MISSILE DEFENSE AGENCY (MDA)
16.2 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

INTRODUCTION

The Missile Defense Agency's (MDA) mission is to develop and deploy a layered Ballistic Missile Defense System (BMDS) to defend the United States, its deployed forces, allies, and friends from ballistic missile attacks of all ranges in all phases of flight.

The MDA Small Business Innovation Research (SBIR) Program is implemented, administrated, and managed by the MDA SBIR/STTR Program Management Office (PMO), located within Advanced Technology (DV). Specific questions pertaining to the administration of the MDA SBIR Program should be submitted to:

Missile Defense Agency
SBIR/STTR Program Office
MDA/DVR
Bldg 5224, Martin Road
Redstone Arsenal, AL 35898

Email: sbirsttr@mda.mil
Phone: 256-955-2020

Proposals not conforming to the terms of this announcement will not be considered. MDA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded. Only Government personnel with active non-disclosure agreements will evaluate proposals. MDA reserves the right to withdraw from negations at any time prior to contract award.

Please read the entire DoD announcement and MDA instructions carefully prior to submitting your proposal. Please go to https://www.sbir.gov/about/about-sbir#sbir-policy-directive to read the SBIR Policy Directive issued by the Small Business Administration.

Federally Funded Research and Development Centers (FFRDCs) and Support Contractors

The offeror's attention is directed to the fact that non-Government advisors to the Government may review and provide support in proposal evaluations during source selection. Non-Government advisors may have access to the offeror's proposals, may be utilized to review proposals, and may provide comments and recommendations to the Government's decision makers. These advisors will not establish final assessments of risk and will not rate or rank offeror's proposals. They are also expressly prohibited from competing for MDA SBIR or STTR awards in the SBIR/STTR topics they review and/or on which they provide comments to the Government.

All advisors are required to comply with procurement integrity laws. Non-Government technical consultants/experts will not have access to proposals that are labeled by their proposers as "Government Only." Pursuant to FAR 9.505-4, the MDA contracts with these organizations include a clause which requires them to (1) protect the offerors' information from unauthorized use or disclosure for as long as it remains proprietary and (2) refrain from using the information for any purpose other than that for which it was furnished. In addition, MDA requires the employees of those support contractors that provide

technical analysis to the SBIR/STTR Program to execute non-disclosure agreements. These agreements will remain on file with the MDA SBIR/STTR PMO.

Non-Government advisors will be authorized access to only those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. In accomplishing their duties related to the source selection process, employees of the aforementioned organizations may require access to proprietary information contained in the offerors' proposals.

OFFEROR SMALL BUSINESS ELIGIBILITY REQUIREMENTS

Each offeror must qualify as a small business at time of award per the Small Business Administration's (SBA) regulations at 13 CFR 121.701-121.705 and certify to this in the Cover Sheet section of the proposal. Additionally, in accordance with SBA SBIR Program Policy Directive dated 24 February 2014 offerors must re-certify at certain points during the Phase I and Phase II period of performance to ensure that the awardee is in compliance with the program's requirements.

SBA Company Registry

Per the SBIR Policy Directive, all SBIR applicants are required to register their firm at SBA's Company Registry prior to submitting an application. Upon registering, each firm will receive a unique control ID to be used for submissions at any of the 11 participating agencies in the SBIR or STTR programs. For more information, please visit the SBA's Firm Registration Page: http://www.sbir.gov/registration.

Performance Benchmark Requirements for Phase I Eligibility

MDA does not accept proposals from firms that are currently ineligible for Phase I awards as a result of failing to meet the benchmark rates at the last assessment. Additional information on Benchmark Requirements can be found in the DoD Instructions of this announcement.

ORGANIZATIONAL CONFLICTS OF INTEREST

Contract awards to firms owned by or employing current or previous Federal Government employees could create conflicts of interest for those employees which may be a violation of federal law. Proposing firms should contact the MDA SBIR/STTR PMO for further guidance in this situation.

The basic rules are covered in FAR 9.5 as follows (the Contractor is responsible for compliance):

(1) the Contractor's objectivity and judgment are not biased because of its present or planned interests which relate to work under this contract;

(2) the Contractor does not obtain unfair competitive advantage by virtue of its access to non-public information regarding the Government's program plans and actual or anticipated resources; and

(3) the Contractor does not obtain unfair competitive advantage by virtue of its access to proprietary information belonging to others.

All other applicable rules under the FAR Section 9.5 apply to Contractors.

USE OF FOREIGN NATIONALS

See the "Foreign Nationals" section of the DoD program announcement for the definition of a Foreign National (also known as Foreign Persons).

ALL offerors proposing to use foreign nationals MUST disclose this information regardless of whether the topic is subject to export control restrictions. Identify any foreign citizens or individuals holding dual citizenship expected to be involved on this project as a direct employee, subcontractor, or consultant. For these individuals, please specify their country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. You may be asked to provide additional information during negotiations in order to verify the foreign citizen's eligibility to participate on a SBIR contract. Supplemental information provided in response to this paragraph will be protected in accordance with the Privacy Act (5 U.S.C. 552a), if applicable, and the Freedom of Information Act (5 U.S.C. 552(b)(6)).

Proposals submitted with a foreign national listed will be subject to security review during the contract negotiation process (if selected for award). If the security review disqualifies a foreign national from participating in the proposed work, the contractor may propose a suitable replacement. In the event a proposed foreign person is found ineligible to perform proposed work, the contracting officer will advise the offeror of any disqualifications but may not disclose the underlying rationale.

EXPORT CONTROL RESTRICTIONS

The technology within some MDA topics is restricted under export control regulations including the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). ITAR controls the export and import of listed defense-related material, technical data and services that provide the United States with a critical military advantage. EAR controls military, dual-use and commercial items not listed on the United States Munitions List or any other export control lists. EAR regulates export controlled items based on user, country, and purpose. You must ensure that your firm complies with all applicable export control regulations. Please refer to the following URLs for additional information: http://www.pmddtc.state.gov/regulations_laws/itar.html and http://www.bis.doc.gov/index.php/regulations/export-administration-regulations-ear.

Proposals submitted to export control-restricted topics will be subject to security review during the contract negotiation process (if selected for award). In the event a firm is found ineligible to perform proposed work, the contracting officer will advise the offeror of any disqualifications but may not disclose the underlying rationale.

CLAUSE H-08 PUBLIC RELEASE OF INFORMATION (Publication Approval)

Clause H-08 pertaining to the public release of information is incorporated into all MDA SBIR and STTR contracts and subcontracts without exception. All materials which relate to work performed by the contractor under MDA SBIR and STTR contracts must be submitted to MDA for review and approval prior to release to the public. Subcontractor public information materials must be submitted for approval through the prime contractor to MDA.

OWNERSHIP ELIGIBILITY

Prior to award, the Missile Defense Agency may request business/corporate documentation to assess ownership eligibility as related to the requirements of the Guide to SBIR/STTR Program Eligibility. These documents include, but may not be limited to, the Business License; Articles of Incorporation or Organization; By-Laws/Operating Agreement; Stock Certificates (Voting Stock); Board Meeting Minutes for the previous year; and a list of all board members and officers. If requested by MDA, the contractor

shall provide all necessary documentation for evaluation prior to SBIR/STTR award. Failure to submit the requested documentation may lead to loss of consideration or award.

USE OF LENOVO INFORMATION TECHNOLOGY PRODUCTS

The contractor shall not procure, use, or deliver Lenovo Information Technology products relating to all work performed under this contract. Questions related to Lenovo Information Technology products should be emailed to MDAIndustrialSecurity@mda.mil.

FRAUD, WASTE, AND ABUSE

To Report Fraud, Waste, or Abuse, Please Contact:

MDA Fraud, Waste & Abuse
Hotline: (256) 313-9699
MDAHotline@mda.mil

DoD Inspector General (IG) Fraud, Waste & Abuse
Hotline: (800) 424-9098
hotline@dodig.mil

Additional information on Fraud, Waste and Abuse may be found in the DoD Instructions of this announcement; sections 3.6 and 4.19.

PROPOSAL FUNDAMENTALS

Proposal Submission

All proposals MUST be submitted online using the DoD SBIR/STTR submission system (https://sbir.defensebusiness.org). Any questions pertaining to the DoD SBIR/STTR submission system should be directed to the DoD SBIR/STTR Help Desk: 1-800-348-0787.

Classified Proposals

Classified proposals **are not** accepted under the MDA SBIR/STTR Program. Contractors currently working under a classified MDA SBIR/STTR contract must use the security classification guidance provided under that contract to verify new SBIR/STTR proposals are unclassified prior to submission. Phase I contracts are not typically awarded for classified work. However, in some instances, work being performed on Phase II proposals will require security clearances. If a Phase II contract will require classified work, the proposing firm must have a facility clearance and appropriate personnel clearances in order to perform the classified work. For more information on facility and personnel clearance procedures and requirements, please visit the Defense Security Service Web site at: http://www.dss.mil/index.html.

Communication

All communication from the MDA SBIR/STTR PMO will originate from the sbirsttr@mda.mil email address. Please white-list this address in your company's spam filters to ensure timely receipt of communications from our office.

Proposal Status

The MDA SBIR/STTR PMO will distribute selection and non-selection email notices to all firms who submit a MDA SBIR/STTR proposal. The email will be distributed to the "Corporate Official" and

"Principal Investigator" listed on the proposal coversheet. MDA cannot be responsible for notification to a company that provides incorrect information or changes such information after proposal submission.

