contractor shall insert this clause, including this paragraph (g), suitably modified to reflect the relationship of the parties, in all subcontracts that may require the furnishing of sensitive information.

(End of clause)

LIST OF ATTACHMENTS

LIST OF ATTACHMENTS

The following documents are attached hereto and made a part of this contract:

[*Insert a table that identifies each contract Attachment (contract documents, exhibits, etc.), the Date of the attachment, and the Number of Pages for each attachment.*]

(End of Clause)

Appendix F: STTR Phase 2 Model Contract

SUPPLIES OR SERVICES AND PRICES/COSTS

1852.216-78 Firm Fixed Price. (DEC 1988)

The total firm fixed price of this contract is $[*Insert the appropriate amount*].

(End of clause)

SUPPLIES AND/OR SERVICES TO BE PROVIDED

The Contractor shall provide all resources (except as may be expressly stated in the contract as furnished by the Government) necessary to deliver and/or perform the items below in accordance with the Description/Specifications/Statement of Work incorporated [*insert attachment number and/or section identifier of the Spec/SOW*].

[*data item deliverable table*]

(End of clause)

DESCRIPTION/SPECIFICATIONS/STATEMENT OF WORK

SPECIFICATION/STATEMENT OF WORK

The Contractor shall provide the item or services specified in Section B in accordance with the following:

[*Insert the Title of the Specification and/or Statement of Work*]

(End of text)

INSPECTION AND ACCEPTANCE

52.246-7 Inspection of Research and Development - Fixed-Price. (AUG 1996)

52.246-16 Responsibility for Supplies. (APR 1984)

1852.246-72 Material Inspection and Receiving Report. (AUG 2003)

(a) At the time of each delivery to the Government under this contract, the Contractor shall furnish a Material Inspection and Receiving Report (DD Form 250 series) prepared in [*Insert number of copies, including original*] copies, an original and [ ] copies (Insert number of copies).

(b) The Contractor shall prepare the DD Form 250 in accordance with NASA FAR Supplement 1846.6. The Contractor shall enclose the copies of the DD Form 250 in the package or seal them in a waterproof envelope, which shall be securely attached to the exterior of the package in the most protected location.

(c) When more than one package is involved in a shipment, the Contractor shall list on the DD Form 250, as additional information, the quantity of packages and the package numbers. The Contractor shall forward the DD Form 250 with the lowest numbered package of the shipment and print the words "CONTAINS DD FORM 250" on the package.

(End of clause)

DELIVERIES OR PERFORMANCE

52.242-15 Stop-Work Order. (AUG 1989)

52.247-34 F.o.b. Destination. (NOV 1991)

PERIOD OF PERFORMANCE

The period of performance of this contract is [*Insert specific dates (i.e. "from___ to ___") or the negotiated period in terms of weeks, months, or years (ex: "12 months from the effective date of the contract").*]

(End of clause)

DELIVERY AND/OR COMPLETION SCHEDULE

The Contractor shall deliver and/or complete performance of the items required under this contract as follows:

[*Insert a table which details for each item, the item number, description, quantity, unit of measure, and delivery/completion date.*]

(End of clause)

ADDITIONAL INFORMATION ON REPORTS OF WORK - SBIR/STTR Phase II

(a) Interim Technical Progress Reports. (1) At the end of every third month of contract performance (quarterly), the Contractor shall submit an interim progress report of all work accomplished. The report shall be in narrative form, be brief, and informal. This report shall include --

(i) A quantitative description of work performed during the period;

(ii) An indication of any current problems which may impede performance or impact program schedule or cost, and proposed corrective action;

(iii) A discussion of the work to be performed during the next reporting period;

(iv) Description of any changes to the planned use of subcontractors since contract award; and

(v) Estimated percentage of physical completion of the contract.

This report shall be submitted via the NASA SBIR Electronic Contract Administration Handbook. Instructions for the electronic submission process are available to contractors on the NASA SBIR home page at http://sbir.nasa.gov.

(2) Interim Technical Progress Reports are to be submitted within (10) days following the period to be reported, except for the Final report which shall be submitted no later than the final day of the contract performance period.

(b) Final Report, Project Summary Document & Project Summary Chart. The Contractor shall submit a Final Report within twenty four (24) months from the effective date of this contract. The report shall be in narrative form documenting and summarizing the results of the entire contract work. The following instructions apply to the final report and are in addition to the requirements of the "Final Scientific and Technical Reports" clause of this contract.

(1) The Final Report shall include both a single-page project summary as the first page, identifying the purpose of the research, a brief description of the research carried out and the research findings or results, and a "Final Phase

2 Summary Chart." The project summaries are to be submitted without restriction for NASA publication. These documents should not contain any proprietary data and should be submitted without any restrictive markings. Instructions for the electronic submission of the project summary and a sample of the Summary Chart are posted on the NASA SBIR Electronic Contract Administration Handbook located in the NASA SBIR/STTR Forms Library.

(2) The project summary and the final summary chart shall be submitted with each copy of the final report and as a separate electronic submission via the NASA SBIR Electronic Contract Administration Handbook.

(3) The balance of the report should indicate in detail the project objectives, work carried out, results obtained, and assessment of technical feasibility. The potential applications of the project results in Phase III both for NASA purposes and for commercial purposes shall also be included. Rights to both interim and final report data (except for the project summary) shall be in accordance with clause 52.227-20, Rights in Data -- SBIR Program, of this contract. The Contractor shall mark all pages of reports (except the project summary described above) with the SBIR Rights Notice set forth in clause 52.227-20.

(c) The final report shall also serve as the last interim report.

(d) Report Documentation Page. The Contractor shall include a completed Report Documentation Page (Standard Form 298) as the final page of the each report submitted in paragraphs (a) and (b) of this clause.

(e) Reports Distribution. Reports shall be distributed electronically to the recipients designated below in accordance with instructions posted on the NASA SBIR Home Page at http://sbir.nasa.gov. In addition to the electronic submission of the final report, one paper copy (reproducible) plus one copy of the final report on a Compact Disc (CD) shall be sent to the contracting officer's representative (COTR). The paper copy and CD sent to NASA shall be marked for the attention of the COTR and addressed in accordance with the shipping instructions provided in the Delivery Schedule of this contract. New Technology reporting should be handled in accordance with the New Technology Reporting clause of this contract.

	Interim	Final
Procurement Contract Administrator	1*	1*
Center SBIR Program Manager	0	1*
COTR	1*	3**
NASA Center for Aerospace Information (CASI)	0	2***

*Electronic copy via NASA's SBIR Electronic Handbook
**Electronic copy, plus one paper copy (reproducible) plus one CD. All graphics must be included.
***One paper copy (reproducible) plus one CD. All graphics must be included. NOTE: Only unclassified reports shall be submitted to the CASI.

(End of clause)

CONTRACT ADMINISTRATION DATA

1852.227-11 Patent Rights - Retention by the Contractor (Short Form).

1852.227-72 Designation of New Technology Representative and Patent Representative. (JUL 1997)

(a) For purposes of administration of the clause of this contract entitled "New Technology" or "Patent Rights - Retention by the Contractor (Short Form)," whichever is included, the following named representatives are hereby designated by the Contracting Officer to administer such clause:

Title
[ ]

Office Code
[ ]
Address (including zip code)
[ ]
New Technology Representative
[ ]
Patent Representative
[ ]

(b) Reports of reportable items, and disclosure of subject inventions, interim reports, final reports, utilization reports, and other reports required by the clause, as well as any correspondence with respect to such matters, should be directed to the New Technology Representative unless transmitted in response to correspondence or request from the Patent Representative. Inquires or requests regarding disposition of rights, election of rights, or related matters should be directed to the Patent Representative. This clause shall be included in any subcontract hereunder requiring a "New Technology" clause or "Patent Rights - Retention by the Contractor (Short Form)" clause, unless otherwise authorized or directed by the Contracting Officer. The respective responsibilities and authorities of the above-named representatives are set forth in 1827.305-370 of the NASA FAR Supplement.

(End of clause)

1852.245-70 Contractor Requests for Government-Provided Property. (DEVIATION) (SEP 2007)

(a) The Contractor shall provide all property required for the performance of this contract. The Contractor shall not acquire or construct items of property to which the Government will have title under the provisions of this contract without the Contracting Officer's written authorization. Property which will be acquired as a deliverable end item as material or as a component for incorporation into a deliverable end item is exempt from this requirement.

