

**MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
SBIR 09.3 Supplemental Proposal Submission Instructions**

INTRODUCTION

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

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sbirsttr@mda.mil

MDA/DV
7100 Defense Pentagon
Washington, DC 20301-7100
FAX: (703) 882-6350

If you have any questions regarding the administration of the MDA SBIR/STTR Program please call 703-882-8300 or e-mail: sbirsttr@mda.mil.

Additional information on the MDA SBIR/STTR Program can be found on the MDA SBIR/STTR home page at <http://www.mdasbir.com/>. Information regarding the MDA mission and programs can be found at <http://www.mda.mil>.

MDA participates in one DoD SBIR Solicitation each year (xx.3). Proposals not conforming to the terms of this Solicitation 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 will evaluate proposals.

Questions about SBIR and Solicitation Topics

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8:00 am to 5:00 pm EDT). For technical questions about the topic during the pre-solicitation period (27 July 2009 through 23 August 2009), contact the Topic Authors listed under each topic on the <http://www.dodsbir.net> Web site by 23 August 2009. Please Note: During the pre-release period, you may talk directly with the Topic Authors to ask technical questions about the topics. Their names, phone numbers, and e-mail addresses are listed within each solicitation topic. For reasons of competitive fairness, direct communication between proposers and topic authors is not allowed when DoD begins accepting proposals for each solicitation. However, proposers may still submit written questions about solicitation topics through the [SBIR/STTR Interactive Topic Information System \(SITIS\)](#), in which the questioner and respondent remain anonymous and all questions and answers are posted electronically for general viewing until the solicitation closes. All proposers are advised to monitor SITIS during the solicitation period for questions and answers, and other significant information, relevant to the SBIR/STTR topic under which they are proposing.

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

Only Government personnel will evaluate proposals. In some circumstances, non-government, technical personnel from the following Federally Funded Research and Development Centers (FFRDCs) and support contractors will provide advisory and assistance services to MDA, including providing technical analyses of proposals submitted against MDA topics and of applications submitted to the MDA Phase II Transition Program.

FFRDCs: The Aerospace Corporation, Massachusetts Institute of Technology Lincoln Laboratory, Oak Ridge National Laboratory.

Universities / Non-Profit Organizations: Draper Laboratory, Institute of Defense Analyses, Johns Hopkins University Applied Physics Laboratory (JHU/APL), Utah State University Space Dynamics Laboratory, Aerospace Corporation, MITRE Corporation, University of Connecticut, Sandia National Laboratory.

Support Contractor Organizations: BAE Systems, The Boeing Company, Booz Allen Hamilton, Cobham Analytic Services (Sparta, Inc), CACI International, Inc., Computer Sciences Corporation (CSC), deciBel Research, Inc., Dynamic Research Corporation, Inc., ERC, Inc., General Dynamics Information Technology, L-3 Communications Corporation, Lockheed Martin, MacAulay Brown, Inc., Millennium Engineering and Integration, Inc., Modern Technology Solutions, Inc., Northrop Grumman, Paradigm Technologies, Photon Research Associates, Inc. (Raytheon), Radiance Technology, Raytheon Company, Schafer Corporation, Science Applications International Corporation (SAIC), SYColeman Corporation, United International Engineering, Universal Technology Corporation.

Individual support contractors from these organizations 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. These organizations are expressly prohibited from rating proposals or making recommendations for award selection. 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.

Pursuant to FAR 9.505-4, the MDA contracts with these support contractors 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.

Conflicts of Interest

You must avoid any actual or potential organizational conflicts of interest (OCI) while participating in any MDA-funded contracts, regardless of whether it was awarded by MDA. You must report to the MDA SBIR/STTR Program Office via e-mail any potential OCI before submitting your proposal or application. The MDA SBIR/STTR Program Office will review and coordinate any possible solutions or mitigation to the potential conflict with the contracting officer. If you do not make a timely and full disclosure and obtain clearance from the contracting officer, MDA may reject your proposal or application, or terminate any awarded contracts for default. See FAR Subpart 9.5 for more information on organizational conflicts of interest.

PHASE I GUIDELINES

MDA intends for the Phase I effort to determine the merit and technical feasibility of the concept. Only UNCLASSIFIED proposals will be entertained. Phase I proposals may be submitted for an amount normally not to exceed \$100,000.

A list of the topics currently eligible for proposal submission is included in section 8, below, followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics originated from the MDA Programs and are directly linked to their core research and development requirements.

Please assure that your mailing address, e-mail address, and point of contact (Corporate Official) listed in the proposal are current and accurate. MDA cannot be responsible for notification to a company that provides incorrect information or changes such information after proposal submission.

PHASE I PROPOSAL SUBMISSION

Read the front section of the DoD solicitation, including Section 3.5, for detailed instructions on proposal format and program requirements. Proposals not conforming to the terms of this solicitation will not be considered. MDA will evaluate and select

If the offeror proposes to use foreign nationals: Identify the foreign nationals you expect to be involved on this project, country of origin and level of involvement. If a proposal is selected for award, provide the following information about any foreign national: individual's full name (including alias or other spellings of name); date of birth; place of birth; nationality; registration number or visa information; port of entry; type of position and brief description of work to be performed; address where work will be performed; and copy of visa card or permanent resident card. Please Note: If selected for award - proposals submitted to ITAR restricted topics and/or with a foreign national listed, will be subject to security review during the contract negotiation process. 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 or firm is found ineligible to perform proposed work, the contracting officer will advise the offeror of any disqualifications but will not disclose the underlying rationale.

The technology within some of the MDA topics is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. You must ensure that your firm complies with all applicable ITAR provisions. Please refer to the following URL for additional information: <http://www.pmddtc.state.gov/compliance/index.html>.

You must submit the ENTIRE technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report electronically through the DoD SBIR/STTR Web site at www.dodsbir.net/submission/SignIn.asp. If you have any questions or problems with the electronic proposal submission, contact the DoD SBIR/STTR Helpdesk at 1-866-724-7457. Refer to section 3.0 of the DoD solicitation for complete instructions and requirements.

MAXIMUM PAGE LIMIT FOR MDA IS 20 PAGES

Only proposals submitted via the Submission Web site on or before the deadline of 6:00 am (ET) on 23 September 2009 will be processed. **Please Note:** The maximum page limit for your technical proposal is twenty (20) pages. Any pages submitted beyond this, will not be evaluated. Your cost proposal and Company Commercialization Report DO NOT count towards your maximum page limit.

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 am (ET) 23 September 2009.

- ___ a. DoD Proposal Cover Sheet
- ___ b. Technical Proposal (**DOES NOT EXCEED 20 PAGES**): Any pages submitted beyond this, will not be evaluated. Your cost proposal and Company Commercialization Report **DO NOT** count towards your maximum page limit.
- ___ c. DoD Company Commercialization Report (required even if your firm has no prior SBIRs).
- ___ d. Cost Proposal (**Online cost proposal form is REQUIRED by MDA**)

___2. The Phase I proposed cost does not exceed \$100,000.

MDA PROPOSAL EVALUATIONS

MDA will utilize the Phase I Evaluation criteria in Section 4.2 of the DoD solicitation, including potential benefit to the Ballistic Missile Defense System (BMDS) in assessing and selecting for award those proposals offering the best value to the Government.

MDA will use the Phase II Evaluation criteria in Section 4.3 of the DoD solicitation, including potential benefit to BMDS and ability to transition the technology into an identified BMDS, in assessing and selecting for award those proposals offering the best value to the Government. In the Phase II Evaluations, Criterion C is more important than criteria A and B, individually. Criteria A and B are of equal importance.

In Phase I and Phase II, firms with a Commercialization Achievement Index (CAI) at the 20th percentile will be penalized in accordance with DoD Section 3.5d.

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. Where technical evaluations are essentially equal in merit, cost or price to the government will be considered in determining the successful offeror.

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 and their personal knowledge. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be contained or referenced in the proposal and will count toward the applicable page limit.

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 is not responsible for any money expended by the proposer before award of any contract.

INFORMATION ON PROPOSAL STATUS

The Principal Investigator (PI) and Corporate Official (CO) indicated on the Proposal Coversheet will be notified by e-mail regarding proposal selection or non - selection. If your proposal is tentatively selected to receive an MDA award, the PI and CO will receive a single notification. If your proposal is not selected for an MDA award, the PI and CO may receive up to two messages. The first message will provide notification that your proposal has not been selected for an MDA award and provide information regarding the ability to request a proposal debriefing. The second message will contain debrief status information (if requested), or information regarding the debrief request. **Small Businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the proposal number and topic number referenced.**

IMPORTANT: We anticipate having all the proposals evaluated and our Phase I contract decisions in the December 2009 timeframe. All questions concerning the evaluation and selection process should be directed to the MDA SBIR/STTR Program Management Office (PMO).

MDA SUBMISSION OF FINAL REPORTS

All final reports will be submitted in accordance with the Contract Data Requirements List (CDRL) of the resulting Contract. Refer to section 5.3 of the DoD Solicitation for additional requirements.