Debriefing

MDA offers debriefings to unsuccessful offerors in accordance with Federal Acquisition Regulation (FAR) Subpart 15.5. Requests for debriefing must be submitted in writing to the MDA SBIR/STTR PMO within 30 calendar days of non-selection notification. Non-selection notifications will provide instructions for requesting a proposal debriefing.

Discretionary Technical Assistance (DTA)

Section 9(b) of the SBIR and STTR Policy Directives allows agencies to enter into agreements with vendors to provide technical assistance to SBIR or STTR awardees, which may include access to a network of scientists and engineers engaged in a wide range of technologies or access to technical and business literature available through on-line data bases.

The purpose of this technical assistance is to assist SBIR awardees in:

- Making better technical decisions on SBIR projects;
- Solving technical problems that arise during SBIR projects;
- Minimizing technical risks associated with SBIR projects; and
- Commercializing the SBIR product or process.

MDA permits award recipients to obtain technical assistance in accordance with the SBIR and STTR Policy Directives through MDA. Alternatively, an SBIR or STTR firm may acquire the technical assistance services described above on its own. Firms must request this authority from MDA and demonstrate in its SBIR or STTR proposal that the individual or entity selected can provide the specific technical services needed. In addition, costs must be included in the cost volume of the offeror's proposal. The DTA provider may not be the requesting firm, an affiliate of the requesting firm, an investor of the requesting firm, or a subcontractor or consultant of the requesting firm otherwise required as part of the paid portion of the research effort (e.g. research partner or research institution).

If the awardee demonstrates this requirement sufficiently, MDA will permit the awardee to acquire such technical assistance itself, in an amount up to $5,000 per year, as an allowable cost of the SBIR or STTR award. The per year amount will be in addition to the award and is not subject to any profit or fee by the requesting firm and is inclusive of all indirect rates. The per-year amount is based on the original contract period of performance and does not apply to period of performance extensions. Requests for DTA funding outside of the Phase I or Phase II proposal submission will not be considered.

PHASE I PROPOSAL GUIDELINES

The DoD SBIR/STTR Proposal Submission system (available at https://sbir.defensebusiness.org) will lead you through the preparation and submission of your proposal. Read the front section of the DoD announcement for detailed instructions on proposal format and program requirements. Proposals not conforming to the terms of this announcement will not be considered.

MAXIMUM PHASE I PAGE LIMIT FOR MDA IS 20 PAGES

Any pages submitted beyond the 20-page limit within the Technical Volume (Volume 2) will not be evaluated**. Your Proposal Cover Sheet (Volume 1), Cost Volume (Volume 3), and Company Commercialization Report (Volume 4) DO NOT count toward your maximum page limit.**

Phase I Proposal

A complete Phase I proposal consists of four volumes:

Volume 1: Proposal Cover Sheet
Volume 2: Technical Volume
Volume 3: Cost Volume
Volume 4: Company Commercialization Report

MDA intends for the Phase I effort to determine the merit and technical feasibility of the concept. The contract period of performance for Phase I shall be six (6) months and the award shall not exceed $100,000. A Phase I Option may be submitted with a period of performance of 6 months and an amount not to exceed $50,000. A list of topics currently eligible for proposal submission is included below, followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time.

References to Hardware, Computer Software, or Technical Data

In accordance with the SBIR Directive, SBIR contracts are to conduct feasibility-related experimental or theoretical R/R&D related to described agency requirements. The object of the Phase I is to determine the scientific and technical merit and feasibility of the proposed effort and quality of performance of the Small Business Concern. It is not for formal end-item contract delivery, and ownership by the Government of your hardware, computer software, or technical data.

Based on this, in your technical proposal, do not use the term "Deliverables" when referring to your hardware, computer software, or technical data. Instead use the term: "Products for Government Testing, Evaluation, and/or Demonstration."

The standard formal deliverables for a Phase I are the Report of Invention and Disclosure, Midterm Status Report, Certificates of Compliance, Computer Software Product (normally not applicable for a Phase I), Prototype Design and Operation Document (normally not applicable for a Phase I), and the Final Report.

PHASE I PROPOSAL SUBMISSION CHECKLIST

All of the following criteria must be met or your proposal will be REJECTED.

____1. The following have been submitted electronically through the DoD submission site by 6:00 a.m. (EDT) 22 June 2016.

_____ a. Volume 1: DoD Proposal Cover Sheet

_____ b. Volume 2: Technical Volume (DOES NOT EXCEED 20 PAGES)**: Any pages submitted beyond this will not be evaluated. Your Proposal Cover Sheet, Cost Volume, and Company Commercialization Report DO NOT count toward your maximum page limit.**

_____ **c. If proposing to use foreign nationals; identify the foreign national(s) you expect to be involved on this project, the type of visa or work permit under which they are performing, country of origin and level of involvement.**

_____ d. Volume 3: Cost Volume. **(Online Cost Volume form is REQUIRED by MDA)**

_____ e. Volume 4: Company Commercialization Report. (required even if your firm has no prior SBIR/STTR awards).

____2. The Phase I proposed cost plus option does not exceed $150,000.

____3. Your firm must be registered with SBA's Company Registry.

PHASE I OPTION MUST BE INCLUDED AS PART OF PHASE I PROPOSAL

MDA implements the use of a Phase I Option that may be exercised at MDA's sole discretion to fund interim Phase I activities while a Phase II contract is being negotiated. Only Phase I efforts selected for Phase II awards through MDA's competitive process will be eligible to have the Phase I Option exercised. The Phase I Option, which must be included as part of the Phase I proposal, should cover activities over a period of up to six months and describe appropriate initial Phase II activities that may lead to the successful demonstration of a product or technology. The Phase I Option must be included within the 20-page limit for the Phase I proposal.

Proposal titles, abstracts, anticipated benefits, and keywords of proposals that are selected for contract award will undergo an MDA Policy and Security Review. Proposal titles, abstracts, anticipated benefits, and keywords are subject to revision and/or redaction by MDA. Final approved versions of proposal titles, abstracts, anticipated benefits, and keywords will appear on the DoD SBIR/STTR awards website (https://sbir.defensebusiness.org).

MDA PROPOSAL EVALUATIONS

MDA will evaluate and select Phase I and Phase II proposals using scientific review criteria based upon technical merit and other criteria as discussed in this announcement document. MDA reserves the right to award none, one, or more than one contract under any topic. MDA is not responsible for any money expended by the proposer before award of any contract. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

MDA Phase I and Phase II proposals will be evaluated based on the criteria outlined below, including potential benefit to the Ballistic Missile Defense System (BMDS). Selections will be based on best value to the Government considering the following factors which are listed in descending order of importance:

a) The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
b) The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.
c) The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

In Phase I and Phase II, firms with a Commercialization Achievement Index (CAI) at or below the 20th percentile will be penalized in accordance with the DoD program announcement.

Please note that potential benefit to the BMDS will be considered throughout all the evaluation criteria and in the best value trade-off analysis. When combined, the stated evaluation criteria are significantly more important than cost or price.

It cannot be assumed that reviewers are acquainted with the firm or key individuals or any referenced experiments. Technical reviewers will base their conclusions on information contained in the proposal. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be contained in the proposal and will count toward the applicable page limit.

Qualified advocacy letter(s) will count towards the proposal page limit and will be evaluated towards criterion C. Advocacy letters are not required for Phase I or Phase II.

A qualified advocacy letter is from a relevant commercial or Government Agency procuring organization(s) working with MDA, articulating their pull for the technology (i.e., what BMDS need(s) the technology supports and why it is important to fund it), and possible commitment to provide additional funding and/or insert the technology in their acquisition/sustainment program. This letter should be included as the last page(s) of your technical upload. Advocacy letter(s) which are faxed or e-mailed separately will NOT be considered.

Phase II Proposal Submission

Per DoD SBIR Phase II Proposal guidance, all Phase I awardees from the 16.2 Phase I announcement will be permitted to submit a Phase II proposal for evaluation and potential award selection. Details on the due date, content, and submission requirements of the Phase II proposal will be provided by the MDA SBIR/STTR Program Management Office either in the Phase I award contract or by subsequent notification. Only firms who receive a Phase I award resulting from the 16.2 announcement may submit a Phase II proposal. The one and only time that Phase II proposals based on the 16.2 Phase I awards may be submitted is during this 16.2 Phase II announcement window.

MDA will evaluate and select Phase II proposals using the Phase II evaluation criteria listed in the DoD Program announcement. While funding must be based upon the results of work performed under a Phase I award and the scientific and technical merit, feasibility and commercial potential of the Phase II proposal; Phase I final reports will not be reviewed as part of the Phase II evaluation process. The Phase II proposal should include a concise summary of the Phase I effort including the specific technical problem or opportunity addressed and its importance, the objective of the Phase I effort, the type of research conducted, findings or results of this research, and technical feasibility of the proposed technology. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. MDA does NOT participate in the DoD Fast Track program.

All Phase II awardees must have a Defense Contract Audit Agency (DCAA) approved accounting system. It is strongly urged that an approved accounting system be in place prior to the MDA Phase II award timeframe. If you do not have a DCAA approved accounting system, this will delay/prevent Phase II contract award.