(b)(1) In the event the Contractor is unable to provide the property necessary for performance, and the Contractor requests provision of property by the Government, the Contractor's request shall--

(i) Justify the need for the property;

(ii) Provide the reasons why contractor-owned property cannot be used;

(iii) Describe the property in sufficient detail to enable the Government to screen its inventories for available property or to otherwise acquire property, including applicable manufacturer, model, part, catalog, National Stock Number or other pertinent identifiers;

(iv) Combine requests for quantities of items with identical descriptions and estimated values when the estimated values do not exceed $100,000 per unit; and

(v) Include only a single unit when the acquisition or construction value equals or exceeds $100,000.

(2) Contracting Officer authorization is required for items the Contractor intends to manufacture as well as those it intends to purchase.

(3) The Contractor shall submit requests to the Contracting Officer no less than 30 days in advance of the date the Contractor would, should it receive authorization, acquire or begin fabrication of the item.

(c) The Contractor shall maintain copies of Contracting Officer authorizations, appropriately cross-referenced to the individual property record, within its property management system.

(d) Property furnished from Government excess sources is provided as-is, where-is. The Government makes no warranty regarding its applicability for performance of the contract or its ability to operate. Failure of property obtained from Government excess sources under this clause is insufficient reason for submission of requests for equitable adjustments discussed in the clause at 52.245-1, Government Property.

(End of clause)

SECTION G CONTRACT SPECIFIC ADDITIONAL CLAUSE ONE

INVOICES

Contractor shall submit one (1) copy of each invoice electronically through the Electronic Handbook; no other copies or actions are required. All invoices submitted by the SBC shall be marked with the contract number and invoice number. Hard copies of reports or invoices are not required. Failure to comply with requirements stipulated herein will delay payment.

Payment of invoices will be based upon acceptance and approval of each deliverable by the COTR and CO. Payment may be withheld if the required deliverables have not been properly submitted or accepted by the COTR. All reports and invoices shall be submitted by uploading one (1) copy into the Electronic Handbook (https://sbir.gsfc.nasa.gov/sbir/contract-admin/). The only exception to this requirement is that a copy of the New Technology Report and/or New Technology Summary Report shall be uploaded into the Electronic Handbook AND a copy shall be submitted using the eNTRe reporting system http://invention.nasa.gov/ .

(End of clause)

SECTION G CONTRACT SPECIFIC ADDITIONAL CLAUSE TWO

PHASE II - E OPTION

On active Phase II awards, NASA may execute the option to fund a limited number of Phase II awardees for "Phase II Enhancement" (Phase II-E) to encourage transition of SBIR/STTR projects into NASA programs and projects. The objective of the Phase II-E Option is to serve as an incentive to Phase III awards through providing cost share extension of the R&D efforts to the current Phase II contract. to meet the product/process/software requirements of a NASA program/project or third party investor to accelerate and/or enhance the infusion/commercial potential of the Phase II project, moving it into Phase III. Under this option, NASA will match with SBIR/STTR funds up to $150,000 of non-SBIR/non-STTR investment from a NASA project, NASA contractor, or third party commercial investor to extend an eXisting Phase II project for up to 4 months to perform additional research. The total cumulative award for the Phase II contract plus the Phase II-E match will not exceed $750,000.00 of SBIR/STTR funding. The Non-SBIR contribution is not limited since it is regulated under the guidelines for Phase III award.

(End of clause)

SPECIAL CONTRACT REQUIREMENTS

1852.223-72 Safety and Health (Short Form). (APR 2002)

1852.223-75 Major Breach of Safety or Security. (FEB 2002)

1852.225-70 Export Licenses. (FEB 2000)

(a) The Contractor shall comply with all U.S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this contract. In the absence of available license exemptions/exceptions, the Contractor shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of hardware, technical data, and software, or for the provision of technical assistance.

(b) The Contractor shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of this contract, including instances where the work is to be performed on-site at [*insert name of NASA installation*], where the foreign person will have access to export-controlled technical data or software.

(c) The Contractor shall be responsible for all regulatory record keeping requirements associated with the use of licenses and license exemptions/exceptions.

(d) The Contractor shall be responsible for ensuring that the provisions of this clause apply to its subcontractors.

(End of clause)

1852.232-77 Limitation of Funds (Fixed- Price Contract). (MAR 1989)

(a) Of the total price of items [ ] through [ ], the sum of $[ ] is presently available for payment and allotted to this contract. It is anticipated that from time to time additional funds will be allocated to the contract in accordance with the following schedule, until the total price of said items is allotted:

SCHEDULE FOR ALLOTMENT OF FUNDS

Date	Amounts
[ ]	[ ]

(b) The Contractor agrees to perform or have performed work on the items specified in paragraph (a) of this clause up to the point at which, if this contract is terminated pursuant to the Termination for Convenience of the Government clause of this contract, the total amount payable by the Government (including amounts payable for subcontracts and settlement costs) pursuant to paragraphs (f) and (g) of that clause would, in the exercise of reasonable judgment by the Contractor, approximate the total amount at the time allotted to the contract. The Contractor is not obligated to continue performance of the work beyond that point. The Government is not obligated in any event to pay or reimburse the Contractor more than the amount from time to time allotted to the contract, anything to the contrary in the Termination for Convenience of the Government clause notwithstanding.

(c) (1) It is contemplated that funds presently allotted to this contract will cover the work to be performed until [ ].

(2) If funds allotted are considered by the Contractor to be inadequate to cover the work to be performed until that date, or an agreed date substituted for it, the Contractor shall notify the Contracting Officer in writing when within the next 60 days the work will reach a point at which, if the contract is terminated pursuant to the Termination for Convenience of the Government clause of this contract, the total amount payable by the Government (including amounts payable for subcontracts and settlement costs) pursuant to paragraphs (f) and (g) of that clause will approx-

imate 75 percent of the total amount then allotted to the contract.

(3) (i) The notice shall state the estimate when the point referred to in paragraph (c) (2) of this clause will be reached and the estimated amount of additional funds required to continue performance to the date specified in paragraph (c) (1) of this clause, or an agreed date substituted for it.

(ii) The Contractor shall, 60 days in advance of the date specified in paragraph (c) (1) of this clause, or an agreed date substituted for it, advise the Contracting Officer in writing as to the estimated amount of additional funds required for the timely performance of the contract for a further period as may be specified in the contract or otherwise agreed to by the parties.

(4) If, after the notification referred to in paragraph (c) (3) (ii) of this clause, additional funds are not allotted by the date specified in paragraph (c) (1) of this clause, or an agreed date substituted for it, the Contracting Officer shall, upon the Contractor's written request, terminate this contract on that date or on the date set forth in the request, whichever is later, pursuant to the Termination for Convenience of the Government clause.

(d) When additional funds are allotted from time to time for continued performance of the work under this contract, the parties shall agree on the applicable period of contract performance to be covered by these funds. The provisions of paragraphs (b) and (c) of this clause shall apply to these additional allotted funds and the substituted date pertaining to them, and the contract shall be modified accordingly.

(e) If, solely by reason of the Government's failure to allot additional funds in amounts sufficient for the timely performance of this contract, the Contractor incurs additional costs or is delayed in the performance of the work under this contract, and if additional funds are allotted, an equitable adjustment shall be made in the price or prices (including appropriate target, billing, and ceiling prices where applicable) of the items to be delivered, or in the time of delivery, or both.

(f) The Government may at any time before termination, and, with the consent of the Contractor, after notice of termination, allot additional funds for this contract.

(g) The provisions of this clause with respect to termination shall in no way be deemed to limit the rights of the Government under the default clause of this contract. The provisions of this Limitation of Funds clause are limited to the work on and allotment of funds for the items set forth in paragraph (a) of this clause. This clause shall become inoperative upon the allotment of funds for the total price of said work except for rights and obligations then existing under this clause.

(h) Nothing in this clause shall affect the right of the Government to terminate this contract pursuant to the Termination for Convenience of the Government clause of this contract.

(End of clause)

1852.235-71 Key Personnel and Facilities. (MAR 1989)

(a) The personnel and/or facilities listed below (or specified in the contract Schedule) are considered essential to the work being performed under this contract. Before removing, replacing, or diverting any of the listed or specified personnel or facilities, the Contractor shall (1) notify the Contracting Officer reasonably in advance and (2) submit justification (including proposed substitutions) in sufficient detail to permit evaluation of the impact on this contract.

(b) The Contractor shall make no diversion without the Contracting Officer's written consent; provided, that the Contracting Officer may ratify in writing the proposed change, and that ratification shall constitute the Contracting Officer's consent required by this clause.

(c) The list of personnel and/or facilities (shown below or as specified in the contract Schedule) may, with the consent of the contracting parties, be amended from time to time during the course of the contract to add or delete personnel and/or facilities.