PHASE II GUIDELINES

This Solicitation is for Phase I Proposals. For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those successful Phase I efforts that are **invited** to submit a Phase II proposal will be eligible to submit a Phase II proposal. Invitations will be issued at the discretion of MDA to firms based upon the results of their Phase I effort, the probable value of those results to MDA requirements, and the potential for outside investment in the technology. MDA makes no commitments to any offeror invited to submit a Phase II Proposal. MDA will evaluate and select Phase II proposals using the evaluation criteria in section 4.3 of the DoD SBIR solicitation. Phase II is the prototype/demonstration of the technology that was found feasible in Phase I.

Invitations to submit a Phase II proposal will be made by the MDA SBIR/STTR PMO. Phase II proposals may be submitted for an amount normally not to exceed \$750,000. MDA may consider making Phase II Invitations not to exceed a maximum of \$2.5M. **You may only propose up to the total cost for which you are invited.**

The MDA SBIR/STTR PMO does not provide “debriefs” for firms who were not invited to submit a Phase II proposal.

PHASE II PROPOSAL SUBMISSION

Phase II Proposal Submission is by Invitation only: *A Phase II proposal can be submitted only by a Phase I awardee and only in response to an invitation by MDA.* Invitations are generally issued at or near the Phase I contract completion, with the Phase II proposals generally due one month later. In accordance with SBA policy, MDA reserves the right to negotiate mutually acceptable Phase II proposal submission dates with individual Phase I awardees, accomplish proposal reviews expeditiously, and proceed with Phase II awards. If you have been invited to submit a Phase II proposal, please see the MDA SBIR/STTR Web site <http://www.mdasbir.com/> for further instructions.

Classified proposals are not accepted under the DoD SBIR/STTR Program. Follow Phase II proposal instructions described in Section 3.0 of the Program solicitation at www.dodsbir.net/solicitation and specific instructions provided in the Phase II Invitation. Each Phase II proposal must contain a Proposal Cover Sheet, technical proposal, cost proposal and a Company Commercialization Report submitted through the DoD Electronic Submission Web site at www.dodsbir.net/submission/SignIn.asp **by the deadline specified in the invitation.**

MDA FAST TRACK DATES AND REQUIREMENTS

Introduction: For more detailed information and guidance regarding the DoD Fast Track Program, please refer to Section 4.5 of the solicitation and the Web site links provide there. MDA's Phase II Fast Track Program is focused on transition of technology. The Fast Track Program provides matching SBIR funds to eligible firms that attract investment funds from a DoD acquisition program, a non-SBIR/non-STTR government program or Private sector investments. Phase II awards under Fast Track will be for \$1.0M maximum, unless specified by the MDA SBIR/STTR Program Manager.

- For companies that have never received a Phase II SBIR award from DoD or any other federal agency, the minimum matching rate is 25 cents for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals \$750,000, it must obtain matching funds from the investor of \$187,500.)
- For all other companies, the minimum matching rate is 1 dollar for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals \$750,000, it must obtain matching funds from the investor of \$750,000.)

Submission: The complete Fast Track application along with completed transition questions (see note below), must be received by MDA within 120 days from the Phase I award date. Your complete Phase II Proposal must be received by MDA within 30 days of receiving approval (see section entitled "Application Assessments" herein for further information). Any Fast Track applications or proposals not meeting this deadline may be declined. All Fast Track applications and required information must have a complete electronic submission. The DoD submission site www.dodsbir.net/submission/SignIn.asp will lead you through the process for submitting your application and technical proposal electronically. Each of these documents is submitted separately through the Web site.

Firms who wish to submit a Fast Track Application to MDA MUST utilize the MDA Fast Track Application Template available at <http://www.mdasbir.com> (or by writing sbirstr@mda.mil). Failure to follow these instructions may result in automatic rejection of your application.

Firms who have applied for Fast Track and not selected may still be eligible to compete for a regular Phase II in the MDA SBIR/STTR Program.

Current guidance and instructions may be found at <http://www.mdasbir.com>.

MDA SBIR PHASE II TRANSITION PROGRAM

Introduction: To encourage transition of SBIR projects into BMDS, the MDA's Phase II Transition Program provides matching SBIR funds to expand an existing Phase II contract that attracts investment funds from a DoD acquisition, a non-SBIR/non-STTR government program or Private sector investments. The Phase II Transition Program allows for an existing Phase II SBIR contract to be extended for up to one year per Phase II Transition application, to perform additional research and development. Phase II Transition matching funds will be provided on a one-for-one basis up to a maximum amount of \$500,000

of SBIR funds in accordance with DoD Phase II Enhancement policy at [Section 4.6](#) of the DoD Solicitation. Phase II Transition funding can only be applied to an active DoD Phase II SBIR contract.

The funds provided by the DoD acquisition program or a non-SBIR/non-STTR government program may be obligated on the Phase II contract as a modification prior to or concurrent with the modification adding MDA SBIR funds, OR may be obligated under a separate contract. Private sector funds must be from an “outside investor” which may include such entities as another company, or an investor. It does not include the owners or family members, or affiliates of the small business (13 CFR 121.103).

Background: It is important that all technology development programs in MDA map to a BMDS improvement and, after a period of development and maturity, are transitionable to targeted BMDS end users. End user is defined as the Element, Component or Product Manager to which it is intended to transition the technology. Because of this, it is important that your Phase II contract be at or approaching a Technology Readiness Level of either 5 or 6.

Current guidance and instructions may be found at <http://www.mdasbir.com>.

2009 KEY DATES (PROJECTION)

MDA SBIR/STTR Industry Day (Long Beach)	August 11-12, 2009
09.3 Solicitation Pre-release.....	July 27 – August 23, 2009
09.3 Solicitation Opens	August 24
Solicitation Closes.....	06:00 a.m. ET, September 23, 2009
Phase I Evaluations.....	October – November 2009*
Phase I Selections.....	December 2009*
Letters Distributed	December 2009*
Contract Award Goal	February 2009*
Phase II Recommendation Period (from 08.3 PH I)	August 2009*
Phase II Invitations (from 08.3 PH I)	September 2009*
PH II Proposals Due	October 2009*
Phase II Evaluations	November – December 2009*
Phase II Selections.....	December 2009*
Letters Distributed	January 2009*
Contract Award Goal.....	April 2010*

Phase II Transition Program Solicitation is *generally* announced via <http://www.mdasbir.com> in the March/April timeframe.

*This information is listed for GENERAL REFERENCE ONLY at the time of publication of this solicitation. This date is subject to update/change.

MDA SBIR 09.3 Topic Index by Research Area

INTERCEPTOR TECHNOLOGY

The Interceptor Research Area funds innovative technologies that have the potential to increase the capabilities and effectiveness of present or future interceptors for the Ballistic Missile Defense System (BMDS). The goal of this research area is to introduce technologies that could be incorporated into interceptor designs to enable the development of agile interceptors that are highly accurate.

MDA09-001	Innovative Propulsion Systems for Missile Defense Interceptors
MDA09-002	Interceptor Seekers
MDA09-003	Advanced Divert and Attitude Control
MDA09-004	Advanced Synergistic Structures for Interceptor Kill Vehicles
MDA09-005	Advanced Power Storage Devices for Ballistic Missile Defense Interceptors
MDA09-006	Advanced Interceptor Avionics

MANUFACTURING, PRODUCIBILITY AND FIELD SUSTAINABILITY

The Manufacturing, Producibility and Field Sustainability Research Area focuses on innovative technologies for manufacturing, assembly, production and fielded systems sustainment in all areas of the Ballistic Missile Defense System (BMDS).

MDA09-007	Advanced Materials & Processing Technology for Missile Defense Applications
MDA09-008	Radiation Hardening Manufacturing Technology
MDA09-009	Anti-tamper Technology for Missile Defense
MDA09-010	Ballistic Missile Defense System Innovative Power Storage Devices
MDA09-011	Active Sensor Materials and Process Technology Innovations
MDA09-012	Manufacturing Process Maturation for Propulsion Technology

INNOVATIVE CONCEPTS AND SPECIAL FOCUS PROJECTS

This Research Area solicits innovative concepts and special-focus projects that can provide game changing solutions to increase the performance and reduce the cost of the future BMDS. This year, the Research Area emphasizes new sensor strategies to detect and track ballistic missiles, although its mission spans the full spectrum of BMDS future capabilities. Ideas solicited include high-performance and revolutionary advanced sensor approaches such as Type II strained layer superlattice and other III-V materials, smart focal plane arrays and associated read-out integrated circuits. This research area also has a broad topic which seeks game changing ideas across the board of BMDS capability needs such as pervasive integrated sensors (e.g. radar), EO/IR systems, pervasive weapons, enhanced discrimination, effectiveness in adverse environments (nuclear, clutter, cyber, etc.) and global battle management and communications.

MDA09-013	Develop and Demonstrate High Performance Infrared Focal Plane Arrays with Advanced Quantum Structures
MDA09-014	Smart Infrared Focal Plane Arrays and Advanced Electronics

RADAR

The Radar Research Area focuses on finding the next "game changing" technology development for Ballistic Missile Defense (BMD) radars. Radar Technology also focuses on innovative and/or enhanced technology development or technology that improves radar functionality, packaging and/or affordability.