Approved for Public Release
16-MDA-8575 (22 February 16)

MDA SBIR 16.2 Topic Index

MDA16-001	System-level Post Intercept Assessment
MDA16-002	High-Resolution Measurement Techniques for High Explosive Internal Pressure and Temperature for Lethality Assessment
MDA16-003	Inline Environment Truth Generation
MDA16-004	Chemical and Physical Mechanism Processes for Propulsion Related Signature Events
MDA16-005	Cyber Health and Status Data Collection
MDA16-006	Innovative Ways to Streamline Scenario Generation Across a System of Systems M&S Enterprise
MDA16-007	Intercept Debris Modeling for Non Hit-to-Kill Missile Engagements
MDA16-008	Modeling of the Attenuation Effects of the Ionosphere and Troposphere for Radio Frequency Application
MDA16-009	Modeling of the Attenuation Effects of the Atmosphere for IR/VIS Application
MDA16-010	High Performance Actuators for Solid Propulsion Control Systems
MDA16-011	Radiation Hardened Interceptor Seeker Sensor Technologies
MDA16-012	Software Enhancements to Improve Inertial Measurement Unit Performance
MDA16-013	Additive Manufacturing for Affordable Missile Defense
MDA16-014	Special Tooling and Processes for Repeatable Adhesive Application
MDA16-015	Develop a Repeatable Manufacturing Process for Aerospace Grade Aluminum Alloy Propellant Tanks
MDA16-016	Aft Looking Spectrometer for Plume Characterization and Waking on Re-entry
MDA16-017	Sub-Scale Fly Along Sensor Package
MDA16-018	Optical Signature Modeling of Transmissive Materials
MDA16-019	Modeling of Complex Endo-atmospheric Wakes

MDA SBIR 16.2 Topic Descriptions

MDA16-001 TITLE: System-level Post Intercept Assessment

TECHNOLOGY AREA(S): Battlespace, Information Systems, Sensors, Space Platforms, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop innovative techniques to provide greater robustness assessing success of intercept across multiple sensors and phenomenologies.

DESCRIPTION: To enable shoot-assess-shoot engagements within missile defense applications, a very high confidence must be established for kill assessment, or post-intercept assessment. A successful intercept can prevent the need for follow-on shots and reduce cost. This assessment must include determination of effectiveness of the intercept to determine how well the observed phenomenology matched the predicted physics of the interaction.

Consider a missile defense intercept as a physics interaction among objects under varying conditions, such as strike angle, closing velocity, and range. Various sensing phenomenologies need to be considered from radar to electro-optic, visual as well as parameterizations in frame rates and wavebands. With multiple diverse sensor contributions, the system must determine whether some voting scheme is adequate or whether a better understanding of the physics response by the sensors are expressing common information, or reflecting independent phenomena.

The researcher should consider a radar and an electro-optic or a visual sensor observing the intercept simultaneously and sending a report to the system. Design messages from the sensors to the system that will enable optimal assessment by the system. The developed technique(s) should calculate and report overall confidence in intercept with estimates of effectiveness. Corresponding metrics should be defined and demonstrated.

PHASE I: Develop and demonstrate through analysis, technique(s) to combine intercept information from multiple sensors which accurately assess effectiveness of intercept at the system level. The technique(s) should degrade gracefully when not all sensors are available and a metric should be developed to provide an accurate measure of effectiveness.

PHASE II: Refine and update technique(s) developed in Phase I and demonstrate capability with realistic data from flight tests and physics modeling. A heavy emphasis will be on robustness and reliability of measured results. Messages will need to be defined and worked with the program office to insure adequate information is available to enable the assessment.

PHASE III DUAL USE APPLICATIONS: Demonstrate the technology operationally as part of an element, or a system level test bed. Market technologies to relevant missile defense elements and other DoD entities.

REFERENCES:
1. Retrieved from http:/www.smdc.army.mil/FactSheets/archive/Kill Assessment.

2. U.S. Missile Defense Agency. November 3, 2015. Ballistic Missile Defense System. Retrieved from http://www.mda.mil/index.html.

3. U.S. Department of Defense. Undated. Ballistic Missile Defense Review. Retrieved from http://www.defense.gov/bmdr.

KEYWORDS: kill assessment, hit assessment, post-intercept assessment

MDA16-002 TITLE: High-Resolution Measurement Techniques for High Explosive Internal Pressure and Temperature for Lethality Assessment

TECHNOLOGY AREA(S): Sensors, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop a non-invasive, innovative, and cost-effective methodology for high-resolution measurement of the internal temperatures and pressures of an energetic material during a range of reactive events, from, and including, deflagration to detonation.

DESCRIPTION: Many warhead types have been analyzed and modeled using first-principle techniques; however, the full spectrum of possible responses of High Explosive (HE) sub-munitions/weapons to various stimuli is poorly understood. Experimental test data that captures the various types of low-order response is very limited or not available in existing databases. Development of models for first-principle codes is critical for modeling and simulation of the responses of HE sub-munitions. Experimental data is needed to aid model development, as well as for model benchmarking and validation. Currently modeling approaches are empirical and/or focused on prediction of high-order rather than low-order reactions. Comprehensive modeling for a range of energetic materials requires a new kind of experimental data to fully characterize the internal state of the HE material as it undergoes the range of low-order reactions from deflagration to detonation. Test instrumentation is desired that will reliably measure the temperatures and pressures internal to a HE test article when it undergoes either high-order or low-order reactions. Non-contact instrumentation is desired to avoid affecting the HE response itself with the addition of instrumentation to detect pressure and temperature. If embedded instrumentation, such as taggant, Radio Frequency Identification, or nano-technology is proposed it must be shown that embedding a sensor in the HE test article does not significantly change its response.

PHASE I: Develop an innovative solution to the measurement of pressure and temperature internal to high explosive or energetic materials during deflagration or detonation. High temporal resolution is desired, on the order of a nanosecond; and, the best possible spatial resolution in three dimensions, on the order of cubic micrometers. Through modeling, simulation, and analysis; demonstrate the utility of the proposed approach(s) to measure and characterize the temperatures and pressures of interest. Provide a plan for demonstration of the preferred approach.

PHASE II: Develop a prototype measurement system that can be included in the characterization test of a high explosive or other energetic materials. Demonstrate performance via component and system-level testing that shows the ability to make measurements of internal pressures and temperatures of energetic material under test. Prove performance of the system via demonstration with a test case that can be benchmarked against other measurement techniques.

PHASE III DUAL USE APPLICATIONS: Transition the measurement and characterization system from a developmental unit to a test asset and use it to provide test data for characterization testing of energetic materials. Transition data developed under this program to developers of first-principles codes which model reactions of energetic materials for systems of interest to the government. This technology would benefit insensitive munitions testing of reactive materials (HE and propellants) and other DoD weapon program modeling and simulation. Other commercial applications could include explosive ordinance disposal and safety transport which could leverage this information to better perform these missions.

REFERENCES:
1. Lee and Tarver. December 1980. “Phenomenological model of shock initiation in heterogeneous explosives.” Physics of Fluids, 23 (12). 2362-2372.

2. LL Gibson, DM Dattelbaum, et al. 2014. "Shock initiation sensitivity and Hugoniot-based equation of state of composition B obtained using in situ electromagnetic gauging." 18th APS-SCCM and 24th AIRAPT, Journal of Physics: Conference Series 500 192004.

3. P. R. Guduru, G. Ravichandran, and A. J. Rosakis. Undated. "Observations of transient high temperature vortical microstructures in solids during adiabatic shear banding." PHYSICAL REVIEW E, Vol. 64, 036128.

4. C.H. Fan and J.P. Longtin. 2000. "Laser-based measurement of liquid temperature or concentration at a solid-liquid interface." Experimental Thermal and Fluid Science, 23. 1-9.

5. Brown, et al. 2013. "Investigations of rf Emissions from Hypervelocity Impacts of Various Metals." The 12th Hypervelocity Impact Symposium, Procedia Engineering, 58. 418-423.

6. Koch, et al. 2010. "Hurricane: A simplified optical resonator for optical-power-based sensing with nano-particle taggants." Sensors and Actuators B 147. 573-580.

7. Wang, et al. December 2015. "Ultrasonic wave based pressure measurement in a small diameter pipeline." Ultrasonics, Vol. 63. 1-6.

8. J. M. Gordon, K. C. Gross, and G. P. Perram. February 2014. "Temperature dynamics of aluminized cyclotrimethylenetrinitramine fireballs for event classification." Optical Engineering 53(2), 021106.

KEYWORDS: energetic materials, temperature measurements, pressure measurements, high-speed non-contact instrumentation, deflagration, HE materials characterization

MDA16-003 TITLE: Inline Environment Truth Generation

TECHNOLOGY AREA(S): Battlespace, Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop an innovative, low-cost approach to facilitate the inline generation of environments likely to be encountered by missile defense sensors and weapon systems.