[*List here the personnel and/or facilities considered essential, unless they are specified in the contract Schedule.*]

(End of clause)

1852.235-73 Final Scientific and Technical Reports. (DEC 2006) -- Alternate III (JAN 2005)

1852.235-74 Additional Reports of Work - Research and Development. (FEB 2003)

In addition to the final report required under this contract, the Contractor shall submit the following report(s) to the Contracting Officer:

(a) Quarterly progress reports. The Contractor shall submit separate quarterly reports of all work accomplished during each three-month period of contract performance. In addition to factual data, these reports should include a separate analysis section interpreting the results obtained, recommending further action, and relating occurrences to the ultimate objectives of the contract. Sufficient diagrams, sketches, curves, photographs, and drawings should be included to convey the intended meaning.

(b) Submission dates. Quarterly reports shall be submitted within 10 days following the period to be reported. No quarterly report need be submitted for the final three months of contract effort since that period will be covered in the final report. The final report shall be submitted within ____days after the completion of the effort under the contract.

(End of clause)

1852.244-70 Geographic Participation in the Aerospace Program. (APR 1985)

SECTION 508 COMPLIANCE

(a) The Workforce Investment Act of 1998 amended section 508 of the Rehabilitation Act of 1973 to require that :
(1) When developing, procuring, maintaining or using Electronic and Information Technology (EIT), agencies must ensure that employees with disabilities have access to and use of information and data that is comparable to that for other employees; and
(2) Members of the public with disabilities seeking information or services from an agency have access to and use of information and data that is comparable to that for members of the public without disabilities.
(b) Section 508 standards should be taken into consideration in the design of prototypes. Failure to meet Section 508 standards will impact the Government's ability to make future purchases of the technology developed under this contract. Information regarding Section 508 standards can be obtained at http://www.access-board.gov/508.htm.

(End of clause)

CONTRACT CLAUSES

52.202-1 Definitions. (JUL 2004)

52.203-3 Gratuities. (APR 1984)

52.203-5 Covenant Against Contingent Fees. (APR 1984)

52.203-6 Restrictions on Subcontractor Sales to the Government. (SEP 2006)

52.203-7 Anti-Kickback Procedures. (JUL 1995)

52.203-8 Cancellation, Rescission, and Recovery of Funds for Illegal or Improper Activity. (JAN 1997)

52.203-10 Price or Fee Adjustment for Illegal or Improper Activity. (JAN 1997)

52.203-12 Limitation on Payments to Influence Certain Federal Transactions. (SEP 2007)

52.204-4 Printed or Copied Double-Sided on Recycled Paper. (AUG 2000)

52.204-7 Central Contractor Registration. (APR 2008)

52.209-6 Protecting the Government's Interest When Subcontracting with Contractors Debarred, Suspended, or Proposed for Debarment. (SEP 2006)

52.211-5 Material Requirements. (AUG 2000)

52.215-2 Audit and Records - Negotiation. (JUN 1999)

52.215-8 Order of Precedence - Uniform Contract Format. (OCT 1997)

52.215-17 Waiver of Facilities Capital Cost of Money. (OCT 1997)

52.217-2 Cancellation Under Multi-year Contracts. (OCT 1997)

52.217-9 Option to Extend the Term of the Contract. (MAR 2000)

(a) The Government may extend the term of this contract by written notice to the Contractor within [*insert the period of time within which the Contracting Officer may exercise the option*]; provided that the Government gives the Contractor a preliminary written notice of its intent to extend at least [ ]days (*60 days unless a different number of days is inserted)* before the contract expires. The preliminary notice does not commit the Government to an extension.

(b) If the Government exercises this option, the extended contract shall be considered to include this option clause.

(c) The total duration of this contract, including the exercise of any options under this clause, shall not exceed [ ](months)(years).

(End of clause)

52.219-6 Notice of Total Small Business Set-Aside. (JUN 2003)

52.219-8 Utilization of Small Business Concerns. (MAY 2004)

52.219-28 Post-Award Small Business Program Rerepresentation. (APR 2009)

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

Long-term contract means a contract of more than five years in duration, including options. However, the term does not include contracts that exceed five years in duration because the period of performance has been extended for a cumulative period not to exceed six months under the clause at 52.217-8, Option to Extend Services, or other appropriate authority.

Small business concern means a concern, including its affiliates, that is independently owned and operated, not dominant in the field of operation in which it is bidding on Government contracts, and qualified as a small business under the criteria in 13 CFR part 121 and the size standard in paragraph (c) of this clause.

(b) If the Contractor represented that it was a small business concern prior to award of this contract, the Contractor shall rerepresent its size status according to paragraph (e) of this clause or, if applicable, paragraph (g) of this clause, upon the occurrence of any of the following:

(1) Within 30 days after execution of a novation agreement or within 30 days after modification of the contract to include this clause, if the novation agreement was executed prior to inclusion of this clause in the contract.

(2) Within 30 days after a merger or acquisition that does not require a novation or within 30 days after modification of the contract to include this clause, if the merger or acquisition occurred prior to inclusion of this clause in the contract.

(3) For long-term contracts -

(i) Within 60 to 120 days prior to the end of the fifth year of the contract; and

(ii) Within 60 to 120 days prior to the exercise date specified in the contract for any option thereafter.

(c) The Contractor shall rerepresent its size status in accordance with the size standard in effect at the time of this rerepresentation that corresponds to the North American Industry Classification System (NAICS) code assigned to this contract. The small business size standard corresponding to this NAICS code can be found at *http://www.sba.gov/ services/contractingopportunities/ sizestandardstopics/*.

(d) The small business size standard for a Contractor providing a product which it does not manufacture itself, for a contract other than a construction or service contract, is 500 employees.

(e) Except as provided in paragraph (g) of this clause, the Contractor shall make the rerepresentation required by paragraph (b) of this clause by validating or updating all its representations in the Online Representations and Certifications Application and its data in the Central Contractor Registration, as necessary, to ensure they reflect current status. The Contractor shall notify the contracting office by e-mail, or otherwise in writing, that the data have been validated or updated, and provide the date of the validation or update.

(f) If the Contractor represented that it was other than a small business concern prior to award of this contract, the Contractor may, but is not required to, take the actions required by paragraphs (e) or (g) of this clause.

(g) If the Contractor does not have representations and certifications in ORCA, or does not have a representation in ORCA for the NAICS code applicable to this contract, the Contractor is required to complete the following rerepresentation and submit it to the contracting office, along with the contract number and the date on which the rerepresentation was completed:

The Contractor represents that it ___ is, ___ is not a small business concern under NAICS Code _____ assigned to contract number _____. (*Contractor to sign and date and insert authorized signer's name and title).*

(End of clause)

52.222-3 Convict Labor. (JUN 2003)

52.222-19 Child Labor - Cooperation with Authorities and Remedies. (FEB 2008)

52.222-20 Walsh-Healey Public Contracts Act. (DEC 1996)

52.222-21 Prohibition of Segregated Facilities. (FEB 1999)

52.222-26 Equal Opportunity. (MAR 2007)

52.222-35 Equal Opportunity for Special Disabled Veterans, Veterans of the Vietnam Era, and Other Eligible Veterans. (SEP 2006)

52.222-36 Affirmative Action for Workers with Disabilities. (JUN 1998)

52.222-37 Employment Reports on Special Disabled Veterans, Veterans of the Vietnam Era, and Other Eligible Veterans. (SEP 2006)

52.222-50 Combating Trafficking in Persons. (FEB 2009)

52.223-3 Hazardous Material Identification and Material Safety Data. (JAN 1997) - Alternate I (JUL 1995)

52.223-5 Pollution Prevention and Right-to-Know Information. (AUG 2003)

52.223-6 Drug-Free Workplace. (MAY 2001)

52.223-14 Toxic Chemical Release Reporting. (AUG 2003)

52.223-15 Energy Efficiency in Energy-Consuming Products. (DEC 2007)

52.225-1 Buy American Act - Supplies. (FEB 2009)

52.225-13 Restrictions on Certain Foreign Purchases. (JUN 2008)

52.227-1 Authorization and Consent. (DEC 2007) -- Alternate I (APR 1984)

52.227-2 Notice and Assistance Regarding Patent and Copyright Infringement. (DEC 2007)

52.227-11 Patent Rights--Ownership by the Contractor. (DEC 2007)

(a) As used in this clause--

"Invention" means any invention or discovery that is or may be patentable or otherwise protectable under title 35 of the U.S. Code, or any variety of plant that is or may be protectable under the Plant Variety Protection Act (7 U.S.C. 2321, et seq.)

"Made" means--

(1) When used in relation to any invention other than a plant variety, the conception or first actual reduction to practice of the invention; or

(2) When used in relation to a plant variety, that the Contractor has at least tentatively determined that the variety has been reproduced with recognized characteristics.