MDA09-015	Radar Multi-Beam Receive Arrays
MDA09-016	Photonic Multi-Beam Receive Arrays

- MDA09-017 Innovative Waveforms and Related Signal Processing for Missile Defense Radars
- MDA09-018 Clutter Suppression and Debris Mitigation Techniques and Algorithms for Missile Defense Radars
- MDA09-019 Innovative Low-Cost Encrypted Mobile Ground Systems

SPACE TECHNOLOGY

The Space Technology Research area focuses on developing and transitioning technologies to enable or improve the operation of Ballistic Missile Defense System Elements in the long-term orbital environment. Primary emphasis is on technologies to support space-based tracking of targets in the ascent phase, but technologies enabling other systems are of term interest as well. One of the over-arching requirements for all work in this area is the ability to survive and operate in orbit: this means a tougher natural radiation environment (and potential enhancement by man-made threats) than on earth, the absence of atmosphere, and micro-gravity. Most of the efforts are hardware oriented, however, software improvements are also of interest.

- MDA09-020 Payload Thermal Management Technology
- MDA09-021 Improvements in Spacecraft Assembly, Integration and Test
- MDA09-022 Large Format Space Focal Plane Array Technologies
- MDA09-023 Enhanced Spacecraft Survivability
- MDA09-024 Space Component Miniaturization
- MDA09-025 Radiation Hardened Monolithic Heterogeneous Processors

COMMAND, CONTROL, BATTLE MANAGEMENT AND COMMUNICATIONS (C2BMC)

The Command, Control, Battle Management and Communications (C2BMC) Research Area funds technological innovations related to supporting this integrating element of the Ballistic Missile Defense System (BMDS). The C2BMC Research Area seeks technological innovations that apply novel solutions to inherent challenges in Ballistic Missile Defense.

- MDA09-026 Resource Optimization for Battle Management
- MDA09-027 Track Correlation
- MDA09-028 Discrimination
- MDA09-029 Radiation Hardened End-to-End Communication Links
- MDA09-030 Information Assurance

MODELING & SIMULATION

The Modeling and Simulation Research Area funds technological innovations in Modeling & Simulation (M&S) to support development and testing of the Ballistic Missile Defense System (BMDS).

- MDA09-031 Effects of Hardbody-Plume Interactions on Radar Returns
- MDA09-032 Advanced Radiation Transport Models for Next Generation Rocket Exhaust Flowfield Processes
- MDA09-033 Plume EO-RCS Data Fusion
- MDA09-034 Terahertz Signature Modeling for Kill Assessment and Warhead Materials Identification
- MDA09-035 Creation of a Global UV-VIS-IR Ocean Background Model That is a Function of Time, Location and Sea State

DIRECTED ENERGY

The ultimate Directed Energy Research Area technical objective is to take innovative optics, laser, and RF technology developed by dynamic small businesses and insert the technology into air and ground weapon systems for integration into the Ballistic Missile Defense community.

- MDA09-036 High Power Fiber Laser Technology and Beam Combining
- MDA09-037 High Energy Laser Technology Innovations for BMDS Directed Energy, Tracking, and Illumination
- MDA09-038 Improved High Speed and High Dynamic Range Photon Counting Sensors for Active Imaging
- MDA09-039 High Energy Laser and Laser Illumination Optics Improvements
- MDA09-040 High Powered Laser Diodes for Pump Sources and other BMDS applications

MDA SBIR 09.3 Topic Index

MDA09-001	Innovative Propulsion Systems for Missile Defense Interceptors
MDA09-002	Interceptor Seekers
MDA09-003	Advanced Divert and Attitude Control
MDA09-004	Advanced Synergistic Structures for Interceptor Kill Vehicles
MDA09-005	Advanced Power Storage Devices for Ballistic Missile Defense Interceptors
MDA09-006	Advanced Interceptor Avionics
MDA09-007	Advanced Materials & Processing Technology for Missile Defense Applications
MDA09-008	Radiation Hardening Manufacturing Technology
MDA09-009	Anti-tamper Technology for Missile Defense
MDA09-010	Ballistic Missile Defense System Innovative Power Storage Devices
MDA09-011	Active Sensor Materials and Process Technology Innovations
MDA09-012	Manufacturing Process Maturation for Propulsion Technology
MDA09-013	Develop and Demonstrate High Performance Infrared Focal Plane Arrays with Advanced Quantum Structures
MDA09-014	Smart Infrared Focal Plane Arrays and Advanced Electronics
MDA09-015	Radar Multi-Beam Receive Arrays
MDA09-016	Photonic Multi-Beam Receive Arrays
MDA09-017	Innovative Waveforms and Related Signal Processing for Missile Defense Radars
MDA09-018	Clutter Suppression and Debris Mitigation Techniques and Algorithms for Missile Defense Radars
MDA09-019	Innovative Low-Cost Encrypted Mobile Ground Systems
MDA09-020	Payload Thermal Management Technology
MDA09-021	Improvements in Spacecraft Assembly, Integration and Test
MDA09-022	Large Format Space Focal Plane Array Technologies
MDA09-023	Enhanced Spacecraft Survivability
MDA09-024	Space Component Miniaturization
MDA09-025	Radiation Hardened Monolithic Heterogeneous Processors
MDA09-026	Resource Optimization for Battle Management
MDA09-027	Track Correlation
MDA09-028	Discrimination
MDA09-029	Radiation Hardened End-to-End Communication Links
MDA09-030	Information Assurance
MDA09-031	Effects of Hardbody-Plume Interactions on Radar Returns
MDA09-032	Advanced Radiation Transport Models for Next Generation Rocket Exhaust Flowfield Processes
MDA09-033	Plume EO-RCS Data Fusion
MDA09-034	Terahertz Signature Modeling for Kill Assessment and Warhead Materials Identification
MDA09-035	Creation of a Global UV-VIS-IR Ocean Background Model That is a Function of Time, Location and Sea State
MDA09-036	High Power Fiber Laser Technology and Beam Combining
MDA09-037	High Energy Laser Technology Innovations for BMDS Directed Energy, Tracking, and Illumination
MDA09-038	Improved High Speed and High Dynamic Range Photon Counting Sensors for Active Imaging
MDA09-039	High Energy Laser and Laser Illumination Optics Improvements
MDA09-040	High Powered Laser Diodes for Pump Sources and other BMDS application

MDA SBIR 093 Topic Descriptions

MDA09-001

TITLE: Innovative Propulsion Systems for Missile Defense Interceptors

TECHNOLOGY AREAS: 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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop innovative technologies for propulsion systems for Ballistic Missile Interceptors. The goal is to develop high mass fraction motors (> 0.9) and propellants that have high specific impulse (> 275 with a goal of 300) while that are suitable for use in the operational environment. It is also desired that these technologies reduce cost; improve reliability; meet DoD insensitive munitions (IM) objectives; remain stable in long term silo storage and/or mobile environments; are tolerant of many sea level to high altitude environmental cycles; deliver Thrust Vector Control (TVC) and variable thrust; reduce maintenance requirements; and incorporate non-destructive integrity inspection / test features.

DESCRIPTION: Increased interceptor terminal velocity and reduced overall time of flight are desired to increase system battlespace for operations with off-board sensors, to address advanced threats and degraded or alternate sensor handover capability. In particular, addressing the challenges for ascent phase engagement will require advanced propulsion systems for missile defense interceptors. Innovative development in the following enabling technologies is desired:

Innovative test solutions simulating pre and post dynamics of hypersonic missiles during the staging event are desired. Such solutions should give insight into the separation aerodynamics with the goal of minimizing flight timeline maneuvering constraints.

Advanced propellant chemistry resulting in improved specific performance, packaging, operational flexibility, and maintenance / support requirements are desired. Low toxicity, high performance, and suitability for application in cold and airborne environments are necessary technology features.

Innovative applications of unconventional propulsion (e.g., hybrid, alternate architecture, etc.) technologies are desired to increase mission flexibility, system performance and safety. Emphasis should be placed on the use of more environmentally and operationally "friendly" propellants (i.e., low toxicity, insensitive), with little or no decrease in impulse and response performance relative to current state of the art alternatives.

Booster component design and material advancements enabling performance, packaging, durability, manufacturability, and cost improvements are desired. Examples of such technologies include but are not limited to: a) Motor case technology - high strength, high stiffness and lightweight polymer matrix or metal matrix composite cases and liner/insulation materials and processes; b) Integral vehicle health monitoring - research into technologies related to "cradle-to-grave" monitoring of solid rocket motor cases, including sensors, fiber optics or conventional wiring, readout electronics, and diagnostic or prognostic software/hardware; c) Thrust Vector Control technologies – High vectoring magnitude and response capability at reduced system power, mass, and volume footprint.

PHASE I: Demonstrate proof of concept of the proposed propulsion technology. Identify candidate materials, designs and/or test capabilities. Fabricate and characterize materials for component technologies or define proof of capabilities test concepts. For propellant improvements, conduct research and experimental efforts to quantify potential benefits (e.g., impulse improvement, packaging improvement, storage and environmental benefits).