DESCRIPTION: Seek new and innovative approaches to perform inline environment generation for real-time Hardware-in-the-Loop (HWIL) testing and constructive digital simulations and eliminate the nee d for pre-generating environment data, to support Tier 1 and Tier 2 (two levels of end-to-end missile defense simulations) modeling and simulation (M&S). Currently, the government has a full suite of environment models for atmosphere, space, gravity, etc. but execution of these models can impair real-time digital simulation throughput within the M&S Enterprise. For some venues comparatively few test cases have environments "turned on" during simulation execution due in large part to the computation-intensive production of the environment data and its subsequent processing in system-level simulations. What is needed is a new, innovative process to perform inline, environment generation in system-level simulations without increasing total test case runtime by more than 10% (threshold)/5% (objective) without significantly reducing the fidelity of the system-level simulations. This innovative process should allow more test cases to be executed with environments "turned on", thereby enhancing the realism of the simulations in the M&S Enterprise and allowing the production of greater quantities of credible decision quality data. The optimal solution could utilize a modular "plug and play" approach that would facilitate technology insertions (i.e., replacing one environment model with a comparable model) while requiring limited recoding and/or changes in hardware. Rather than seeking new environment models, the government is seeking ways to make better use of the existing environment models and/or environment data. Techniques to achieve this may include improvements in mathematical techniques; data processing hardware; software acceleration; a hybrid approach;

optimization; or other techniques.

PHASE I: Design and develop a concept for inline environment truth generation by utilizing a model such as the SHARC/SAMM Atmosphere Generator in an unclassified missile defense simulation or any similarly complex non-missile defense simulation. The goal for Phase I is to demonstrate the proof-of-concept for the offeror's approach while achieving at least the threshold performance and to specify the Phase II development plan that will deliver a prototype that incorporates additional environment models and/or environment data, and performance improvements.

PHASE II: Develop a prototype for inline environment truth generation by utilizing models such as SAMM, MODTRAN, PROPMOD, and WBMOD in an unclassified or possibly classified missile defense simulation. The goal for Phase II is to demonstrate that these models can be incorporated into the prototype without major rework or significant additional cost while achieving the objective performance.

PHASE III DUAL USE APPLICATIONS: Complete development of the inline environment truth generator. Add the remaining natural environment and manmade environment models needed by the government. Incorporate the inline environment truth generator into the extant missile defense simulations. The contractor should pursue commercialization of the various technologies developed in Phase II+ for other military and commercial users. Any users with simulations requiring the assessment of the influence of natural and manmade environments on system performance will be keenly interested in technology that allows them to use their existing environment models or easily insert alternative models while improving the throughput of their simulations. The commercialization prospects would increase greatly if the technologies developed also are applicable to models other than environment models.

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KEYWORDS: simulation environments, software acceleration, hardware acceleration, optimization, SAG, SAMM, MODTRAN, PROPMOD, WBMOD

MDA16-004 TITLE: Chemical and Physical Mechanism Processes for Propulsion Related Signature Events

TECHNOLOGY AREA(S): Air Platform, Information Systems, Sensors, Space Platforms

OBJECTIVE: Extend capabilities of existing, propulsion-related signature tools to characterize emission phenomena over a broad portion of the electromagnetic spectrum, from ultraviolet (UV) through the long-wave infrared (LWIR).

DESCRIPTION: State of the art propulsion related signature models include exhaust plume phenomena observed in the short-wave through mid-wave infrared portions of the electromagnetic spectrum. Missile defense applications would benefit from increased capabilities in the form of more accurate signature characterizations across a wider region of the electro-optic (EO) spectrum from the UV through LWIR. The general suite of propulsion-related signature modeling tools (which include 2-D/3-D computational fluid dynamic codes, Direct Simulation Monte Carlo models and radiation transport solvers) provide the basic framework for flow-field and signature generation, but do not contain the underlying chemical and physical mechanisms and processes to properly account for all spectral emissions. The driving phenomena in these band regions (e.g. particle optical properties, molecular band model parameters, molecular collision cross-sections, and quenching/excitation mechanism pathways) are not well established or characterized. Passive signatures in these wavebands have been measured in data collections from many flight tests as well as other past DoD-sponsored missions, but the ability to model these observations accurately needs improvement. The emission phenomena include all EO features that may be observed passively through the entire missile flight envelope, from launch through boost phase to impact, that are generated from associated propulsion subsystems or other related phenomenology. While not comprehensive, the list of relevant propulsion events to be examined across the UV to LWIR bands includes: boost phase plumes for all types of propellant systems; propellant fuel and oxidizer venting; particle trails; and solid rocket motor chuffing. Event observables include molecular and particle emission and scattering.

PHASE I: For one propulsion-related signature event observable of interest, identify the chemical and physical phenomena needed to model, and properly account for, the complete process (from propellant combustion through signature emission); and, prioritize the importance of each component as a function of altitude, velocity, and spectral band. Finally, select one important complex component and demonstrate an innovative methodology (theoretical or experimental) to solve for that component unknown. If possible, demonstrate this complex component upgrade within the existing government propulsion related signature tools. Maximum practical use of the existing government propulsion related flow-field and signature framework is desired to reduce both development and validation costs.

PHASE II: Identify additional signature processes and other pertinent phenomenology needed to model propulsion-related signatures in the alternative bands. Demonstrate these new or updated code modules, chemical reaction, and/or physical process databases within the existing suite of government propulsion related signature models. Further, maximum practical use of available plume software is desired to reduce both development and validation costs. Deliver all demonstrations, upgraded software modules/databases, technical documentation, and validation to the government for independent test and evaluation.

PHASE III DUAL USE APPLICATIONS: Transition advanced methodology into existing signature models used to support government elements. Apply software to a variety of missile defense sensor and missile interceptor systems as well as other problems of interest to the government.

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KEYWORDS: plumes, boost phase signatures, high altitude, ultraviolet, visible, near-infrared, long-wave infrared, computational fluid dynamic, Direct Simulation Monte Carlo, particle optical properties, kinetic rates, collisional cross sections, two-phase flow; reacting flow

MDA16-005 TITLE: Cyber Health and Status Data Collection

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop new and novel methods that not only collect the correct cyber data from modeling and simulation (M&S) federated and non-federated simulations, but help identify what data should be collected and how it should be collected for analysis and protection requirements.

DESCRIPTION: There is a need to better understand the health and status of M&S systems that connect to larger M&S systems. Most models focus on the object of representation and little technical rigor and planning is conducted for many of the cybersecurity risks. Government M&S needs a novel method for automatically collecting and analyzing the health and status of cybersecurity data for individual models and simulations that can also be used in a large federated or integrated system-level simulation. A key aspect of this technology needs to focus on data protection and making the cybersecurity data collected easily accessible yet secure. A new approach to cyber operations is a key to success. This effort should focus on the awareness aspect of that approach involving automated systems and processes to provide a complete, accurate, real-time understanding of the health and status of the network(s). The maturity of the cyber model should be "Information Enabled" and indicate that the organization(s) within the community are all aware of the issues related to security and have the processes and mechanisms in place to identify security relevant events. The goal at this level is to improve upon the information sharing mechanisms within the community to enable the community to effectively correlate seemingly disparate pieces of information, especially information relevant to cybersecurity.

PHASE I: Develop a proof of concept design/study and a concept of operations. Identify designs/models, and conduct a feasibility assessment for the proposed mathematical technique, model, and/or methods. Work should clearly validate the viability of the proposed solution with a clear concept-of-operation document. The contractor should identify the strengths/weaknesses associated with different solutions, methods, and concepts.

PHASE II: Based on the results and findings of Phase I, develop and refine the proposed solution. Validate the feasibility of the Phase I concept by development and demonstrations that will be tested to ensure performance objectives are met. Validation would include, but is not limited to, system simulations, operation in test-beds, or operation in a demonstration subsystem. This phase should result in a prototype with substantial commercialization potential. This prototype design will be used to form the development and implementation of a mature, full-scale capability in Phase III.

PHASE III DUAL USE APPLICATIONS: The contractor will apply the innovations demonstrated in the first two phases to one or more missile defense applications. The objective is to demonstrate the scalability of the developed technology, transition the component technology to the missile defense M&S Enterprise, mature it for insertion, and demonstrate the technology in M&S environments.

The contractor will pursue commercialization of the various technologies and models developed in Phase II for potential commercial uses in cybersecurity. Scale-up the capability from the prototype utilizing the new hardware and/or software technologies developed in Phase II into a mature, field-able capability.

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KEYWORDS: system of systems simulations, cybersecurity, enterprise, modeling and simulation, software development testing, simulation testing, automation

MDA16-006 TITLE: Innovative Ways to Streamline Scenario Generation Across a System of Systems M&S Enterprise

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop a set of capabilities that significantly improves the quality and timeliness of scenario generation and streamlines the development, integration, and validation of those scenarios for System of Systems (SoS) integrated system-level simulations.

DESCRIPTION: The government's modeling and simulation enterprise desires a new, innovative approach to streamline scenario generation across the SoS M&S Enterprise (specifically Hardware-in-the-Loop and Digital system level simulations). The current scenario generation process is a cumbersome, sequential resource and time intensive effort that requires work by every component of the integrated simulation plus supporting organizations impacting the responsiveness of the M&S. The Scenario generation process includes a physical representation of the threat (Red Force), Blue Force, and environments. Currently this is a time-intensive manual process where scenario requirements are generated to meet engagement and test objective goals with the least amount of test cases and scenarios as possible. These scenarios are then fed into a Test Case Description Document that is used to create the SoS scenarios. This topic seeks solutions to the following issues with the current scenario generation process: 1) reduce the time it takes to generate the scenarios; 2) improve object clarity in how the scenarios meet event objectives; 3) reduce and prioritize the scenarios generated; 4) improve the mechanism to validate the scenarios against configurations; 5) improve re-use of validated scenario packages that can be used across multiple events and multiple campaigns; 6) develop methods for consistent comparisons across events and campaigns. Proposed solutions must be able to span across multiple intended uses and levels of abstraction, taking into account the need of constituent systems.