"Nonprofit organization" means a university or other institution of higher education or an organization of the type described in section 501(c)(3) of the Internal Revenue Code of 1954 (26 U.S.C. 501(c)) and exempt from taxation under section 501(a) of the Internal Revenue Code (26 U.S.C. 501(a)), or any nonprofit scientific or educational organization qualified under a State nonprofit organization statute.

"Practical application" means to manufacture, in the case of a composition of product; to practice, in the case of a process or method; or to operate, in the case of a machine or system; and, in each case, under such conditions as to establish that the invention is being utilized and that its benefits are, to the extent permitted by law or Government regulations, available to the public on reasonable terms.

"Subject invention" means any invention of the Contractor made in the performance of work under this contract.

(b) Contractor's rights. (1) Ownership. The Contractor may retain ownership of each subject invention throughout the world in accordance with the provisions of this clause.

(2) License. (i) The Contractor shall retain a nonexclusive royalty-free license throughout the world in each subject invention to which the Government obtains title, unless the Contractor fails to disclose the invention within the times specified in paragraph (c) of this clause. The Contractor's license extends to any domestic subsidiaries and affiliates within the corporate structure of which the Contractor is a part, and includes the right to grant sublicenses to the extent the Contractor was legally obligated to do so at contract award. The license is transferable only with the written approval of the agency, except when transferred to the successor of that part of the Contractor's business to which the invention pertains.

(ii) The Contractor's license may be revoked or modified by the agency to the extent necessary to achieve expeditious practical application of the subject invention in a particular country in accordance with the procedures in FAR 27.302(i)(2) and 27.304-1(f).

(c) Contractor's obligations. (1) The Contractor shall disclose in writing each subject invention to the Contracting Officer within 2 months after the inventor discloses it in writing to Contractor personnel responsible for patent matters. The disclosure shall identify the inventor(s) and this contract under which the subject invention was made. It shall be sufficiently complete in technical detail to convey a clear understanding of the subject invention. The disclosure shall also identify any publication, on sale (i.e., sale or offer for sale), or public use of the subject invention, or whether a manuscript describing the subject invention has been submitted for publication and, if so, whether it has been accepted for publication. In addition, after disclosure to the agency, the Contractor shall promptly notify the Contracting Officer of the acceptance of any manuscript describing the subject invention for publication and any on sale or public use.

(2) The Contractor shall elect in writing whether or not to retain ownership of any subject invention by notifying the Contracting Officer within 2 years of disclosure to the agency. However, in any case where publication, on sale, or public use has initiated the 1-year statutory period during

which valid patent protection can be obtained in the United States, the period for election of title may be shortened by the agency to a date that is no more than 60 days prior to the end of the statutory period.

(3) The Contractor shall file either a provisional or a nonprovisional patent application or a Plant Variety Protection Application on an elected subject invention within 1 year after election. However, in any case where a publication, on sale, or public use has initiated the 1-year statutory period during which valid patent protection can be obtained in the United States, the Contractor shall file the application prior to the end of that statutory period. If the Contractor files a provisional application, it shall file a nonprovisional application within 10 months of the filing of the provisional application. The Contractor shall file patent applications in additional countries or international patent offices within either 10 months of the first filed patent application (whether provisional or nonprovisional) or 6 months from the date permission is granted by the Commissioner of Patents to file foreign patent applications where such filing has been prohibited by a Secrecy Order.

(4) The Contractor may request extensions of time for disclosure, election, or filing under paragraphs (c)(1), (c)(2), and (c)(3) of this clause.

(d) Government's rights--(1) Ownership. The Contractor shall assign to the agency, on written request, title to any subject invention--

(i) If the Contractor fails to disclose or elect ownership to the subject invention within the times specified in paragraph (c) of this clause, or elects not to retain ownership; provided, that the agency may request title only within 60 days after learning of the Contractor's failure to disclose or elect within the specified times.

(ii) In those countries in which the Contractor fails to file patent applications within the times specified in paragraph (c) of this clause; provided, however, that if the Contractor has filed a patent application in a country after the times specified in paragraph (c) of this clause, but prior to its receipt of the written request of the agency, the Contractor shall continue to retain ownership in that country.

(iii) In any country in which the Contractor decides not to continue the prosecution of any application for, to pay the maintenance fees on, or defend in reexamination or opposition proceeding on, a patent on a subject invention.

(2) License. If the Contractor retains ownership of any subject invention, the Government shall have a nonexclusive, nontransferable, irrevocable, paid-up license to practice, or have practiced for or on its behalf, the subject invention throughout the world.

(e) Contractor action to protect the Government's interest. (1) The Contractor shall execute or have executed and promptly deliver to the agency all instruments necessary to--

(i) Establish or confirm the rights the Government has throughout the world in those subject inventions in which the Contractor elects to retain ownership; and

(ii) Assign title to the agency when requested under paragraph (d) of this clause and to enable the Government to obtain patent protection and plant variety protection for that subject invention in any country.

(2) The Contractor shall require, by written agreement, its employees, other than clerical and non-

technical employees, to disclose promptly in writing to personnel identified as responsible for the administration of patent matters and in the Contractor's format, each subject invention in order that the Contractor can comply with the disclosure provisions of paragraph (c) of this clause, and to execute all papers necessary to file patent applications on subject inventions and to establish the Government's rights in the subject inventions. The disclosure format should require, as a minimum, the information required by paragraph (c)(1) of this clause. The Contractor shall instruct such employees, through employee agreements or other suitable educational programs, as to the importance of reporting inventions in sufficient time to permit the filing of patent applications prior to U.S. or foreign statutory bars.

(3) The Contractor shall notify the Contracting Officer of any decisions not to file a nonprovisional patent application, continue the prosecution of a patent application, pay maintenance fees, or defend in a reexamination or opposition proceeding on a patent, in any country, not less than 30 days before the expiration of the response or filing period required by the relevant patent office.

(4) The Contractor shall include, within the specification of any United States nonprovisional patent or plant variety protection application and any patent or plant variety protection certificate issuing thereon covering a subject invention, the following statement, "This invention was made with Government support under (identify the contract) awarded by (identify the agency). The Government has certain rights in the invention."

(f) Reporting on utilization of subject inventions. The Contractor shall submit, on request, periodic reports no more frequently than annually on the utilization of a subject invention or on efforts at obtaining utilization of the subject invention that are being made by the Contractor or its licensees or assignees. The reports shall include information regarding the status of development, date of first commercial sale or use, gross royalties received by the Contractor, and other data and information as the agency may reasonably specify. The Contractor also shall provide additional reports as may be requested by the agency in connection with any march-in proceeding undertaken by the agency in accordance with paragraph (h) of this clause. The Contractor also shall mark any utilization report as confidential/proprietary to help prevent inadvertent release outside the Government. As required by 35 U.S.C. 202(c)(5), the agency will not disclose that information to persons outside the Government without the Contractor's permission.

(g) Preference for United States industry. Notwithstanding any other provision of this clause, neither the Contractor nor any assignee shall grant to any person the exclusive right to use or sell any subject invention in the United States unless the person agrees that any products embodying the subject invention or produced through the use of the subject invention will be manufactured substantially in the United States. However, in individual cases, the requirement for an agreement may be waived by the agency upon a showing by the Contractor or its assignee that reasonable but unsuccessful efforts have been made to grant licenses on similar terms to potential licensees that would be likely to manufacture substantially in the United States, or that under the circumstances domestic manufacture is not commercially feasible.

(h) March-in rights. The Contractor acknowledges that, with respect to any subject invention in which it has retained ownership, the agency has the right to require licensing pursuant to 35 U.S.C. 203 and 210(c), and in accordance with the procedures in 37 CFR 401.6 and any supplemental regulations of the agency in effect on the date of contract award.

(i) Special provisions for contracts with nonprofit organizations. If the Contractor is a nonprofit organization, it shall--

(1) Not assign rights to a subject invention in the United States without the written approval of the agency, except where an assignment is made to an organization that has as one of its primary functions the management of inventions, provided, that the assignee shall be subject to the same

provisions as the Contractor;

(2) Share royalties collected on a subject invention with the inventor, including Federal employee co-inventors (but through their agency if the agency deems it appropriate) when the subject invention is assigned in accordance with 35 U.S.C. 202(e) and 37 CFR 401.10;

(3) Use the balance of any royalties or income earned by the Contractor with respect to subject inventions, after payment of expenses (including payments to inventors) incidental to the administration of subject inventions for the support of scientific research or education; and

(4) Make efforts that are reasonable under the circumstances to attract licensees of subject inventions that are small business concerns, and give a preference to a small business concern when licensing a subject invention if the Contractor determines that the small business concern has a plan or proposal for marketing the invention which, if executed, is equally as likely to bring the invention to practical application as any plans or proposals from applicants that are not small business concerns; provided, that the Contractor is also satisfied that the small business concern has the capability and resources to carry out its plan or proposal. The decision whether to give a preference in any specific case will be at the discretion of the Contractor.