PHASE II: Develop and demonstrate prototype designs incorporating Phase I technology in a relevant test environment. Develop and document design and/or test approaches. Perform appropriate characterization and testing, e.g. sub-scale motor tests, accelerated long term storage and / or cyclic environmental load compatibility testing, and IM related testing such as fast and slow cook-off. Conduct Proof of capabilities aerodynamic testing as

appropriate for innovative testing of advanced axial booster designs. A partnership with the current or potential supplier of BMDS element systems, subsystems, or components is highly desirable.

PHASE III: Conduct engineering and manufacturing development, test and evaluation and hardware qualification. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed with insertion planning for a missile defense interceptor.

COMMERCIALIZATION: Axial rocket and missile propulsion technology has direct applicability to DoD, commercial and NASA launch capability. Component technologies, e.g. high temperature materials, can have broad industrial application in chemical processing, energy production and manufacturing.

REFERENCES:

1. George P. Sutton, "Rocket Propulsion Elements: an Introduction to the Engineering of Rockets." 7th Edition, John Wiley & Sons, 2001.
2. Palaszewski, Bryan, 'Propellant Technologies: A Persuasive Wave of Future Propulsion Benefits', NASA Glenn Research Center, Cleveland, OH, Feb. 1997., <http://sbir.grc.nasa.gov/launch/Propellant.htm>.
3. US DoD Insensitive Munitions Program Anthony J. Melita , <http://www.dtic.mil/ndia/2003gun/mel.pdf>

KEYWORDS: Propulsion, Materials, Chemical Compatibility, Propellants, Insensitive Munitions, Hybrid Propulsion, Green Propellants

MDA09-002

TITLE: Interceptor Seekers

TECHNOLOGY AREAS: 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 3.5.b.(7) of the solicitation.

OBJECTIVE: Design, develop and demonstrate highly integrated, compact, high performance, lightweight interceptor seeker technologies to include advanced active, passive and multi-mode seekers, sensors, and seeker components, for EO/IR seekers. These technologies will be part of an integrated seeker suite and they will be used for insertion into spiral upgrades to current BMDS interceptor systems to enable advanced, agile interceptors and miniature interceptors that are survivable in adverse environments to defeat various targets, facilitate discrimination, and defeat the asymmetric threat. A primary objective is for long range detection, tracking and intercept of all Ballistic Missile Defense (BMD) endo- and exo- atmospheric targets in all phases of flight, boost, midcourse and terminal.

DESCRIPTION: Key functions of a missile defense interceptor are to detect, track, discriminate, and engage threat objects. Those functions rely on seeker technology to measure line of sight angle, and in some cases, range and range rate, to intercept targets successfully. They may also measure discrimination data such as IR radiance in multiple bands, target images in several dimensions, and dynamics. Both active and passive seekers, and the combination of them in a gimbal or strapdown (preferred) configuration are critical for future discrimination seekers. The seekers must perform all of these functions while the sun, moon, or earth limb are within a few degrees of the seekers' optical field of view.

This topic calls for passive and active interceptor seekers and their components that will be able to detect, track, and discriminate targets at long ranges (1000Km) . For passive infrared seekers at 10 micrometer cutoff wavelengths, the following figure of merit should be met: the focal plane array format larger than 256 x256, pixel pitch less than or equal to 30 micrometers, median specific detectivity larger than 2×10^{11} cm Hz^{1/2}/watt, uniformity larger than 96%, operability larger than 95%. Focal plane arrays operating at very long infrared with cutoff wavelengths up to

14 micron are also solicited with similar figures of merit. In addition, innovations are sought after for pixel-co registered multi-band focal plane arrays that have two to four wavebands, i.e., MW/LW, LW/LW+VIS, LW/VLW or MW/LW/LW. Novel ideas in advanced readout circuit are encouraged to reduce the dark current, accommodate device polarities, improve the dynamic range and reduce the output data rate. Active strapdown seekers to include laser ranger, and laser radar are also to be considered. The innovative concepts, components and technologies to be developed under this topic include multi-mode active/passive seekers and their components, on FPA and near FPA data processing, data rate reduction, and dual Field of View lenses (to enable zoomable lens). For both passive and active seekers, both optical baffle development and optical seeker miniaturization are needed.

Improvements are also sought for interceptor light-weight, compact or miniature, strapdown active seeker components. Technologies are sought to substantially advance the performance of line of sight pointing systems, achieving ± 60 degrees steering with stable submillisecond response across the field of regard. System accuracy should be able to achieve stable microradian accuracy within the period of response. Volume constraints are in the order of 500mL, and stable operation in vacuum is required. Transmitters with chip-scale-packaging, scalable sources for increased ranging are needed. Active readout integrated circuits with a 512 x 512 dual mode capability, ability to process multiple returns per pixel from each transmitter pulse and address photon counting direct detection and coherent doppler imaging (bandwidth up to 4 GHz) are desired.

PHASE I: Research, quantitatively analyze, and develop a conceptual design and assess the feasibility of an active, passive, or multi-mode seeker system or component. In the case of a component it is desirable (budget permitting) that a prototype be developed and demonstrated.

PHASE II: Design, develop, and characterize a prototype of the active, passive, or multi-mode seeker system (or component) and demonstrate its functionality. Investigate private sector applications along with military uses of key components developed in Phase II.

PHASE III: Develop and execute a plan to manufacture the sensor system, or component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing.

COMMERCIALIZATION: The contractor will pursue commercialization of the various technologies and EO/IR components developed in Phase II for potential commercial uses in such diverse fields as law enforcement, rescue and recovery operations, maritime and aviation collision avoidance sensors, medical uses and homeland defense applications.

REFERENCES:

1. W. Dyer, W. Reeves, and G. Dezenberg, "The Advanced Discriminating Interceptor", AIAA Missile Science Conference Proceedings, 1994.
2. M. Z. Tidrow, "MDA Infrared Sensor Technology Program and Applications", SPIE Proceedings Vol 5074 (2003), p39.
3. J. L. Miller, Principles of Infrared Technology, Chapman & Hall, 1994.
4. A. V. Jelalian, Laser Radar Systems, Artech House, Inc., 1992.
5. J.S. Acceta and D.L. Shumaker, "The infrared and electro-optical systems handbook", SPIE Optical Engineering Press, Bellingham, Washington, 1993.
6. Sood, A. K., et. al., "Design and development of multicolor detector arrays," Proc. SPIE, Vol. 5564, p. 27-33.
7. Dhar, N. K. and Tidrow, M. Z., "Large format IRFPA development on Silicon," Proc. SPIE, Vol. 5564, p. 34-43.

KEYWORDS: Remote Sensing, Multispectral Imaging, Discrimination, IR Detectors, IR Baffles, Spectral Characteristics of Materials, Miniaturization

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: DV

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OBJECTIVE: Develop and demonstrate advanced solid/liquid interceptor DACS components and systems for atmospheric/exo-atmospheric use, operational at the ambient temperature (-60 Deg F to 170 deg F). Criteria include low cost (<\$200K), light weight (<10 Kg including fuel with delta V > 1,000 m/sec), high performance, fast reaction (<10 ms), and resistance to high temperature (2500 degrees C) and high pressure (2000 psi) with minimum out-gassing. Novel concepts for lightweight DACS with high delta velocity (> 1,000 m/sec) and high thrust (>> 5 gs) that enable large mass fraction (> 40% system mass fraction and 60% DACS mass fraction) are of special interest. The life expectancy of the all-up round is >10 yrs.

DESCRIPTION: Advanced DACS technologies are needed to address cost reduction, insensitive munitions and safety requirements, while maximizing the kill vehicle (KV) divert capability and/or reducing the KV weight within restricted geometries. Advanced solid and liquid propellants that provide improved performance and reduced environmental impacts are needed with high density-specific impulse products. The increased combustion temperatures (>2500 degrees C) associated with advanced solid and liquid propulsion require more robust materials and processes, and propulsion systems with lifetimes commensurate with interceptor system operational requirements. Advanced techniques for propulsion components, such as nanotechnology, and materials such as carbon matrix composites, ceramic matrix composites, cermets, and refractory metals to increase the operating temperature, reduce oxidation and erosion are sought. Desired materials include both composite and monolithic. In addition to temperature resistant materials, techniques for cooling or thermally managing components are needed (provided they are compatible with a light weight, low cost DACS; e.g., thermal coatings)). Proposals that address survivability of propulsion electronics in an interceptor radiation environment are also sought, especially for DACS electronics.

Other areas of interest include innovative component and subsystem design for the pressurization, propellant storage and delivery, and feed systems (e.g., thermally augmented or mini-pump feed systems are potential additions – lower pressures results in hazard reductions as well as size reductions). In the thruster area, there are also component design techniques that may result in substantial footprint reductions by achieving component dimensional reductions (e.g., plug or expansion deflection nozzles; Chamber techniques to produce a much shorter length versus L*).