PHASE I: Design and develop improved solutions, methods, and concepts for streamlined scenario generation. The solutions should capture the key areas where new development is needed, suggest appropriate methods and technologies to minimize the time intensive processes, and incorporate new technologies researched during design development. Define the architecture and validity in SoS simulation enterprise.

PHASE II: Complete a detailed SoS prototype design incorporating government performance requirements. The contractor will coordinate with the government during prototype design and development to ensure that the delivered products will be relevant to ongoing and planned missile defense projects. This prototype design will be used to form the development and implementation of a mature, full-scale capability in Phase III.

PHASE III DUAL USE APPLICATIONS: Scale-up the capability from the prototype utilizing the new hardware and/or software technologies developed in Phase II into a mature, field-able capability. Work with missile defense integrators to integrate the technology for a missile defense system level test-bed and test in a relevant environment.

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KEYWORDS: system of systems simulations, scenario generation, enterprise, modeling and simulation, software development testing, simulation testing

MDA16-007 TITLE: Intercept Debris Modeling for Non Hit-to-Kill Missile Engagements

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Extend fast-running intercept debris initial condition modeling to address debris from non hit-to-kill (NHTK) missile engagements.

DESCRIPTION: Modeling debris from NHTK missile engagements poses a number of challenges including sensitivities to engagement conditions, interceptor warhead characteristics, and threat characteristics. Relevant engagement conditions include the standoff distance, closing speed, engagement geometry, and number of fragment impacts. Relevant interceptor warhead characteristics include fragment mass, shape, and material; fragment number, density and pattern; fragment speeds; and blast effects. Relevant threat characteristics include geometry, materials, and payload type. Outputs should include fragment characteristics needed to support the simulation of fragment propagation, fragment signatures, and sensor scenes. Outputs should be based on time-ordered penetration and damage modeling for interceptor warhead fragments including shock-to-detonation effects for threats containing high explosives. Debris modeling for NHTK engagements should consider fragment characteristics and correlations that are less sensitive to engagement type. Innovative debris modeling for NHTK engagements should be anchored using a combination of data from light gas gun, arena, sled, and flight tests. The tool developed needs to be capable of actively supporting Hardware-in-the-Loop ground testing and range safety assessments for flight tests in digital M&S venues.

PHASE I: Identify and prioritize sensitivities for NHTK debris modeling including engagement conditions, interceptor characteristics, and threat characteristics. Develop an approach and conceptual model to modeling the primary sensitivities, penetration and damage, and correlations for NHTK debris. This approach should be generally consistent with HTK debris modeling in terms of outputs and execution time. Identify data and an approach for anchoring and validation.

PHASE II: Based upon the findings from Phase I, the contractor will complete a detailed prototype design of the software/model incorporating government performance requirements. This prototype design should be used to form the development and implementation of a mature, full-scale capability in Phase III that could run in real time.

PHASE III DUAL USE APPLICATIONS: Execute the approach to address limitations of the initial model developed in Phase II and to complete anchoring and validation. Generate complete documentation including a basis of confidence. Support integration into other models and simulations.

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http://www.mda.mil/global/documents/pdf/KIDD_Product_Sheet_Mar2012.pdf

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KEYWORDS: modeling, simulation, intercept debris, fragmentation

MDA16-008 TITLE: Modeling of the Attenuation Effects of the Ionosphere and Troposphere for Radio Frequency Application

TECHNOLOGY AREA(S): Information Systems, Sensors

OBJECTIVE: Develop and demonstrate methods to enhance the accuracy of ionosphere models across missile defense application Radio Frequency (RF) bands to address lowering the probability of false alarm, the effect on signal to noise ratio, and the effect on track accuracy.

DESCRIPTION: Seek creative applications for modeling RF ionospheric and tropospheric effects in real time in support of future ground and flight tests. Radar wavebands of interest include UHF through X band and the K band. Numerous highly ranked, persistent effects are caused by the atmosphere, notably the troposphere and ionosphere. Some of the effects that are of interest include: ionospheric scintillation, range delay, ionospheric loss, tropospheric scintillation, tropospheric refraction and auroral clutter. Currently there are models that address the ionosphere effects on the RF bands and to a lesser extent the effects of the troposphere. These models produce medium to high fidelity results; however, there are current limitations in the development of real time modeling of these effects within the specified bands. The desired model should enable the prediction and preparation for the effects on the radar systems in regards to performance, fidelity, and/or resolution in real time. Techniques to achieve this may include improvements in mathematical techniques, improvements in data processing, hardware or software acceleration or a hybrid approach, optimization, or other techniques.

PHASE I: Provide a proof of concept of the model. The model should capture the key areas where new development is needed, suggest appropriate methods and technologies to realize the desire of real-time modeling based on the research performed, and incorporate new technologies researched during design development. The contractor should identify the attenuation effects along the RF bands for the effects of the ionosphere and troposphere.

PHASE II: Based upon the findings from Phase I, the contractor should complete a detailed prototype design of the software/model incorporating government performance requirements. This prototype design should be used to form the development and implementation of a mature, full-scale capability in Phase III that could run in real time.

PHASE III DUAL USE APPLICATIONS: Scale-up the capability from the prototype utilizing the new software/model technologies developed in Phase II into a mature, field-able capability. Modeling of the effects of the ionosphere would be applicable to industries that utilize RF sensors, communications, and/or radars.

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3. J.K. Hargreaves. 1992. “The Solar-Terrestrial Environment: An Introduction to Geospace.” Cambridge University Press.

4. J.V. Eccles, R. D. Hunsucker, D. Rice, and J. J. Sojka. 2005. “Space weather effects on midlatitude HF propagation paths: observations and a data-driven D-region model.” Space Weather, 3, S01002,

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KEYWORDS: radio wave, wave, sensor, ionosphere, ionospheric, troposphere; tropospheric, atmosphere, environment effects, radar, model, simulation, radio frequency, attenuation

MDA16-009 TITLE: Modeling of the Attenuation Effects of the Atmosphere for IR/VIS Application

TECHNOLOGY AREA(S): Information Systems, Sensors

OBJECTIVE: Develop enhanced models for atmospheric (troposphere, ionosphere, etc.) effects on light propagating in different visible (Vis) /infrared (IR) frequency bands, for use with a scene generation tool to help create Vis/IR scenes in real time.

DESCRIPTION: Numerous higher order persistent effects on radiation are caused by the atmosphere, notably the troposphere and ionosphere. Some effects that are of interest are: atmospheric attenuation, cloud background effects, earth limb effects, celestial background effects, and auroral effects. Current models that address atmospheric effects on Vis/IR radiation produce medium to high fidelity results; however, they do not provide results in real time. The desired model should enable the prediction and preparation of effects on the sensor systems with regard to performance, fidelity, and/or resolution in real time with the possibility of use in concert with scene generation tools like Fast Line-of-sight Imagery for Target and Exhaust-plume Signatures (FLITES). Techniques to achieve this may include improvements in mathematical techniques, improvements in data processing, hardware or software acceleration or a hybrid approach, optimization, or other techniques.

PHASE I: Provide a proof of concept of the model. The model will capture the key areas where new development is needed, suggest appropriate methods and technologies to realize the desire of streamlining scenario generation based on the research performed, and incorporate new technologies researched during design development. The contractor should identify the attenuation effects along the Vis/IR bands for the effects of the atmosphere (ionosphere and troposphere).

PHASE II: Based upon the findings from Phase I, the contractor will complete a detailed prototype design of the software/model incorporating government performance requirements. This prototype design should be used to form the development and implementation of a mature, full-scale capability in Phase III that could run in real time.

PHASE III DUAL USE APPLICATIONS: Scale-up the capability from the prototype utilizing the new software/model technologies developed in Phase II into a mature, fieldable capability. Deploy the fully tested, verified, and validated missile defense capability. Modeling effects of the atmosphere would be applicable to

industries that utilize sensor and satellites in support of future ground and flight tests.

REFERENCES:
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KEYWORDS: visible, infrared, sensor, ionosphere, ionospheric, troposphere, tropospheric, atmosphere, environment, environment effects, model, simulation, attenuation

MDA16-010 TITLE: High Performance Actuators for Solid Propulsion Control Systems

TECHNOLOGY AREA(S): Electronics, Materials/Processes, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop and demonstrate innovative architectures and/or high temperature electronics for increasing the temperature capability of actuators used with proportionally controlled valves/thrusters.

DESCRIPTION: Seek solid propellant, propulsion control systems with longer operation times, increased performance, and reduced size, weight, power, and cost (SWaP-C). There is particular interest in developing and maturing robust Solid Propulsion Control Systems (SPCS)component technologies. Solid propellant exhaust gases are commonly 2,000-4,000°F while the actuator to valve/thruster interface commonly must be limited to less than 200-300°F. This relatively low temperature limit at the actuator interface is often a driving design factor in many propulsion control systems. The development and maturation of proportionally controlled actuators that are capable of enduring higher temperatures while aiming to maintain performance and/or reduce SWaP-C will improve the

robustness of future SPCS architectures. Successful development of higher temperature capable actuators has the potential to increase the operation times of future SPCS and offer propulsion vendors increased system design flexibility. The proposer could potentially achieve these desired improvements through innovative actuator architectures or designs, high temperature electronics focused on actuators, or enhanced materials for actuators.