(5) Allow the Secretary of Commerce to review the Contractor's licensing program and decisions regarding small business applicants, and negotiate changes to its licensing policies, procedures, or practices with the Secretary of Commerce when the Secretary's review discloses that the Contractor could take reasonable steps to more effectively implement the requirements of paragraph (i)(4) of this clause.

(j) Communications. [*Complete according to agency instructions.*]

(k) Subcontracts. (1) The Contractor shall include the substance of this clause, including this paragraph (k), in all subcontracts for experimental, developmental, or research work to be performed by a small business concern or nonprofit organization.

(2) The Contractor shall include in all other subcontracts for experimental, developmental, or research work the substance of the patent rights clause required by FAR Subpart 27.3.

(3) At all tiers, the patent rights clause must be modified to identify the parties as follows: references to the Government are not changed, and the subcontractor has all rights and obligations of the Contractor in the clause. The Contractor shall not, as part of the consideration for awarding the subcontract, obtain rights in the subcontractor's subject inventions.

(4) In subcontracts, at any tier, the agency, the subcontractor, and the Contractor agree that the mutual obligations of the parties created by this clause constitute a contract between the subcontractor and the agency with respect to the matters covered by the clause; provided, however, that nothing in this paragraph is intended to confer any jurisdiction under the Contract Disputes Act in connection with proceedings under paragraph (h) of this clause.

(End of clause)

52.227-16 Additional Data Requirements. (JUN 1987)

52.227-20 Rights in Data--SBIR Program. (DEC 2007)

52.229-3 Federal, State, and Local Taxes. (APR 2003)

52.232-2 Payments under Fixed-Price Research and Development Contracts. (APR 1984)

52.232-8 Discounts for Prompt Payment. (FEB 2002)

52.232-11 Extras. (APR 1984)

52.232-17 Interest. (OCT 2008)

52.232-23 Assignment of Claims. (JAN 1986)

52.232-25 Prompt payment. (OCT 2008)

52.232-34 Payment by Electronic Funds Transfer - Other than Central Contractor Registration. (MAY 1999)

(a) *Method of payment*. (1) All payments by the Government under this contract shall be made by electronic funds transfer (EFT) except as provided in paragraph (a)(2) of this clause. As used in this clause, the term EFT refers to the funds transfer and may also include the payment information transfer.

(2) In the event the Government is unable to release one or more payments by EFT, the Contractor agrees to either -

(i) Accept payment by check or some other mutually agreeable method of payment; or

(ii) Request the Government to extend payment due dates until such time as the Government makes payment by EFT (but see paragraph (d) of this clause).

(b) *Mandatory submission of Contractor's EFT information*. (1) The Contractor is required to provide the Government with the information required to make payment by EFT (see paragraph (j) of this clause). The Contractor shall provide this information directly to the office designated in this contract to receive that information (hereafter: designated office) by [*the Contracting Officer shall insert date, days after award, days before first request, the date specified for receipt of offers if the provision at 52.232-38 is utilized, or concurrent with first request as prescribed by the head of the agency; if not prescribed, insert no later than 15 days prior to submission of the first request for payment*]. If not otherwise specified in this contract, the payment office is the designated office for receipt of the Contractor's EFT information. If more than one designated office is named for the contract, the Contractor shall provide a separate notice to each office. In the event that the EFT information changes, the Contractor shall be responsible for providing the updated information to the designated office(s).

(2) If the Contractor provides EFT information applicable to multiple contracts, the Contractor shall specifically state the applicability of this EFT information in terms acceptable to the designated office. However, EFT information supplied to a designated office shall be applicable only to contracts that identify that designated office as the office to receive EFT information for that contract.

(c) *Mechanisms for EFT payment*. The Government may make payment by EFT through either the Automated Clearing House (ACH) network, subject to the rules of the National Automated Clearing House Association, or the Fedwire Transfer System. The rules governing Federal payments through the ACH are contained in 31 CFR part 210.

(d) *Suspension of payment*. (1) The Government is not required to make any payment under this contract until after receipt, by the designated office, of the correct EFT payment information from the Contractor.

Until receipt of the correct EFT information, any invoice or contract financing request shall be deemed not to be a proper invoice for the purpose of prompt payment under this contract. The prompt payment terms of the contract regarding notice of an improper invoice and delays in accrual of interest penalties apply.

(2) If the EFT information changes after submission of correct EFT information, the Government shall begin using the changed EFT information no later than 30 days after its receipt by the designated office to the extent payment is made by EFT. However, the Contractor may request that no further payments be made until the updated EFT information is implemented by the payment office. If such suspension would result in a late payment under the prompt payment terms of this contract, the Contractor's request for suspension shall extend the due date for payment by the number of days of the suspension.

(e) *Liability for uncompleted or erroneous transfers*. (1) If an uncompleted or erroneous transfer occurs because the Government used the Contractor's EFT information incorrectly, the Government remains responsible for -

(i) Making a correct payment;

(ii) Paying any prompt payment penalty due; and

(iii) Recovering any erroneously directed funds.

(2) If an uncompleted or erroneous transfer occurs because the Contractor's EFT information was incorrect, or was revised within 30 days of Government release of the EFT payment transaction instruction to the Federal Reserve System, and -

(i) If the funds are no longer under the control of the payment office, the Government is deemed to have made payment and the Contractor is responsible for recovery of any erroneously directed funds; or

(ii) If the funds remain under the control of the payment office, the Government shall not make payment and the provisions of paragraph (d) shall apply.

(f) *EFT and prompt payment*. A payment shall be deemed to have been made in a timely manner in accordance with the prompt payment terms of this contract if, in the EFT payment transaction instruction released to the Federal Reserve System, the date specified for settlement of the payment is on or before the prompt payment due date, provided the specified payment date is a valid date under the rules of the Federal Reserve System.

(g) *EFT and assignment of claims*. If the Contractor assigns the proceeds of this contract as provided for in the assignment of claims terms of this contract, the Contractor shall require as a condition of any such assignment, that the assignee shall provide the EFT information required by paragraph (j) of this clause to the designated office, and shall be paid by EFT in accordance with the terms of this clause. In all respects, the requirements of this clause shall apply to the assignee as if it were the Contractor. EFT information that shows the ultimate recipient of the transfer to be other than the Contractor, in the absence of a proper assignment of claims acceptable to the Government, is incorrect EFT information within the meaning of paragraph (d) of this clause.

(h) *Liability for change of EFT information by financial agent.* The Government is not liable for errors resulting from changes to EFT information provided by the Contractor's financial agent.

(i) *Payment information*. The payment or disbursing office shall forward to the Contractor available payment information that is suitable for transmission as of the date of lease of the EFT instruction to the Federal Reserve System. The Government may request the Contractor to designate a desired format and method(s) for delivery of payment information from a list of formats and methods the payment office is capable of executing. However, the Government does not guarantee that any particular format or method of delivery is available at any particular payment office and retains the latitude to use the format and delivery method most convenient to the Government. If the Government makes payment by check in accordance with paragraph (a) of this clause, the Government shall mail the payment information to the remittance address in the contract.

(j) *EFT information*. The Contractor shall provide the following information to the designated office. The Contractor may supply this data for this or multiple contracts (see paragraph (b) of this clause). The Contractor shall designate a single financial agent per contract capable of receiving and processing the EFT information using the EFT methods described in paragraph (c) of this clause.

(1) The contract number (or other procurement identification number).

(2) The Contractor's name and remittance address, as stated in the contract(s).

(3) The signature (manual or electronic, as appropriate), title, and telephone number of the Contractor official authorized to provide this information.

(4) The name, address, and 9-digit Routing Transit Number of the Contractor's financial agent.

(5) The Contractor's account number and the type of account (checking, saving, or lockbox).

(6) If applicable, the Fedwire Transfer System telegraphic abbreviation of the Contractor's financial agent.

(7) If applicable, the Contractor shall also provide the name, address, telegraphic abbreviation, and 9-digit Routing Transit Number of the correspondent financial institution receiving the wire transfer payment if the Contractor's financial agent is not directly on-line to the Fedwire Transfer System; and, therefore, not the receiver of the wire transfer payment.