Despite recent progress, several technical propulsion challenges remain, including, but not limited to:

- * Understanding the compatibility of ablative composites (tank/seal) materials in green & non-green liquid propellant environment (HAN, ADN, Hydrazine...).
- * Demonstration of complex braided structures and integral assemblies for green & non-green liquid monopropellants specific hardware.
- * Enhanced matrix compositions that improve life for oxidizing environments at 2500 deg C and beyond to exploit emerging high performance propellant formulations.

Additional technologies of interest to the topic also include: monolithic SiC or silicon thrusters using liquid or gel propellants; colloidal thrusters; phase change solid -to-gas or liquid-to-gas electro-thermal thrusters, innovative bipropellant or monopropellant concepts; solid propellant multi-pulse or breech concepts; pulse detonation rocket engines; solid/liquid hybrid propulsion; micro/MEMS propellant valves.

PHASE I: Develop a design and a plan of approach for development for above stated objectives. Through analysis and M&S, identify approaches for potential solutions to the above listed challenges.

PHASE II: Implement one of the promising approaches identified during phase I. Fabricate a prototype that demonstrates the proof of concept. The demonstration should include materials compatibility at or above 2500Deg C. Offerors are strongly encouraged to align their effort towards a relevant BMDS system and payload contractors to ensure technology transition.

PHASE III: The developed technology should have direct insertion potential into missile defense systems.

COMMERCIALIZATION: The technologies developed under this SBIR topic should have commercial applications such as unmanned vehicles, commercial space industry, etc.

REFERENCES:

1. George P. Sutton, "Rocket propulsion Elements; Introduction to Engineering of Rockets" 7th edition, John Willey & Sons, 2001.
2. Paschal N, Strickland B, Lianos D, " Miniature Kill Vehicle Program", 11th Annual AIAA/BMDO Technology Conference, Monterey, CA, August 2002.
3. Vigor Yang, Thomas B. Brill, and Wu-Zhen Ren, "Solid Propellant Chemistry, Combustion, and Motor Interior Ballistics", AIAA, 2000.
4. Murthy S.N., Curran E.T, "Development in High Speed Vehicle Propulsion Systems, AIAA, 1996.
5. G. Hagemann, H. Immich, T. Nguyen "Advanced Rocket Nozzles" Journal of Propulsion and Power , Vol 14, No 5, pp620-634, AIAA, 1998.
6. Handbook of Radiation Effects, 2nd Edition, Chapter 7, A. Holmes-Siedle and Len Adams, Oxford University Press, 2002.

KEYWORDS: Solid propellants, liquid propellants, Divert and Attitude Control, DACS, Actuator, Hot gas generator, HAN

MDA09-004 TITLE: Advanced Synergistic Structures for Interceptor Kill Vehicles

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: DV

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop technology for an interceptor Kill Vehicle (KV) that integrates disparate components into the load bearing structure to increase the performance of the KV.

DESCRIPTION: The phrase "Synergistic Structures" in this context refers to Structures with multiple functions (e.g., fuel tanks or batteries that function as load-bearing KV structure and/or protect against hostile environment) or structures with embedded components (e.g., electrical, optical, power, cabling, propulsion, sub-structures, isolation, etc). The synergy must not compromise the integrity of the interceptor. The MDA has funded numerous technology development programs that could be applied toward KVs. However, many of these efforts focused on an individual component without the consideration of combining components into a system to save mass, volume, and ensure structural integrity. The MDA is interested in developing revolutionary and evolutionary KV technologies that will significantly improve key performance parameters (speed, volume, mass, accuracy, agility, etc.). In recent years, a

number of new technologies have emerged (new materials, nano-research, component/electronic miniaturization, enhanced kill effects, etc.) that make it feasible to integrate components in a system without degradation of other subsystems. This effort will focus on the development of embedded components of previously independent structures/subsystems with considerations to the following: radiation shielding, structural stability, harmonics, mass, reduced part count, enhanced lethality, and reduced volume. Additionally, the structural system must be designed to the operational environment (temperature variations, high acoustic levels, maneuvering loads, high shock loads, nuclear effects, and severe vibration loads). Proposals should provide sufficient detail to allow the evaluation team to ascertain the potential benefits and risks associated with the concept and describe the system-level benefits.

PHASE I: Develop initial design concept; conduct analytical and experimental efforts to demonstrate proof-of-principle; develop preliminary design complete with documentation that will provide proof-of-functionality; and model or produce/demonstrate "breadboard operational prototype" to ensure proof of basic design concept. Proposed concepts should be modeled with representative KV-type environment. The contractor will provide any embedded components for models, breadboards, etc. Simulated embedded components may be substituted for actual components if their use is substantiated by analyses. The contractor will develop a Phase II strategy plan that includes (but not limited to) development and integration strategy, potential demonstration opportunities, program schedule, and estimated costs.

PHASE II: Design and fabricate a prototype structural concept that could be demonstrated in a representative KV environment. The goal is to transition and commercialize this technology by developing working relationships with the relevant BMDS systems and contractors. The contractor will provide any embedded components for prototypes.

PHASE III: Develop and execute a plan to manufacture the sensor system, or component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing. The contractor will provide any embedded components.

COMMERCIALIZATION: The commercial potential for highly integrated/synergistic structures is immense in the aerospace, automobile, and infrastructure industries.

REFERENCES:

1. Starr, A.F., et al., "Fabrication and Characterization of a Negative-Index Composite Metamaterial," *Physical Review B*, Vol. 70, 113102 (2004).
2. Adams, J.H., "AIAA 2001-0326, 39th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, 8 January 2001.
3. Wilson, J.W., et al, "E-Beam-Cure Fabrication Polymer Fiber/Matrix Composites for Multifunctional Radiation Shielding," AIAA 2004-6029, Space 2004 Conference and Exhibit, San Diego, CA, 28-30 September 2004.
4. Thostenson, E.T., Ren, Z, Chou T-W, "Advances in the science and technology of carbon nanotubes and their composite: a review" *Composites Science and Technology*, 61, pages 1899-1912, 2001
5. Ruffin, P. B., "Nanotechnology for Missiles" *Quantum Sensing and Nanophotonic Devices*, Proc. Of SPIE, Vol. 5359, Bellingham WA, 2004.

KEYWORDS: Synergistic Structures, Integrated Structures, Kill Vehicles, Radiation Shielding, Communications, Optics, Composite Materials, Nano-Materials

MDA09-005

TITLE: Advanced Power Storage Devices for Ballistic Missile Defense Interceptors

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Space Platforms, Weapons

ACQUISITION PROGRAM: GM, AB, KI, KV, QS, SS, TC, TH

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 3.5.b.(7) of the solicitation.

OBJECTIVE: MDA is seeking to develop next generation power sources for interceptors through innovative ideas applied in creative ways to accommodate unique, existing and future MDA system, subsystem and component requirements. These include developing new technologies, improving existing technologies, adapting new applications of existing technologies, and inventive uses of commercial off-the-shelf and military off-the shelf technologies. Please note that some technology encompassed by this topic may be restricted under the International Traffic in Arms Regulations (ITAR, CFR 22, Part 121), which controls the export and import of defense-related material and services. If applicable, Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish.

DESCRIPTION: MDA currently uses a variety of rechargeable and non-rechargeable batteries to power Ballistic Missile Defense System (BMDS) interceptors. These power storage devices provide in-vehicle power for up to several hours and in some cases must source tens of kilowatts in relatively compact volumes. Next generation MDA applications are projected to demand even high power and energy levels, and this topic is seeking technologies that can achieve those levels. For this solicitation, areas of interest include (but are not limited to) the following:

Nonrechargeable Batteries: One main interest area is new battery technology that provides a revolutionary increase in power and energy levels now attainable with thermal batteries (e.g. peak specific power of greater than 10 kW/kg, specific energy greater than 200 Whr/kg at the battery level). Another main interest area is new battery technology that provides a revolutionary increase in power and energy levels now attainable with lithium oxyhalide reserve batteries (e.g. peak specific power of greater than 1 kW/kg, specific energy greater than 300 Whr/kg at the battery level). For these new technologies, consideration should be given for long shelf life (e.g. remain inert for up to 20 years prior to use), volume & packaging efficiency, high current capability, ability to achieve high voltage levels (>200 volts), safety and reliability for the intended use in interceptor vehicles.

Rechargeable Batteries: The main interest area is new battery technology that provides a large increase in power and energy levels now attainable with Li-ion batteries (e.g. peak specific power of greater than 10 kW/kg, specific energy greater than 275 Whr/kg at the battery level). For candidate technologies, consideration should be given for a suitably long calendar life (e.g. 5 or more years), safety, reliability, ability to achieve moderate to high charge and discharge rates with suitable voltage characteristics and suitable cycle life at high depths of discharge (e.g. over 70%, and over 500 cycles) for the intended use in interceptor vehicles.

PHASE I: Develop conceptual framework for battery or battery production process design/design modification for integration into MDA interceptor systems or subsystems to increase performance, lower cost and increase reliability and producibility. Where possible, limited scale demonstrations should be provided to assist in the judging of merit of the new technology.

PHASE II: Validate the feasibility of the power storage device or manufacturing process technology by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation by demonstration should sufficiently show near term application to one or more MDA-interest systems. A partnership with a current or potential supplier of MDA element systems, subsystems or components is highly desirable. The possibility of commercial benefit or application opportunities for the innovation is desirable.