PHASE I: Develop a proof of concept solution; identify candidate materials, electronics, technologies, or actuator architectures. Complete a preliminary evaluation of the proposed improvement(s). Complete an initial design for the actuator technology to demonstrate the proof of concept. Include laboratory experimentation and/or modeling as appropriate to verify the proposed concept. Deliver an initial design for the prototype along with performance estimates.

PHASE II: Expand on Phase I results by completing detailed prototype design and produce components for testing in a simulated environment that can demonstrate the performance of the technology. Testing should verify design assumptions and performance estimates. Include a detailed design and detailed performance analysis from the prototype testing.

PHASE III DUAL USE APPLICATIONS: Work with the appropriate missile interceptor integrator (prime contractor, propulsion vendor, or actuator vendor) to refine the requirements and demonstrate the technology in a relevant environment. A successful Phase III would transition the technology into a missile defense application.

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KEYWORDS: actuator, SDACS, high temperature electronics, proportionally controlled, control system, valve, thruster

MDA16-011 TITLE: Radiation Hardened Interceptor Seeker Sensor Technologies

TECHNOLOGY AREA(S): Electronics, Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Design, develop, and demonstrate high performance long-wave infrared (LWIR) sensor technologies for interceptor systems that can resist or ameliorate the deleterious effects of radiation in the near-Earth orbital environment.

DESCRIPTION: Over the course of an engagement, an interceptor seeker may be exposed to background radiation or radiation resulting from nuclear events (including x-ray, prompt and persistent gamma, single event effects, total ionizing dose, and optical flash) which may adversely affect sensor components (e.g. focal plane arrays, readout integrated circuits, memories, processors, and other electronic components). This topic seeks innovative sensor technologies that are radiation-hardened either by process, by design, by architecture, or by a combination of these approaches. Ideally, hardening approaches should enable sensors to survive and reliably operate in these environments without increasing weight or decreasing performance. In addition, more information on radiation degradation mechanisms and the degree of radiation hardness achieved through various hardening approaches is

desired.

PHASE I: Identify the LWIR sensor component or subsystem which is assessed to be vulnerable to the space radiation environment specified above and elaborate on the specific phenomenology involved.
Document proposed techniques to improve the sensor component or subsystem design that enhance the radiation hardness and compare to available experimental results. Report should include a plan to experimentally test proposed techniques and incorporate them into the sensor system. Any limitations of the proposed techniques (specifically for radiation intensity or duration) should be identified, along with mitigation techniques which might be reasonably implemented during Phase II.

PHASE II: Implement the concepts developed in Phase I with the identified improvements. Results should be extrapolated to device operation within the orbital environment or perform experiments within a space environment simulator that replicates or closely approximates the spectrum of radiation in the orbital environment. Approaches based on theoretical methods should be experimentally validated. Sensor performance and service life should be estimated. Projects should identify device improvements that could extend service life and test a radiation resistant prototype in an orbital environment simulator or reasonable analogue. Validation of results at the component level is encouraged.

PHASE III DUAL USE APPLICATIONS: Manufacture IR sensor components that incorporate the design(s) developed in Phase II. Document their performance in a realistic space radiation simulator or a suitable analogue. Perform a prolonged, mission simulation test in which the subsystems are operated within the radiation environment specified above. Report on their expected performance, service life, operational limits, and market forecasts based on the results of those tests.

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KEYWORDS: strained layer superlattice, radiation resistance, radiation hardened, long wavelength infrared, LWIR, focal plane array, FPA, interceptor seeker

MDA16-012 TITLE: Software Enhancements to Improve Inertial Measurement Unit Performance

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop and demonstrate innovative approaches for advanced and adaptive software that enhances any Inertial Measurement Unit's (IMUs) long duration performance through severe environments. The expectation is to increase IMU accuracy by reducing sensor error accumulation.

DESCRIPTION: IMUs provide onboard navigational and positional capability to aid guidance and tracking systems. Gyroscopes and accelerometers employed in missile defense IMU applications encounter severe shock and vibration during all phases of operation. In addition, IMU in flight systems (interceptors, airborne platforms, and space assets) are constrained by limits on size, weight, power, and cost (SWaP-C) while requiring high performance. This topic seeks innovations which increase IMU accuracy and decrease SWaP while enabling continuous operation through harsh environments without degradation in performance. In particular, the government seeks innovative software solutions that reduce total error accumulation to enhance the performance capabilities of any IMU during long operating times to include operation in harsh environments and without the use of external aids. The performance improvements provided by the software are expected to be at least two times better than the current state of the art IMU. Solutions should address both the software and the desired implementation electronics. Emphasis will be placed on solutions that are portable, modular, do not increase the SWaP-C, and can be easily implemented on existing or new IMUs.

PHASE I: Develop the conceptual framework or preliminary design for the new and innovative IMU software and electronics that exceeds current IMU performance. Perform modeling, simulation and analysis (MS&A) and/or laboratory experimentation to demonstrate the proof of concept. Proof of concept demonstration may be subscale and used in conjunction with MS&A results to verify scaling laws, feasibility and demonstrate the ability to maintain performance standards in realistic flight environments. Although not desired, Offeror's are highly encouraged to team with manufacturers capable of incorporating the developed technology into useable product lines. The Government will not provide contact information. Deliver an initial design for the prototype along with performance estimates, software analysis and IMU integration/implementation path.

PHASE II: Complete critical design, demonstrate and validate the use of the technology on an IMU prototype. Evaluate the effectiveness of the technology against a non-enhanced IMU for missile defense applications through testing in simulated environments. Updated MS&A and characterization testing within the financial and schedule constraints of the program will be performed to show level of performance achieved compared to stated government goals and comparison between predictions and test results.

PHASE III DUAL USE APPLICATIONS: Work with missile defense integrators to integrate the software technology into a critical system application, for a missile defense application system level test-bed and testing in a relevant environment. This phase will demonstrate the application to one or more government element systems, subsystems, or components as well as the product's performance improvements. When complete, an analysis will be conducted to evaluate the ability of the technology to provide accurate navigation capability in a real world situation.

REFERENCES:
1. Missile Defense Agency. Undated. Overview of missile defense systems. Retrieved from http://www.mda.mil

2. Department of Defense. Undated. Link to documents with some information on some BMD near-term and long-term capabilities. Retrieved from http://www.defense.gov/bmdr

3. Department of Defense. Undated. MIL-STD-810, Environmental Engineering Considerations and Laboratory Tests.

4. SMC-S-016. Undated. Air Force Space Command and Space and Missile Systems Center document. Test Requirements for Launch, Upper-Stage and Space Vehicles.

5. Northrop Grumman. 2013. "LN-200 FOG Family Advanced Airborne IMU/AHRS." Retrieved fromhttp://www.northropgrumman.com/Capabilities/LN200FOG/Documents/ln200.pdf.

6. Honeywell. 2012. "Inertial Measurement Units." Retrieved from http://aerospace.honeywell.com/en/products/communication-nav-and-surveillance/inertial-navigation/defense-navigation/inertial-measurement-units/hg1700.

KEYWORDS: IMU, software, electronics, inertial measurement unit

MDA16-013 TITLE: Additive Manufacturing for Affordable Missile Defense

TECHNOLOGY AREA(S): Materials/Processes, Space Platforms, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Leverage advancements in additive manufacturing technologies to reduce cost and/or shorten delivery lead times of non-critical parts for missile defense applications, including missiles, kill vehicles, sensors, and radars.

DESCRIPTION: This effort is primarily geared towards replacing non-critical parts with parts made using additive manufacturing methods. Oftentimes, aerospace parts that need to be manufactured have long-lead times for procurement, or the supplier is no longer in the business of making the parts. Advancements in additive manufacturing could be used to address this situation. Additive Manufacturing (AM) is a name to describe technologies that build 3D objects by adding layer-upon-layer of material. The term AM encompasses many technologies including subsets like 3D Printing, Rapid Prototyping (RP), Direct Digital Manufacturing (DDM), layered manufacturing, and additive fabrication. One hurdle in implementing these new manufacturing methods for replacement parts is the stringent, time consuming, and costly qualification processes that must be followed because of the change in manufacturing process or material. The current limitation for applying additive manufacturing methods to aerospace part fabrication is that most of the processes create microstructure that is significantly different than traditional manufacturing processes. While the microstructure that results within a specific part is often repeatable, it has been difficult to control and therefore tends to be unique in each type of part. There are currently no accepted certifications for additive manufacturing equipment, processes, or the resulting material; therefore, each part must be approached individually to receive certification. Before these parts can be trusted or receive flight certification, the material and the manufacturing process need to be certified to establish parameters for getting the best results in large-scale production. This topic seeks the ability to produce non-critical parts which have the potential to transform logistics and sustainment practices and to provide a multitude of suppliers to support more competitive sourcing and reduce supply chain brittleness. These parts include but are not limited to such items as brackets, ducting, housings, shrouds, covers, and hoses. Additive manufacturing of parts for missile defense application components could also be a basis for an anti-obsolescence parts program. Produced parts should be manufactured using aerospace quality materials and meet required specifications and tolerances.