(End of clause)

52.233-1 Disputes. (JUL 2002)

52.233-3 Protest after Award. (AUG 1996)

52.233-4 Applicable Law for Breach of Contract Claim. (OCT 2004)

52.242-13 Bankruptcy. (JUL 1995)

52.243-1 Changes - Fixed-Price. (AUG 1987) - Alternate V (APR 1984)

52.244-6 Subcontracts for Commercial Items. (MAR 2009)

52.245-1 Government Property. (JUN 2007)

52.245-9 Use and Charges. (JUN 2007)

52.246-23 Limitation of Liability. (FEB 1997)

52.246-25 Limitation of Liability - Services. (FEB 1997)

52.247-64 Preference for Privately Owned U.S.-Flag Commercial Vessels. (FEB 2006)

52.249-2 Termination for Convenience of the Government (Fixed-Price). (MAY 2004)

52.249-9 Default (Fixed-Price Research and Development). (APR 1984)

52.252-2 Clauses Incorporated by Reference. (FEB 1998)

This contract incorporates one or more clauses by reference, with the same force and effect as if they were given in full text. Upon request, the Contracting Officer will make their full text available. Also, the full text of a clause may be accessed electronically at this/these address(es): Federal Acquisition Regulation (FAR) clauses:

http://www.acqnet.gov/far/

NASA FAR Supplement (NFS) clauses:

http://www.hq.nasa.gov/office/procurement/regs/nfstoc.htm

(End of clause)

52.252-6 Authorized Deviations in Clauses. (APR 1984)

(a) The use in this solicitation or contract of any Federal Acquisition Regulation (48 CFR Chapter 1) clause with an authorized deviation is indicated by the addition of (DEVIATION) after the date of the clause.

(b) The use in this solicitation or contract of any NASA FAR Supplement (48 CFR 18) clause with an authorized deviation is indicated by the addition of (DEVIATION) after the name of the regulation.

(End of clause)

52.253-1 Computer Generated Forms. (JAN 1991)

1852.204-76 Security Requirements for Unclassified Information Technology Resources. (MAY 2007)

(a) The Contractor shall be responsible for information and information technology (IT) security when -

(1) The Contractor or its subcontractors must obtain physical or electronic (i.e., authentication level 2 and above as defined in National Institute of Standards and Technology (NIST) Special Publication (SP) 800-63, Electronic Authentication Guideline) access to NASA's computer systems, networks, or IT infrastructure; or

(2) Information categorized as low, moderate, or high by the Federal Information Processing Standards (FIPS) 199, Standards for Security Categorization of Federal Information and Information Systems is stored, generated, processed, or exchanged by NASA or on behalf of NASA by a contractor or subcontractor, regardless of whether the information resides on a NASA or a contractor/subcontractor's information system.

(b) IT Security Requirements.

(1) Within 30 days after contract award, a Contractor shall submit to the Contracting Officer for NASA approval an IT Security Plan, Risk Assessment, and FIPS 199, Standards for Security Categorization of Federal Information and Information Systems, Assessment. These plans and assessments, including annual updates shall be incorporated into the contract as compliance documents.

(i) The IT system security plan shall be prepared consistent, in form and content, with NIST SP 800-18, Guide for Developing Security Plans for Federal Information Systems, and any additions/augmentations described in NASA Procedural Requirements (NPR) 2810, Security of Information Technology. The security plan shall identify and document appropriate IT security controls consistent with the sensitivity of the information and the requirements of Federal Information Processing Standards (FIPS) 200, Recommended Security Controls for Federal Information Systems. The plan shall be reviewed and updated in accordance with NIST SP 800-26, Security Self-Assessment Guide for Information Technology Systems, and FIPS 200, on a yearly basis.

(ii) The risk assessment shall be prepared consistent, in form and content, with NIST SP 800-30, Risk Management Guide for Information Technology Systems, and any additions/augmentations described in NPR 2810. The risk assessment shall be updated on a yearly basis.

(iii) The FIPS 199 assessment shall identify all information types as well as the "high water mark," as defined in FIPS 199, of the processed, stored, or transmitted information necessary to fulfill the contractual requirements.

(2) The Contractor shall produce contingency plans consistent, in form and content, with NIST SP 800-34, Contingency Planning Guide for Information Technology Systems, and any additions/augmentations described in NPR 2810. The Contractor shall perform yearly "Classroom Exercises." "Functional Exercises," shall be coordinated with the Center CIOs and be conducted once every three years, with the first conducted within the first two years of contract award. These exercises are defined and described in NIST SP 800-34.

(3) The Contractor shall ensure coordination of its incident response team with the NASA Incident Response Center (NASIRC) and the NASA Security Operations Center, ensuring that incidents are reported consistent with NIST SP 800-61, Computer Security Incident Reporting Guide, and the United States Computer Emergency Readiness Team's (US-CERT) Concept of Operations for reporting security incidents. Specifically, any confirmed incident of a system containing NASA data or controlling NASA assets shall be reported to NASIRC within one hour that results in unauthorized access, loss or modification of NASA data, or denial of service affecting the availability of NASA data.

(4) The Contractor shall ensure that its employees, in performance of the contract, receive annual IT security training in NASA IT Security policies, procedures, computer ethics, and best practices in accordance with NPR 2810 requirements. The Contractor may use web-based training available from NASA to meet this requirement.

(5) The Contractor shall provide NASA, including the NASA Office of Inspector General, access to the Contractor's and subcontractors' facilities, installations, operations, documentation, databases, and personnel used in performance of the contract. Access shall be provided to the extent required to carry out IT security inspection, investigation, and/or audits to safeguard against

threats and hazards to the integrity, availability, and confidentiality of NASA information or to the function of computer systems operated on behalf of NASA, and to preserve evidence of computer crime. To facilitate mandatory reviews, the Contractor shall ensure appropriate compartmentalization of NASA information, stored and/or processed, either by information systems in direct support of the contract or that are incidental to the contract.

(6) The Contractor shall ensure that system administrators who perform tasks that have a material impact on IT security and operations demonstrate knowledge appropriate to those tasks. Knowledge is demonstrated through the NASA System Administrator Security Certification Program. A system administrator is one who provides IT services (including network services, file storage, and/or web services) to someone other than themselves and takes or assumes the responsibility for the security and administrative controls of that service. Within 30 days after contract award, the Contractor shall provide to the Contracting Officer a list of all system administrator positions and personnel filling those positions, along with a schedule that ensures certification of all personnel within 90 days after contract award. Additionally, the Contractor should report all personnel changes which impact system administrator positions within 5 days of the personnel change and ensure these individuals obtain System Administrator certification within 90 days after the change.

(7) The Contractor shall ensure that NASA's Sensitive But Unclassified (SBU) information as defined in NPR 1600.1, NASA Security Program Procedural Requirements, which includes privacy information, is encrypted in storage and transmission.

(8) When the Contractor is located at a NASA Center or installation or is using NASA IP address space, the Contractor shall -

(i) Submit requests for non-NASA provided external Internet connections to the Contracting Officer for approval by the Network Security Configuration Control Board (NSCCB);

(ii) Comply with the NASA CIO metrics including patch management, operating systems and application configuration guidelines, vulnerability scanning, incident reporting, system administrator certification, and security training; and

(iii) Utilize the NASA Public Key Infrastructure (PKI) for all encrypted communication or non-repudiation requirements within NASA when secure email capability is required.

(c) Physical and Logical Access Requirements.

(1) Contractor personnel requiring access to IT systems operated by the Contractor for NASA or interconnected to a NASA network shall be screened at an appropriate level in accordance with NPR 2810 and Chapter 4, NPR 1600.1, NASA Security Program Procedural Requirements. NASA shall provide screening, appropriate to the highest risk level, of the IT systems and information accessed, using, as a minimum, National Agency Check with Inquiries (NACI). The Contractor shall submit the required forms to the NASA Center Chief of Security (CCS) within fourteen (14) days after contract award or assignment of an individual to a position requiring screening. The forms may be obtained from the CCS. At the option of NASA, interim access may be granted pending completion of the required investigation and final access determination. For Contractors who will reside on a NASA Center or installation, the security screening required for all required access (e.g., installation, facility, IT, information, etc.) is consolidated to ensure only one investigation is conducted based on the highest risk level. Contractors not residing on a NASA installation will be screened based on their IT access risk level determination only. See NPR 1600.1, Chapter 4.

(2) Guidance for selecting the appropriate level of screening is based on the risk of adverse impact to NASA missions. NASA defines three levels of risk for which screening is required (IT-1 has the highest level of risk).

(i) IT-1 - Individuals having privileged access or limited privileged access to systems whose misuse can cause very serious adverse impact to NASA missions. These systems include, for example, those that can transmit commands directly modifying the behavior of spacecraft, satellites or aircraft.