PHASE III: The intention is to successfully implement the new power storage technology for use by MDA interceptor weapon systems and other customers as appropriate. Implementation would include, but not be limited to, demonstration in a real system or operation in a system level test bed, and flight testing of the battery concept. The new power source technology should be implemented at a manufacturer and be ready for inclusion in MDA interceptor applications.

COMMERCIALIZATION: High power batteries have commercial uses, and it is anticipated the battery technologies developed under this SBIR will likely find wider use in non-MDA applications. High power batteries are used in some consumer applications (e.g. cordless tools) and in various industrial settings (e.g. load leveling).

REFERENCES:

1. <http://www.acq.osd.mil/mda/mdalink/html/mdalink.html> provides an overview of MDA platforms.
2. <http://www.sandia.gov/news-center/resources/tech-library/index.html> provides links to documents (some detailed) describing various MDA-interest battery technologies.
3. <http://www.electrochem.org> provides detailed information on current state-of-the-art advances and research, mainly for MDA-interest rechargeable batteries.
4. Handbook of Batteries, 3rd Edition, McGraw-Hill, provides detailed information regarding the design and construction of thermal, liquid reserve and rechargeable batteries.

KEYWORDS: power density, energy density, battery, lithium, interceptor

MDA09-006 TITLE: Advanced Interceptor Avionics

TECHNOLOGY AREAS: Air Platform, Information Systems, Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: DV, GMD, KEI, THAAD

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 3.5.b.(7) of the solicitation.

OBJECTIVE: The objective of this research and development effort is to encourage the development of innovative, high performance avionics systems, subsystems, and components that will enhance the capability of current and future interceptors in a hostile environment.

DESCRIPTION: Advancement of avionics and electronics components is essential to support lightweight, low cost, advanced Ballistic Missile Defense System (BMDS) interceptors. Next generation interceptor designs will demand performance enhancements to support new missions, provide robust operation in severe thermal and vibration environments while simultaneously reducing weight and power dissipation. In general, Interceptor Avionics includes the seeker signal/image processors, flight computer, gyros, accelerometers, associated electronics and their integrated units (Inertial Reference Unit, Inertial Measurement Unit), with or without Global Positioning System (GPS) augmentation, secure interceptor communication system (with or without implementation of Software Defined Radio (SDR) solutions), internal wiring/wireless interconnectivity, connectors, networks, and interceptor power sources and conditioning. Specifically, innovation of IMU technology to support advanced interceptor avionics is desired.

As interceptor systems upgrade toward longer-range capabilities along with increasing requirements for agility, processing power, and accuracy, a new Guidance, Navigation and Control modular architecture, along with compact, inexpensive, advanced Guidance, Navigation and Control components is needed. In addition, as the interceptor migrates toward a more flexible and agile vehicle, the size, weight, and performance requirements of the Guidance, Navigation and Control components will be more challenging and capability for external navigation updates such as Global Positioning System is needed. Special emphasis will be placed on low cost, high bandwidth (>500hz with goal of 1khz), low data latency (<100usec) navigation grade IMUs that are capable of withstanding high shock [Shock Response Spectrum Envelope: 100 Hz,120 G; 850 Hz, 1550 G; 10,000 Hz, 1550 G], vibration [Maximum Predicted Environment (MPE) Envelope (Hz,G²/Hz): 20 Hz,0.02; 150 Hz,0.16; 1500 Hz,0.16; 1800 Hz,0.24; 3000 Hz,0.24] and radiation environments. These IMUs coupled with Fast Steering Mirrors (FSM) and

High Frame Rate Seekers will support line of sight stabilization in the presence of stressing environments. This SBIR topic also solicits novel concepts and technologies in producing small, accurate Guidance, Navigation and Control components such as gyros, accelerometers, associated electronics, and fully integrated navigation systems that are low in cost, lightweight, compact, and of high performance. The desired performance goals to guide the research are drift rates on the order of 0.1-2 deg/hr, angle random walk on the order of 0.1-0.002 deg/square root-hr, and data rates and bandwidths in the kHz range. Weight goals for the overall navigation system should be less than 400 grams with volume less than 3.0 cu. in. The Guidance, Navigation and Control components and integrated system must be able to withstand high shock and vibration upon missile lift-off, stage separation events, and during Divert-Altitude Control System operation, impose minimum operational requirements prior to launch, and operate in a thermal environment from -50 C to + 80 C (85 C intermittent). They should not be sensitive to Electro-magnetic Interference or prolonged storage at the above temperatures. Radiation hardness to >300krad is desirable. Capability for ten years of dormancy prior to launch is desirable. An integrated Global Positioning System receiver is desired to provide greater flexibility in launcher placement, improved guidance accuracy, and integrated operations, but the Guidance, Navigation and Control suite should also be able to operate autonomously in a Global Positioning System-denial environment.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed technology to enhance avionics performance. Determine expected performance through extensive analysis/modeling effort. Identify technical risks for the avionics and subsystems and develop a risk mitigation plan. Proposed designs should strive for greater performance over current technology at lower cost, and strongly suggest a growth opportunity for further performance increases and cost reduction.

PHASE II: Design, develop and characterize prototypes of the proposed technologies and demonstrate functionality. Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Develop and execute a plan to manufacture the avionics IMU system component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing.

COMMERCIALIZATION: The proposed avionics technology growth areas would have applicability to the automobile and aircraft industries (to augment navigation aids), micro-satellites and light-weight UAVs.. The contractor will pursue commercialization of the proposed technologies in the fields of munitions and missile guidance, instrumentation for motion control, simulation & training, vehicle safety and personal navigation.

REFERENCES:

1. "Missile Technology drivers for the Future", 2001 munitions Executive Summit, 13 February 2001, available through DTIC.
2. "In Flight Alignment Techniques for Navy Theater Wide Missiles", E.J Ohlmeyer, T.R. Pepitone, AIAA 2001-4401.
3. "Fundamental of High Accuracy Inertial Navigation", AIAA Progress in Astronautics and Aeronautics Vol. 174.
4. IEEE Standards 528-2001/p1559 Standard for Inertial Sensor Terminology, IEEE.
5. IEEE Std P1554 Recommended Practice for Inertial Sensor Test Equipment, Instrumentation, Data Acquisition and Analysis.
6. IEEE Std 1431 Coriolis Vibratory Gyro Specification Format Guide and Test Procedure.
7. MIL-STD-461, "Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference", military standard, procedure CE106.

KEYWORDS: interceptor, avionics, gyros, accelerometer, inertial measurement unit (IMU), inertial navigation system (INS), global positioning system (GPS), electronics

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: DEP

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OBJECTIVE: Enhance the performance and/or producibility of missile body structures, components and thermal protection systems for implementation into Ballistic Missile Defense (BMD) systems through development or utilization of novel materials and processes. Provide materials solutions to reduce procurement cost, lower life cycle cost, lower operational maintenance, reduce lead time, enhance mission reliability and improve manufacturability for low-rate, non-labor intensive production for BMD systems.

DESCRIPTION: MDA is seeking high-performance materials and process technologies for enhancement of current and block upgraded missile defense systems. These endo-atmospheric and exo-atmospheric intercept systems are highly complex missile systems. Novel materials and process technologies offer a significant potential for enhancing performance properties while improving producibility of these structures. Process technologies should be appropriate for modest production volumes; incorporate modularity, flexibility, simplified and/or low-cost tooling; and be consistent with Lean and Six Sigma methodologies. The focus of this topic is for the missile body and kill vehicle structures or components, excluding propulsion systems.

Technical areas of interest include, but are not limited to:

Aerostructures/Radomes: Advanced missile defense interceptors require lightweight thermal protection systems (TPS), radomes and aerostructures designed to minimize internal temperature rise and ensure missile airframe structural integrity during flight, including operation in adverse weather. These systems must meet a variety of requirements such as weight, erosion/ablation performance, cost, non-ionizing chemistry, and component survivability. New advanced interceptors are expected to achieve much higher velocities and longer flight times resulting in more severe aerothermal heating and loads than current systems. Aeroheating environments vary throughout the structure, but cold wall heating rates of 50-400 Btu/ft²-s and shear rates of 10-50 psf can be used for preliminary material suitability analysis. Ceramic matrix composites and involute composite designs capable of operating in the temperature range of 2500-6000F are of interest. Proposals are sought that develop lightweight integrated heat shield, radome and airframe designs which enhance the current designs and improve insulative performance of the TPS, lightning strike performance, electromagnetic window performance, and rain erosion performance.