PHASE I: Develop and demonstrate additive manufacturing process(es) to rapidly manufacture and qualify non-critical aerospace parts, with a focus on key elements of the missile defense systems. Identify and prioritize parts to pilot the new manufacturing processes and certifications approaches. Document steps on how parts were chosen, how key qualification issues were addressed, and lessons learned for implementing new manufacturing methods on similar parts in the future.

PHASE II: Demonstrate repeatability of the process(es) developed in Phase I and scale them up to verify other components. Select representative materials that would be used in non-critical parts. Fabricate a set of material test samples and demonstrate that the material properties (e.g., elastic modulus and ultimate strength) match the material properties for forged samples of the same materials. Working with appropriate engineering authorities to work through qualification of manufacturing processes, pilot the process on 2-3 identified parts employed in missile defense. Provide data useful for design rules as well as details on how to specify and evaluate similar products supplied by different vendors. Develop plans for implementing an anti-obsolescence part program based on additive

manufacturing processes/parts.

PHASE III DUAL USE APPLICATIONS: Further commercialize the capability to qualify replacement parts. Enhance the automation of the process and work with missile defense integrators to integrate the technology into missile defense kill vehicles, sensors, and radar manufacturing processes.

REFERENCES:
1. Dr. M Kinsella, AFRL, and Dr. C. Clinton, NASA MSFC. June 2015. Additive Manufacturing Qualification and Certification for Space and Missile Applications Workshop, National Space and Missile Materials Symposium, Chantilly, VA.

2. 2015. "Creating Innovative Paths Towards Game-Changing Results." Agenda. Defense Manufacturing Conference.

KEYWORDS: additive manufacturing, sustainment, reverse engineering, qualification, 3D printing

MDA16-014 TITLE: Special Tooling and Processes for Repeatable Adhesive Application

TECHNOLOGY AREA(S): Materials/Processes, Space Platforms, Weapons

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OBJECTIVE: Develop application process(es) for applying Liquid Locking Compounds (LLCs) used in missile production and deliver a process solution along with associated tooling to enable reproducible application of LLC for missile components.

DESCRIPTION: This topic seeks to develop innovative, reliable, and repeatable volumetric dispensing processes for applying liquid LLCs or equivalent fluids. The use of adhesive locking features or LLCs as a means of providing a secondary locking feature has been used for decades across many missile defense programs. These compounds are intended to augment preload in the resistance to vibration-induced loosening; however, where there are a number of specifications for prevailing torque locking features depending on the type of design (e.g., nut, bolt, helicoil, insert, etc.), few quantitative process specifications and/or specialized tooling solutions exist for the application of LLCs. As such, variability in application quantity and location exists between production floor operators, resulting in a corresponding variability in the application and robustness of the threaded fastening system. The issue of variability is of primary concern in many threaded fastening systems used in aerospace applications that incorporate locking features that do not depend on fastener preload to function as a resistance to fastener rotation. The primary desire of this topic is to reduce this variability and develop highly reproducible applications of liquid locking compounds through robust processes and/or tooling solutions to aid in the application. Potential solutions of interest include, but are not limited to, enhancements to industry applications that leverage current methods/tools such as micro-pipetting devices and techniques that afford dispensing of controlled, reproducible liquid volumes.

PHASE I: Characterize the LLCs to identify processing sensitivities, determine proper cure time, and the minimum amount of LLC that is required to achieve optimum breakaway torque values. Develop process(es) for application of the LLC and deliver an initial concept/tool for reproducible application.

PHASE II: Deliver a comprehensive Phase II test, verification, and validation plan that would support Phase II demonstration, test, and implementation activities. Develop and demonstrate the prototype application process(es) as well as the design for associated tooling for the application of the LLC.

PHASE III DUAL USE APPLICATIONS: Automate the LLC application process(es) and implement the solution as part of a pilot program in collaboration with select Original Equipment Manufacturers on programs of interest to the

government. Further commercialize the capability to benefit other DoD Agencies, NASA, and other potential commercial partners.

REFERENCES:
1. Johnny L. Golden, et. al. September 2012. "Process Sensitivity, Performance, and Direct Verification Testing of Adhesive Locking Features." NASA. Landley Research Center, Hampton, VA.

2. Patrick J. Courtney and Mike Shannahan. October 2002. "Assembly Adhesives." Henkel Loctite Corporation.

KEYWORDS: Loctite, liquid locking compounds

MDA16-015 TITLE: Develop a Repeatable Manufacturing Process for Aerospace Grade Aluminum Alloy Propellant Tanks

TECHNOLOGY AREA(S): Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop and demonstrate a manufacturing process that consistently reproduces an ultra-lightweight propellant tank design from aerospace grade aluminum alloys (e.g. Aluminum 2219, ultra-lightweight aluminum alloy, etc.).

DESCRIPTION: Seek optimized manufacturing process(es) for aerospace grade aluminum alloy tank design to include a high-quality joint in the fabricated structure containing a microstructure consistent with the finished aluminum alloy component. Significant fuel cost savings can be realized in the aerospace industry by employing lightweight materials in the design and fabrication of vehicular components. To date, the exploitation of lightweight aluminum alloys in component fabrication has been restricted due to their limited formability at room temperatures in conventional metal stamping processes. Stir welding is a current process that generates high-quality joints in the fabricated structure and is the baseline joining process for other emerging aerospace aluminum alloy structures such as cryogenic tanks and lightweight structures. This topic seeks improvements to this process or the forming process to produce a more practical, elevated-temperature, rapid-production, manufacturing system for the production of ultra-lightweight aluminum components. Specific areas of interest include incorporating solid state stir welding techniques to enable and expand stir welding to other high-strength, high-temperature alloys using solid state joining. Additional areas of interest include incorporating advancements in ultrasonic vibration technology to facilitate the successful fabrication of the finished propellant tank. Proposed manufacturing process improvements should demonstrate the capability to produce parts to within 0.76 mm (1/30th of an inch) with minimal to no post-process machining for the finished part.

PHASE I: Develop an innovative aerospace grade aluminum alloy fabrication process for production of lightweight propellant tanks. Develop and demonstrate the ability to produce high quality joints and the ability to minimize production non-conformance.

PHASE II: Design, fabricate, and test the prototype elevated-temperature manufacturing system and solid state joining process. The final design should meet the desired level of operational performance and be readily adaptable to future vehicle designs. Computer modeling should be used in conjunction with testing results to optimize process parameters in order to enhance component formability. The prototype should offer flexible control features to allow for process optimization. Verify and validate the finished ultra-lightweight aluminum alloy microstructure relationship to grain size, orientation, service loads, test loads, and mechanical response are adequate for intended operational goals.

PHASE III DUAL USE APPLICATIONS: Develop reliable and repeatable propellant tank fabrication manufacturing processes that are ultra-light weight and compatible with intended operating conditions and dynamic environment. Further commercialize the capability to benefit other DoD Agencies, NASA, and other potential commercial partners.

REFERENCES:
1. Jeff Ding, Bob Carter, Kirby Lawless, Dr. Arthur Nunes, Carolyn Russell, Michael Suites, and Dr. Judy Schneider. February 14, 2008. "A Decade of Friction Stir Welding R&D At NASA's Marshall Space Flight Center And a Glance into the Future."

2. L.E. Murr, G. Liu, and J.C. McClure. 1997. "Dynamic recrystallisation in the friction-stir welding of aluminum alloy 1100." Journal of Materials Science Letters 16 (22). 1801–1803.

3. R.E. Sanders. 2001. "Technology Innovation in aluminum Products." The Journal of The Minerals, 53(2). 21–25.

KEYWORDS: solid state stir welding, advanced manufacturing, ultra-lightweight propellant tank

MDA16-016 TITLE: Aft Looking Spectrometer for Plume Characterization and Waking on Re-entry

TECHNOLOGY AREA(S): Electronics, Sensors, Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop a spectrometer that can be mounted on the aft closure of a Re-entry Vehicle (RV) to observe re-entry waking or on the side of a booster to collect plume spectra.

DESCRIPTION: Currently, optical measurements available on target plumes and re-entry wakes are collected by air or ground assets which view the wake/plume photons after the observables have been filtered through the atmosphere. Because these sources are highly spectral (i.e., non-gray emission), the transmission through the atmosphere tends to remove a significant amount of the information needed to anchor models that simulate these phenomena. This topic solicits innovative approaches to mounting a spectrometer on the aft closure of the RV. This innovation would enable collection of near-field spectral measurement data that is unfiltered by the atmosphere. The acquired, unfiltered spectral measurement data should improve the current wake/plume models and expand our knowledge of the wake/plume species and the underlying chemistry of the wake/plume phenomena which are significant contributors to the observed wake/plume phenomenology.

PHASE I: Develop viable RV mounted spectrometer concepts for obtaining near-field wake/plume spectral measurements. Provide size, weight, and power estimates of the proposed concepts. Describe the types of species that should be detected and provide measurement accuracies that should be achieved by the spectrometer. Describe the expected wake/plume chemistry and resulting phenomenology that should be observed with the proposed spectrometer concept. Develop a schedule and discuss plans for transitions from Phase I through Phase III/commercialization.

PHASE II: Design and build a functional prototype capable of surviving a defined flight environment, ascent and re-entry, to collect the desired spectral observables. The prototype must be to-scale and fully functional with a defined flight vehicle. Test the capability of the prototype as it relates to spectral data collection. Demonstrate analytically the capability of the prototype system to withstand the thermochemical and thermophysical flight environment. Demonstrate analytically how the prototype would integrate with the defined flight vehicle.