(ii) IT-2 - Individuals having privileged access or limited privileged access to systems whose misuse can cause serious adverse impact to NASA missions. These systems include, for example, those that can transmit commands directly modifying the behavior of payloads on spacecraft, satellites or aircraft; and those that contain the primary copy of "level 1" information whose cost to replace exceeds one million dollars.

(iii) IT-3 - Individuals having privileged access or limited privileged access to systems whose misuse can cause significant adverse impact to NASA missions. These systems include, for example, those that interconnect with a NASA network in a way that exceeds access by the general public, such as bypassing firewalls; and systems operated by the Contractor for NASA whose function or information has substantial cost to replace, even if these systems are not interconnected with a NASA network.

(3) Screening for individuals shall employ forms appropriate for the level of risk as established in Chapter 4, NPR 1600.1.

(4) The Contractor may conduct its own screening of individuals requiring privileged access or limited privileged access provided the Contractor can demonstrate to the Contracting Officer that the procedures used by the Contractor are equivalent to NASA's personnel screening procedures for the risk level assigned for the IT position.

(5) Subject to approval of the Contracting Officer, the Contractor may forgo screening of Contractor personnel for those individuals who have proof of a -

(i) Current or recent national security clearances (within last three years);

(ii) Screening conducted by NASA within the last three years that meets or exceeds the screening requirements of the IT position; or

(iii) Screening conducted by the Contractor, within the last three years, that is equivalent to the NASA personnel screening procedures as approved by the Contracting Officer and concurred on by the CCS.

(d) The Contracting Officer may waive the requirements of paragraphs (b) and (c) (1) through (c) (3) upon request of the Contractor. The Contractor shall provide all relevant information requested by the Contracting Officer to support the waiver request.

(e) The Contractor shall contact the Contracting Officer for any documents, information, or forms necessary to comply with the requirements of this clause.

(f) At the completion of the contract, the contractor shall return all NASA information and IT resources provided to the contractor during the performance of the contract and certify that all NASA information has been purged from contractor-owned systems used in the performance of the contract.

(g) The Contractor shall insert this clause, including this paragraph (g), in all subcontracts:

(1) Have physical or electronic access to NASA's computer systems, networks, or IT infrastructure; or

(2) Use information systems to generate, store, process, or exchange data with NASA or on behalf of NASA, regardless of whether the data resides on a NASA or a contractor's information system.

(End of clause)

1852.215-84 Ombudsman. (OCT 2003)

(a) An ombudsman has been appointed to hear and facilitate the resolution of concerns from offerors, potential offerors, and contractors during the preaward and postaward phases of this acquisition. When requested, the ombudsman will maintain strict confidentiality as to the source of the concern. The existence of the ombudsman is not to diminish the authority of the contracting officer, the Source Evaluation Board, or the selection official. Further, the ombudsman does not participate in the evaluation of proposals, the source selection process, or the adjudication of formal contract disputes. Therefore, before consulting with an ombudsman, interested parties must first address their concerns, issues, disagreements, and/or recommendations to the contracting officer for resolution.

(b) If resolution cannot be made by the contracting officer, interested parties may contact the installation ombudsman, Rebecca S. Dubuisson, NASA Shared Services Center, rebecca.s.dubuisson@nasa.gov. Concerns, issues, disagreements, and recommendations which cannot be resolved at the installation may be referred to the NASA ombudsman, James A. Balinskas, the Director of the Contract Management Division, at 202-358-0445, facsimile 202-358-3083, e-mail james.a.balinskas@nasa.gov . Please do not contact the ombudsman to request copies of the solicitation, verify offer due date, or clarify technical requirements. Such inquiries shall be directed to the Contracting Officer or as specified elsewhere in this document.

(End of clause)

1852.219-76 NASA 8 Percent Goal. (JUL 1997)

(a) Definitions.

"Historically Black Colleges or University," as used in this clause, means an institution determined by the Secretary of Education to meet the requirements of 34 CFR Section 608.2. The term also includes any nonprofit research institution that was an integral part of such a college or university before November 14, 1986.

"Minority institutions," as used in this clause, means an institution of higher education meeting the requirements of section 1046(3) of the Higher Education Act of 1965 (20 U.S.C. 1135d-5(3)) which for the purposes of this clause includes a Hispanic-serving institution of higher education as defined in section 316(b)(1) of the Act (20 U.S.C. 1059c(b)(1)).

"Small disadvantaged business concern," as used in this clause, means a small business concern that (1) is at least 51 percent unconditionally owned by one or more individuals who are both socially and economically disadvantaged, or a publicly owned business having at least 51 percent of its stock unconditionally owned by one or more socially and economically disadvantaged individuals, and (2) has its management and daily business controlled by one or more such individuals. This term also means a small business concern that is at least 51 percent unconditionally owned by an economically disadvantaged Indian tribe or Native Hawaiian Organization, or a publicly owned business having at least 51 percent of its stock unconditionally owned by one or more of these entities, which has its management and daily business controlled by members of an economically disadvantaged Indian tribe or Native Hawaiian Organization, and which meets the requirements of 13 CFR 124.

"Women-owned small business concern," as used in this clause, means a small business concern (1) which is at least 51 percent owned by one or more women or, in the case of any publicly owned business, at least 51 percent of the stock of which is owned by one or more women, and (2) whose management and daily business operations are controlled by one or more women.

(b) The NASA Administrator is required by statute to establish annually a goal to make available to small disadvantaged business concerns, Historically Black Colleges and Universities, minority institutions, and women-owned small business concerns, at least 8 percent of NASA's procurement dollars under prime contracts or subcontracts awarded in support of authorized programs, including the space station by the time operational status is obtained.

(c) The contractor hereby agrees to assist NASA in achieving this goal by using its best efforts to award subcontracts to such entities to the fullest extent consistent with efficient contract performance.

(d) Contractors acting in good faith may rely on written representations by their subcontractors regarding their status as small disadvantaged business concerns, Historically Black Colleges and Universities, minority institutions, and women-owned small business concerns.

(End of clause)

1852.219-82 Limitation on Subcontracting - STTR Program. (OCT 2006)

1852.219-84 Limitation of the Principal Investigator - STTR Program. (OCT 2006)

(a) The primary employment of the principal investigator (PI) identified in paragraph (b) of this clause is with the small business concern (SBC)/Contractor or the research institution (RI). Primary employment means that more than one-half of the principal investigator's time is spent in the employ of the SBC/Contractor or RI.
(b) The PI is considered to be key personnel in the performance of this contract. The SBC/Contractor, whether or not the employer of the PI, shall exercise primary management direction and control over the PI and be overall responsible for the PI's performance under this contract Deviations from these requirements must be approved in advance and in writing by the Contracting Officer and are not subject to a change in the firm-fixed price of the contract. The PI for this contract is [*insert name*].

(End of clause)

1852.219-85 Conditions for Final Payment - SBIR and STTR Contracts. (OCT 2006)

1852.235-70 Center for AeroSpace Information. (DEC 2006)

1852.237-72 Access to Sensitive Information. (JUN 2005)

(a) As used in this clause, ``sensitive information" refers to information that a contractor has developed at private expense, or that the Government has generated that qualifies for an exception to the Freedom of Information Act, which is not currently in the public domain, and which may embody trade secrets or commercial or financial information, and which may be sensitive or privileged.

(b) To assist NASA in accomplishing management activities and administrative functions, the Contractor shall provide the services specified elsewhere in this contract.

(c) If performing this contract entails access to sensitive information, as defined above, the Contractor agrees to--

(1) Utilize any sensitive information coming into its possession only for the purposes of performing the services specified in this contract, and not to improve its own competitive position in another procurement.

(2) Safeguard sensitive information coming into its possession from unauthorized use and disclosure.

(3) Allow access to sensitive information only to those employees that need it to perform services under this contract.

(4) Preclude access and disclosure of sensitive information to persons and entities outside of the Contractor's organization.

(5) Train employees who may require access to sensitive information about their obligations to utilize it only to perform the services specified in this contract and to safeguard it from unauthorized use and disclosure.

(6) Obtain a written affirmation from each employee that he/she has received and will comply with training on the authorized uses and mandatory protections of sensitive information needed in performing this contract.

(7) Administer a monitoring process to ensure that employees comply with all reasonable security procedures, report any breaches to the Contracting Officer, and implement any necessary corrective actions.

(d) The Contractor will comply with all procedures and obligations specified in its Organizational Conflicts of Interest Avoidance Plan, which this contract incorporates as a compliance document.

(e) The nature of the work on this contract may subject the Contractor and its employees to a variety of laws and regulations relating to ethics, conflicts of interest, corruption, and other criminal or civil matters relating to the award and administration of government contracts. Recognizing that this contract establishes a high standard of accountability and trust, the Government will carefully review the Contractor's performance in relation to the mandates and restrictions found in these laws and regulations. Unauthorized uses or disclosures of sensitive information may result in termination of this contract for default, or in debarment of the Contractor for serious misconduct affecting present responsibility as a government contractor.