Weather Encounter: Advanced missile interceptors have the potential for encountering adverse weather conditions during flight. As a result, there is a need to better characterize the probabilistic weather environment, enhance the analytic methods used to determine of the probability of survivability, and perform higher fidelity ground testing with a verified linkage to the probabilistic flight environment. Adverse weather conditions may include typically occurring natural events such as rain, snow, ice, graupel, sand/dust, or catastrophic naturally occurring weather events such as volcanic particulates. Analytic tools validated with appropriately obtained data are required to predict probability of occurrence as well as survivability. Additionally, significant improvements in ground and flight testing methodologies are required to better support system performance assessments. In particular, improvements in single impact and sled testing methods are needed for all hydrometeor and solid particulate types. New testing concepts are also of interest. As an example, it is of interest to develop a proof of concept capability which considers the use of subscale rockets and dynamic impact measurement grids to record single impact events during flight as well as the impacting droplet diameter over the 3-dimensional surface of the nose cone region. Such a proof of concept would be conducted during actual weather events along with typical meteorological

measurements. Further advancements might include the use of an on-board weather environment measurement system along with adjacent mounted material samples. These subscale vehicles would be recoverable to conduct post-test inspection. Real time recession gauges would also be of interest to capture transient recession data. Typical velocity regimes are in the range of subsonic through high supersonic.

PHASE I: Conduct experimental and/or analytical efforts to demonstrate proof-of-principle and to improve producibility, increase performance, lower cost, or increase reliability. Explore the concept and develop novel material or processes for fabrication of selected missile components. If applicable, produce test coupons of the materials and measure relevant properties. Assess the fabrication cost and impacts on service methods, safety, reliability, and efficiency. Perform a preliminary manufacturability and cost benefit analysis showing that the structure can be produced in reasonable quantities and at reasonable cost/yields, based on quantifiable benefits, by employing techniques suitable for scale up. Conduct weather environment characterization, develop/validate physics based numerical models of vehicle flowfield/weather coupling, develop material impact models, and develop/modify test evaluation methodologies for all aspects of weather encounter phenomena.

PHASE II: Based on the results and findings of Phase I, demonstrate the technology by fabricating and testing a prototype in a representative environment. Demonstrate feasibility and engineering scale up of proposed technology and identify and address technological hurdles. Demonstrate the system's viability and superiority under a wide variety of conditions typical of both normal and extreme operating conditions. Demonstrate scalable manufacturing technology during production of the articles. Identify and assess commercial applications of the material or process technology.

PHASE III: Demonstrate new open/modular, non-proprietary composite and radome materials and/or structures technology. Provide a potentially qualifiable design for an innovative structure that will provide for advancement of the state-of-the-art in aerospace and missile structure performance, safety, weather robustness, life extension, preventative and other maintenance. Demonstrate commercial scalability of the manufacturing process and the implementation of the software-based design tools for the commercial development and deployment of advanced structures and radomes. Commercialize the technology for both military and civilian applications. Demonstration should be in a real system or operational in a system level test-bed.

COMMERCIALIZATION: The proposed technology should benefit commercial and defense manufacturing through cost reduction, improved reliability, or enhanced producibility and performance.

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1. Deason, D.M., Missile Defense Materials & Manufacturing Technology Program, ASM Annual Meeting, Columbus, OH, Oct. 2003.
2. Deason, D.M. and Hilmas, G., et al. "Silicon Carbide Ceramics for Aerospace Applications - Processing, Microstructure, and Property Assessments," Proceedings: Materials Science & Technology Conference, Pittsburg, PA, Oct. 2005.
3. Reynolds, R.A., Nourse, R.N. and Russell, G.W. "Aerothermal Ablation Behavior of Selected Candidate External Insulation Materials," 28th AIAA Joint Propulsion Conference and Exhibit, Jul 1992.
4. Murray, A., Russell, G.W. "Coupled Aeroheating/Ablation Analysis for Missile Configurations," Journal of Spacecraft and Rockets, Vol. 39, No. 4, Apr. 2002.
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6. Russell, G.W. "DoD High Speed Aerothermal Analysis and Design - Historical Review and New State of the Art Approaches," NASA Thermal and Fluids Analysis Workshop, NASA Langley Research Center, Hampton, VA, Aug. 2003.
7. Lindsay, J. and O'Hanlon, M.E. Defending America: The Case for Limited National Missile Defense, Brookings Institute Press, Apr. 2001.

8. Moylan, B., and Russell, G., "Updating Mil-Std-810 to Address High-Speed Weather Encounter Testing", 53rd Annual Technical Meeting of the Institute of Environmental Sciences and Technology. April 29-May2, 2007.

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KEYWORDS: Missiles, Thermal Control, Thermal Insulation, Radomes, Lightweight, Shock Resistance, Vibration Resistance, Rain Erosion, Hybrid Composite, Lightning Strike, Advanced Materials, Reliability, Producibility, Manufacturability

MDA09-008

TITLE: Radiation Hardening Manufacturing Technology

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: DEP

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 3.5.b.(7) of the solicitation.

OBJECTIVE: The overall objective of this effort is to increase the radiation hardness/survivability of electronics components through innovative approaches in design, materials, signal processing algorithms, advanced production processes and capabilities, and/or novel approaches in combining these factors for BMDS systems. The goal of this topic is to provide an increased level of resistance to damage of electronics/semiconductor components induced by nuclear environment radiation with a minimal impact on weight, performance or product availability.

DESCRIPTION: BMDS missile systems must function reliably when exposed to background radiation from space and radiation resulting from nuclear events (including x-ray, any radiation-induced latch-up, single event effects, total ionizing dose, dose rate, etc.). Systems must also survive and function after prolonged periods in battlefield/storage environments. Optimal utilization of mass in missile systems and space platforms precludes exclusive reliance on traditional shielding methods as a means of countering the adverse effects of radiation. MDA is seeking the development of innovative concepts that use radiation-hardening by process, by design, by architecture or a combination of these approaches that will allow systems to endure and reliably operate in BMDS mission environments (radiation, shock, vibration, thermal, etc) without increasing weight or decreasing performance. Systems of interest include all BMDS kill vehicles and space-based platforms.

Technical areas of interest include: advanced designs, advanced materials, and production processes and capabilities. The use of Technology Readiness Levels to describe current technology maturity will be helpful in evaluating the planned effort. This topic's focus is on innovations that are minimally invasive, producible and can be inserted into all missile defense systems.

PHASE I: Define component approach and architecture. Identify key subcomponents. Conduct research and experimental efforts to identify, investigate, and demonstrate materials, unique device designs, novel architectures, and/or production process changes that address reliable operation of BMDS systems in perturbed environments consistent with High Altitude Nuclear Bursts as described in reference 2 or prolonged natural space radiation. A sound basis must also be shown for the radiation hardness capability of the treatment. Where ever possible, modeling, simulation, analysis, and/or testing should be performed to support conclusions. Consider implications for practical implementation of proposed concepts. Offerors are strongly encouraged to work with system and payload contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Using the resulting radiation hardened materials, techniques, designs, Technology Computer Aided Design (TCAD) tools, production and/or process changes or additions in Phase I, implement, test and verify the

proposed concept in prototype fashion to demonstrate feasibility and efficacy. Validation would include, but not be limited to, BMD system simulations, operation in test-beds, operation in a demonstration sub-system, and/or radiation testing. The offerors are encouraged to further seek partnerships with system primes or interceptor vendors as appropriate, and the degree to which the offeror can make such suppliers attracted to their solution is a strong consideration in gauging viability of their approach. Demonstrate applicability to both selected military and commercial applications.

PHASE III: The technology developed will apply to integrated circuit designs having the relatively low production volumes of the Ballistic Missile Defense System including Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) and the initial engineering lots developed for high volume commercial markets. There may be opportunities for the advancement of this technology for use in both commercial and military space activities during phase III program. Partnership with traditional DOD prime-contractors will be pursued since the government applications will receive immediate benefit from a successful program.

COMMERCIALIZATION: Commercial potential exist in the medical community, homeland security sector, and power and automotive industries. Certain technology developed will have a significant impact on the breakthrough of current commercial microelectronics technology and apply to manufacturing of advanced microelectronics for commercial market. Modern integrated circuits are increasingly more susceptible to SEE and this topic will assess quality control features within new devices to assure uniform radiation hard manufacturing producibility.

REFERENCES:

1. <http://www.mda.mil/mdalink/html/basics.html>.
2. Glastone, Samuel, The Effects of Nuclear Weapons, USAEC, USGPO, Washington D.C., 1957.

KEYWORDS: radiation effects, radiation hardening, materials, space

MDA09-009 TITLE: Antitamper Technology for Missile Defense

TECHNOLOGY AREAS: Air Platform, Information Systems, Materials/Processes, Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: DEP, TH, GM

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a means to generate unique and reliable identifiers of system or hardware configuration for the verification and protection of Critical Program Information (CPI) against exploitation.

DESCRIPTION: The MDA Director has issued a directive necessitating the protection of Critical Program Information (CPI) from unintentional transfer and the policy for the implementation of Anti-Tamper (AT) technology on MDA acquisition and associated technology programs. AT technology consists of engineering activities that result in the prevention and/or delayed exploitation of critical technologies in U.S. weapons systems. The purpose is to add longevity to critical technology by deterring efforts to reverse-engineer, exploit, or develop countermeasures against a system or component.

This topic seeks to develop methods to generate unique identifiers as a means to prevent unauthorized access to CPI. Though the particular solution may be tailored to a specific application, the concept and methodology of the solution should be applicable to Commercial Off-The-Shelf (COTS) and military hardware. Preference will be given to solutions that provide protection of CPI without introducing additional risks, weights, or costs to the weapon platform and its mission.