PHASE III DUAL USE APPLICATIONS: Fully qualify the prototype system with a defined flight vehicle and integrate onto a defined government target mission.

REFERENCES:
1. U.S. Missile Defense Agency. November 3, 2015. Ballistic Missile Defense System. Retrieved from http://www.mda.mil/index.html.

2. U.S. Department of Defense. Undated. Ballistic Missile Defense Review. Retrieved from http://www.defense.gov/bmdr.

3. A. Kastengren and J.C. Dutton. June 28, 2004. "Wake Topology in a Three-Dimensional Supersonic Base Flow," AIAA-2004-2340, 34th AIAA Fluid Dynamics Conference and Exhibit, Portland, OR.

KEYWORDS: Spectrometer, plume, waking, modeling

MDA16-017 TITLE: Sub-Scale Fly Along Sensor Package

TECHNOLOGY AREA(S): Electronics, Sensors, Space Platforms

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OBJECTIVE: Develop an innovative suite of miniaturized sensors that can be deployed from current Associated Object (AO) canisters flown on missile test targets and can be used to collect data on the target scene.

DESCRIPTION: Missile test targets often include AO deployment canisters which could be used to house small, deployable, fly along sensors to collect data on a target scene. This topic seeks innovative miniaturized sensor designs that can be packaged into and deployed from one or more of the AO canisters. This innovative Fly Along Sensor Package (FASP) should be designed to fit within the volume constraints of either of two AO cylinder's outer mold lines (12 in. diameter X 29in. long or 6 in diameter X 29 in. long). Once deployed from the AO canister, the FASP should be capable of orienting itself to collect data on multiple objects throughout the course of the mission and telemeter the data to the ground or to another instrumented object capable of relaying the data to ground. The proposed FASP should be designed to incorporate a variety of sensor types (e.g., spectrometer, IR/VIS camera, etc.) and include the associated interface electronics and the AO canister deployment mechanism. The deployed FASP should also be designed to minimize radar cross section and IR signatures and be able to survive (collect and transmit data) during re-entry.

PHASE I: Provide a preliminary design concept of the FASP and its associated features and limitations. Demonstrate thorough understanding of the AO canister design restrictions and identify sensor and navigation technologies necessary to accomplish the basic FASP concept. Develop the system design approach and discuss transition from Phase I through Phase III/commercialization.

PHASE II: Construct a working prototype of the FASP conceptualized in Phase I. Demonstrate proper fit and operation with the AO canister. Demonstrate proper operation of the suite of sensors available for the prototype and navigation/control system via test or analysis. Develop a data collection plan and demonstrate its proper operation.

PHASE III DUAL USE APPLICATIONS: Integrate finalized prototype into the current government mission planning. Verify that flight test hardware can be tested and develop the final flight-worthy FASP. Conduct flight test/analyses of the FASP hardware and ensure that data obtained from the FASP will be collectable and usable by post-mission government analysts.

REFERENCES:

1. U.S. Missile Defense Agency. November 3, 2015. Ballistic Missile Defense System. Retrieved from http://www.mda.mil/index.html.

2. U.S. Department of Defense. Undated. Ballistic Missile Defense Review. Retrieved from http://www.defense.gov/bmdr.

KEYWORDS: associated object, fly along sensor package, navigation

MDA16-018 TITLE: Optical Signature Modeling of Transmissive Materials

TECHNOLOGY AREA(S): Electronics, Sensors, Space Platforms

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OBJECTIVE: This effort seeks to develop computational modeling methodologies that can achieve better accuracy than currently available and develop optical property measurement techniques that provide accurate measurement of the properties desired by computational modeling methodologies.

DESCRIPTION: Seek innovations leading to improved modeling of visible and infrared signatures for objects with partially transmissive surfaces. In particular, this effort seeks to develop a methodology to model the surface and inner component temperatures, transmissive behavior, emission and reflective behavior associated with partially transmissive material surfaces under arbitrary environmental conditions (e.g., solar, earth, and albedo irradiation) with arbitrary material properties. Accuracy and computational efficiency is also important in the methodology development since the methodology must be integrated into a broader scope engineering analysis code. Techniques are needed for high fidelity modeling of the thermal and optical interaction between multiple object components, including radiative wavelength-dependent heat transfer between multiple arbitrary transmissive and opaque materials, and resulting time-dependent temperature distributions. Techniques are also needed for high fidelity wavelength-dependent optical emission, reflection and transmission for an entire object, including both transmissive and opaque materials. Eventually, compatibility with government industry standard codes (e.g., OSC, OPTISIG) is essential. Additionally, the transmissive material's thermophysical and optical properties can vary as a function of temperature and optical properties can vary as a function of incident angle and wavelength. This effort also seeks to develop techniques for the accurate measurement of optical properties of partially transmissive materials.

PHASE I: Develop viable concepts for computational methodologies and/or measurement techniques associated with partially transmissive materials. Perform trade-offs between model fidelity, computer run-time, compatibility with government industry standard codes, and desired material properties data. Determine a resulting preferred approach for developing a high-fidelity transmissive material thermal and optical signature prediction capability.

PHASE II: Fully develop and demonstrate the modeling capability and/or measurement techniques on materials of interest. Integrate the methodology into current government engineering analysis tools and simulations. Provide a measure of accuracy and computational efficiency related to area of interest to the government. Validate models by comparison to available ground and/or flight test temperature and signature data. In the case of optical property measurement techniques, fully develop and build the setup desired to provide accurate optical property measurements for partially transmissive materials. Perform measurements on materials of interest with accuracy bounds. This phase will include validation against measured data sets.

PHASE III DUAL USE APPLICATIONS: Expand the transmissive measurements and modeling capabilities from Phase II and fully integrate them into OSC at a minimum (OPTISIG, if possible). Develop approaches for speeding up the run time by mapping to multiple CPU or GPUs to facilitate faster Monte Carlo simulations and/or to allow for real-time operation.

REFERENCES:
1. U.S. Missile Defense Agency. November 3, 2015. Ballistic Missile Defense System. Retrieved from http://www.mda.mil/index.html.

2. U.S. Department of Defense. Undated. Ballistic Missile Defense Review. Retrieved from http://www.defense.gov/bmdr.

3. U.S. Missile Defense Agency. Undated. Propulsion Related Signature Modeling. Retrieved from http://www.mda.mil/global/documents/pdf/PRSM_Product_Sheet_Apr2012.pdf

4. U.S. Missile Defense Agency. Undated. EO/IR Hardbody Modeling. Retrieved from http://www.mda.mil/global/documents/pdf/EO-IR_hardbody_modeling_Product_Sheet_Oct_2012.pdf

KEYWORDS: transmissive materials, OSC, optical signatures, modeling

MDA16-019 TITLE: Modeling of Complex Endo-atmospheric Wakes

TECHNOLOGY AREA(S): Electronics, Sensors, Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop an anchored approach to modeling infrared (IR) and/or radio-frequency (RF) re-entry wakes produced by re-entry vehicles (RVs) and RV associated spent boosters and flight hardware in high dynamic pressure and angle-of-attack (HDAOA) environments.

DESCRIPTION: This topic seeks development of a set of fast running HDAOA modeling tools to enhance missile defense mission planning, develop new mathematical techniques, and improve mission definition. Desire innovations leading to improved modeling capabilities covering a broad range of re-entering objects for a wide range of velocities/altitudes/angles of attack. In addition, desire modeling tools that can be anchored by existing high fidelity approaches and/or measurements but provide sufficient computational throughput to allow for improved run-times.

PHASE I: Identify candidate methodologies that are anchored by high fidelity codes and/or measurement data. Define the expected accuracy associated with the methodologies over the specified range of objects considered and re-entry conditions (velocities/altitudes/angles-of-attack). Define the expected computational requirements associated with the methodologies. Down select a methodology that can be further developed into the desired set of re-entry wake analysis tools.

PHASE II: Design, develop, and validate a prototype tool. Determine achieved simulation accuracy of the tool over the range of re-entry conditions of interest when compared to high fidelity simulations and/or measurement data. Determine the computational requirements over the range of re-entry conditions of interest.

PHASE III DUAL USE APPLICATIONS: Integrate the developed prototype tool into current government mission planning, signature, mathematical technique development, and/or mission definition simulations. Validate the successfully integrated code(s) and determine achieved simulation accuracy over the range of re-entry conditions of interest when compared to high fidelity simulations and/or measurement data. Determine the computational requirements over the range of re-entry conditions of interest for the newly integrated simulation.

REFERENCES:
1. K.D. Kennedy, C.D. Mikkelsen, and B. J. Walker. October 2009. "Missile Base Flow: Hybrid RANS/LES Computational Fluid Dynamics Comparisons to Measurements; Part II." JANNAF 31st Exhaust Plume and

Signatures Subcommittee Meeting, Dayton, OH.

2. D.E. Wolf, H.S. Pergament, M.J. Thorwart, R.D. Miles, and E.A. Sutton. June 2006. "Modeling of Plume Flowfields and High Frequency RCS for Solid and Liquid Propellant Ballistic Missiles." 29th JANNAF Exhaust Plume Technology Subcommittee Meeting, Littleton, CO.

KEYWORDS: Endo atmospheric Wakes, modeling

Approved for Public Release
16-MDA-8575 (22 February 16)