(f) The Contractor shall include the substance of this clause, including this paragraph (f), suitably modified to reflect the relationship of the parties, in all subcontracts that may involve access to sensitive information

(End of clause)

1852.237-73 Release of Sensitive Information. (JUN 2005)

(a) As used in this clause, "Sensitive information" refers to information, not currently in the public domain, that the Contractor has developed at private expense, that may embody trade secrets or commercial or financial information, and that may be sensitive or privileged.

(b) In accomplishing management activities and administrative functions, NASA relies heavily on the support of various service providers. To support NASA activities and functions, these service providers, as well as their subcontractors and their individual employees, may need access to sensitive information submitted by the Contractor under this contract. By submitting this proposal or performing this contract, the Contractor agrees that NASA may release to its service providers, their subcontractors, and their individual employees, sensitive information submitted during the course of this procurement, subject to the enumerated protections mandated by the clause at 1852.237-72, Access to Sensitive Information.

(c) (1) The Contractor shall identify any sensitive information submitted in support of this proposal or in performing this contract. For purposes of identifying sensitive information, the Contractor may, in addition to any other notice or legend otherwise required, use a notice similar to the following:

Mark the title page with the following legend:

This proposal or document includes sensitive information that NASA shall not disclose outside the Agency and its service providers that support management activities and administrative functions. To gain access to this sensitive information, a service provider's contract must contain the clause at NFS 1852.237-72, Access to Sensitive Information. Consistent with this clause, the service provider shall not duplicate, use, or disclose the information in whole or in part for any purpose other than to perform the services specified in its contract. This restriction does not limit the Government's right to use this information if it is obtained from another source without restriction. The information subject to this restriction is contained in pages [*insert page numbers or other identification of pages*]. Mark each page of sensitive information the Contractor wishes to restrict with the following legend:

Use or disclosure of sensitive information contained on this page is subject to the restriction on the title page of this proposal or document.

(2) The Contracting Officer shall evaluate the facts supporting any claim that particular information is "sensitive." This evaluation shall consider the time and resources necessary to protect the information in accordance with the detailed safeguards mandated by the clause at 1852.237-72, Access to Sensitive Information. However, unless the Contracting Officer decides, with the advice of Center counsel, that reasonable grounds exist to challenge the Contractor's claim that particular information is sensitive, NASA and its service providers and their employees shall comply with all of the safeguards contained in paragraph (d) of this clause.

(d) To receive access to sensitive information needed to assist NASA in accomplishing management activities and administrative functions, the service provider must be operating under a contract that contains the clause at 1852.237-72, Access to Sensitive Information. This clause obligates the service provider to do the following:

(1) Comply with all specified procedures and obligations, including the Organizational Conflicts of Interest Avoidance Plan, which the contract has incorporated as a compliance document.

(2) Utilize any sensitive information coming into its possession only for the purpose of performing the services specified in its contract.

(3) Safeguard sensitive information coming into its possession from unauthorized use and disclosure.

(4) Allow access to sensitive information only to those employees that need it to perform services under its contract.

(5) Preclude access and disclosure of sensitive information to persons and entities outside of the

service provider's organization.

(6) Train employees who may require access to sensitive information about their obligations to utilize it only to perform the services specified in its contract and to safeguard it from unauthorized use and disclosure.

(7) Obtain a written affirmation from each employee that he/she has received and will comply with training on the authorized uses and mandatory protections of sensitive information needed in performing this contract.

(8) Administer a monitoring process to ensure that employees comply with all reasonable security procedures, report any breaches to the Contracting Officer, and implement any necessary corrective actions.

(e) When the service provider will have primary responsibility for operating an information technology system for NASA that contains sensitive information, the service provider's contract shall include the clause at 1852.204-76, Security Requirements for Unclassified Information Technology Resources. The Security Requirements clause requires the service provider to implement an Information Technology Security Plan to protect information processed, stored, or transmitted from unauthorized access, alteration, disclosure, or use. Service provider personnel requiring privileged access or limited privileged access to these information technology systems are subject to screening using the standard National Agency Check (NAC) forms appropriate to the level of risk for adverse impact to NASA missions. The Contracting Officer may allow the service provider to conduct its own screening, provided the service provider employs substantially equivalent screening procedures.

(f) This clause does not affect NASA's responsibilities under the Freedom of Information Act.

(g) The Contractor shall insert this clause, including this paragraph (g), suitably modified to reflect the relationship of the parties, in all subcontracts that may require the furnishing of sensitive information.

(End of clause)

LIST OF ATTACHMENTS

Appendix G: NASA SBIR-STTR Technology Taxonomy

Avionics and Astrionics
- Airport Infrastructure and Safety
- Attitude Determination and Control
- Guidance, Navigation, and Control
- On-Board Computing and Data Management
- Pilot Support Systems
- Spaceport Infrastructure and Safety
- Telemetry, Tracking and Control

Bio-Technology
- Air Revitalization and Conditioning
- Biomass Production and Storage
- Biomedical and Life Support
- Biomolecular Sensors
- Sterilization/Pathogen and Microbial Control
- Waste Processing and Reclamation

Communications
- Architectures and Networks
- Autonomous Control and Monitoring
- Laser
- RF

Cryogenics
- Fluid Storage and Handling
- Instrumentation
- Production

Education
- General Public Outreach
- K-12 Outreach
- Mission Training

Electronics
- Highly-Reconfigurable
- Photonics
- Radiation-Hard/Resistant Electronics
- Ultra-High Density/Low Power

Extravehicular Activity
- Manned-Maneuvering Units
- Portable Life Support
- Suits
- Tools

Information
- Autonomous Reasoning/Artificial Intelligence
- Computer System Architectures
- Data Acquisition and End-to-End-Management
- Data Input/Output Devices
- Database Development and Interfacing
- Expert Systems
- Human-Computer Interfaces
- Portable Data Acquisition or Analysis Tools
- Software Development Environments
- Software Tools for Distributed Analysis and Simulation

Manufacturing
- Earth-Supplied Resource Utilization
- In-situ Resource Utilization
- Microgravity

Materials
- Ceramics
- Composites
- Computational Materials
- Metallics
- Multifunctional/Smart Materials
- Optical & Photonic Materials
- Organics/Bio-Materials
- Radiation Shielding Materials
- Semi-Conductors/Solid State Device Materials
- Superconductors and Magnetic
- Tribology

Microgravity
- Biophysical Utilization
- Combustion
- Liquid-Liquid Interfaces

Power and Energy
- Biochemical Conversion
- Energy Storage
- MHD and Related Conversion
- Nuclear Conversion
- Photovoltaic Conversion
- Power Management and Distribution
- Renewable Energy
- Thermodynamic Conversion
- Thermoelectric Conversion
- Wireless Distribution

Propulsion
- Aerobrake
- Aircraft Engines
- Beamed Energy
- Chemical
- Electromagnetic Thrusters
- Electrostatic Thrusters
- Feed System Components
- Fundamental Propulsion Physics
- High Energy Propellants (Recombinant Energy & Metallic Hydrogen)
- Launch Assist (Electromagnetic, Hot Gas and Pneumatic)
- MHD
- Micro Thrusters
- Monopropellants
- Nuclear (Adv Fission, Fusion, Anti-Matter, Exotic Nuclear)
- Propellant Storage
- Solar
- Tethers

Robotics
- Human-Robotic Interfaces
- Integrated Robotic Concepts and Systems
- Intelligence
- Manipulation
- Mobility
- Perception/Sensing
- Teleoperation

Sensors and Sources
- Biochemical
- Gravitational
- High-Energy
- Large Antennas and Telescopes
- Microwave/Submillimeter
- Optical
- Particle and Fields
- Sensor Webs/Distributed Sensors
- Substrate Transfer Technology

Structures
- Airframe
- Airlocks/Environmental Interfaces
- Controls-Structures Interaction (CSI)
- Erectable
- Inflatable
- Kinematic-Deployable
- Launch and Flight Vehicle
- Modular Interconnects
- Structural Modeling and Tools
- Tankage

Thermal
- Ablatives
- Control Instrumentation
- Cooling
- Reuseable
- Thermal Insulating Materials

Verification and Validation
- Operations Concepts and Requirements
- Simulation Modeling Environment
- Testing Facilities
- Testing Requirements and Architectures
- Training Concepts and Architectures

Research Topics Index

AERONAUTICS RESEARCH

EXPLORATION SYSTEMS

SCIENCE

SPACE OPERATIONS

STTR