This effort will focus on developing innovative unique identifiers that provide protection from counterfeiting, system reconfiguration, or unauthorized access. Attention will be focused on the covertness of the application, personal and mission safety of the proposed methods, low (or no) power requirement, and seamless integration in the BMDS weapon platform. As a result, the MDA will maintain a technological edge in support of the warfighter.

PHASE I: The contractor shall develop the conceptual framework for a new and innovative AT protection technology or technique that is integrated with, or tailorable to, the CPI being protected. The contractor will also perform an analysis and limited bench level testing to demonstrate the concept and an understanding of the new and innovative protection technology.

PHASE II: The contractor shall demonstrate and validate the use of the AT protection technology into one or more prototype efforts, and evaluate the effectiveness of the technique. A partnership with a current or potential supplier of MDA systems, subsystems, or components is highly desirable. The contractor shall also identify any anticipated commercial benefit or application opportunities of the innovation.

PHASE III: Integrate selected AT protection technologies into a critical system application, for a BMDS system level test-bed. This phase will demonstrate the application to one or more MDA element systems, subsystems, or components - as well as the product's utility against industrial espionage. When complete, an analysis will be conducted to evaluate the ability of the technology/technique to protect against tampering in a real-world situation.

COMMERCIALIZATION: Most innovations in manufacturing processes take place at the supplier/subcontract level. The proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, or improve the producibility or performance of products that utilize innovative process technology.

REFERENCES:

1. Willis, L., Newcomb, P., Eds. Reverse Engineering, Kluwer Academic Publishers, 1996.
2. Ingle, K.A., Reverse Engineering, McGraw-Hill Professional, 1994.
3. Furber, S., ARM System-On-Chip Architecture, Addison-Wesley, 2000.
4. Huang, A., Hacking the Xbox: An Introduction to Reverse Engineering, No Starch, 2003.

KEYWORDS: Anti-Tamper, Protection, Reverse Engineering, Exploit, Unique, Identity, Identifier, Verification, Authentication

MDA09-010 TITLE: Ballistic Missile Defense System Innovative Power Storage Devices

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: DEP, SS, TH, GM

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 3.5.b.(7) of the solicitation.

OBJECTIVE: MDA is seeking to improve the quality, reliability and producibility of batteries and related power sources through innovative ideas applied in creative ways to accommodate unique, existing and future MDA system, subsystem and component requirements. These include developing new technologies, improving existing

technologies, new applications of existing technologies, and inventive uses of commercial off-the-shelf and military off-the shelf technologies.

DESCRIPTION: Most battery and power source products made for missile defense applications are manufactured in very low volumes. Enhancements are sometimes transitioned from the laboratory to the factory without a complete understanding of producibility constraints. Therefore, MDA is interested in innovative product enhancements that improve consistency and manufacturability while incorporating evolving technologies for integration into MDA systems. Intended enhancements range from improvements in fabrication of advanced materials to innovative components and processes that improve the capability of current systems. The goal is to enhance producibility of power sources as used in missile defense products, reduce unit cost and improve product reliability and performance to support future capabilities. For this solicitation, areas of interest include (but are not limited to) the following:

Improved Manufacturing & Production: Main interest areas include improving processing techniques to lower power source production costs and enhance performance (e.g. apply modern production technology to heritage processes), eliminating or modifying process steps that induce undesirable characteristics, and innovative software-based tools (e.g. battery design and production models, process CAM/CAD) to aid manufacturers with battery design and production monitoring. Other interest areas include innovations that reduce nonrecurring engineering costs, shorten lead times, and produce lighter, safer, and less expensive cells and batteries. Improvements that accommodate low production volumes, enhance production yield, consistency, reliability, producibility and manufacturability are desirable necessities for overall mission success.

Nonrechargeable Batteries for Missile Applications: Two main interest areas are new and improved reserve battery manufacturing techniques; innovations that result in batteries with higher energy and/or power density (e.g. peak specific power of greater than 7 kW/kg, specific energy greater than 100 Whr/kg at the battery level). Other specifically desired improvements include unconventional shapes for efficient space utilization (e.g. shapes other than right cylindrical or rectangular solids), improving battery safety under normal and abnormal use conditions (e.g. fire exposure); reducing “touch labor” during fabrication, improving subcomponents used in these batteries (e.g. high efficiency insulations, advanced materials for use in thermal batteries), reducing parts count and simplifying fabrication techniques to reduce cost and complexity (e.g. easier to assemble battery subcomponents).

Aerospace-grade Rechargeable Batteries: Two main interest areas for rechargeable lithium batteries are improved manufacturing techniques and developing reliable, lower cost manufacturing processes for optimal cell designs with resulting battery configurations that can accommodate long-duration space missions (e.g. low earth orbit, medium earth orbits for up to ten years calendar life). An additional interest area is smaller rechargeable Li-ion and other types of cells (e.g. 2 Amp hr and above) cells that are suitable for use in missiles at moderate power levels (e.g. 800 W/kg) and high energy levels (e.g. >100 Wh/kg at cell level). These interest areas include achieving long-term available and consistent materials as used in rechargeable lithium and other cell production, beneficial variations to space-quality rechargeable cells that enable them to achieve moderate to high charge and discharge rates with suitable voltage characteristics (e.g. discharge at up to 50C rates), improved calendar life; increased cycle life at greater depths of discharge (e.g. over 20,000 cycles at >50% depth of discharge for space application cells, over 100 cycles for missile battery type cells); improved charging and cell balancing methods to help achieve confidence in cell and battery designs, and improving cell safety (e.g. benign response to abusive conditions like over charging, over discharging).

PHASE I: Develop conceptual framework for battery or battery production process design/design modification for integration into MDA systems or subsystems to increase performance, lower cost and increase reliability and producibility. Where possible, limited scale demonstrations should be provided to assist in the judging of merit of the new technology.

PHASE II: Validate the feasibility of the power storage device or manufacturing process technology by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation by demonstration should sufficiently show near term application to one or more MDA-interest systems. A partnership with a current or potential supplier of MDA element systems, subsystems or components is highly desirable. The possibility of commercial benefit or application opportunities for the innovation is desirable.

PHASE III: The intention is to successfully implement the new power storage technology for use by MDA and other customers as appropriate. Implementation would include, but not be limited to, demonstration in a real system or operation in a system level test bed, and flight testing of the battery or solar array concepts. The new power source technology should be implemented at a manufacturer and be ready for inclusion in MDA applications.

COMMERCIALIZATION: MDA uses different types of power storage devices. Thermal primary batteries are used in military and commercial launch vehicles to power various subsystems in-flight. Lithium oxyhalide (active type) batteries are also used for some commercial applications and may be capable of replacing other battery types (e.g. where weight is a factor). Rechargeable batteries are used in aerospace applications for on-board power and are also widely used in commercial application. Finally, the manufacturing and producibility enhancements for MDA batteries could be applicable to commercial battery manufacturing lines.

REFERENCES:

1. <http://www.acq.osd.mil/mda/mdalink/html/mdalink.html> provides an overview of MDA platforms.
2. http://www.eaglepicher.com/EaglePicherInternet/Technologies/Power_Group/Defense_Applications_Products_Services provides documents describing MDA-interest batteries and related technology.
3. <http://www.lithion.com/lithion/index.html> provides links to various documents describing MDA interest rechargeable lithium battery technology.
4. <http://www.sandia.gov/news-center/resources/tech-library/index.html> provides links to documents (some detailed) describing various MDA-interest battery technologies.
5. <http://www.electrochem.org> provides detailed information on current state-of-the-art advances and research, mainly for MDA-interest rechargeable batteries.
6. Handbook of Batteries, 3rd Edition, McGraw-Hill, provides detailed information regarding the design and construction of thermal, liquid reserve and rechargeable batteries.

KEYWORDS: density, energy density, conformability, battery, lithium, rechargeable, space.

MDA09-011

TITLE: Active Sensor Materials and Process Technology Innovations

TECHNOLOGY AREAS: Air Platform, Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: DEP

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Identify and develop new materials and/or process technology for enabling more compact and producible active sensors with improved kill vehicle mission assurance.

DESCRIPTION: An active sensor uses a time of flight principle by sending a laser pulse in a narrow beam towards the object and measuring the time taken by the pulse to be reflected off the target and returned to the sender. Compact, in terms of size, weight, and power, kill vehicle active sensor systems may need to be used in conjunction with passive IR and/or visible sensors requiring complementary high precision optics. Natural and/or nuclear radiation and/or extreme vibration and shock environments together with scintillation and beam wander effects caused by the presence of air bubbles acting as lenses ranging in size from microscopic to roughly half the height of

the light beam affect transmission loss. These and other mission assurance issues require the design and manufacture of modular component which facilitate a range of scalable performance.

Among innovations sought are:

1) novel component technologies/processes/materials – enabling integrated active and passive optics (e.g., via negative index of refraction filters) - reduce sensor costs and weight, e.g., optical/baffle sizing, improved range – more efficient diodes, improved optical design and compact optics.

2) novel active-passive sensor assembly, alignment and testing - to reduce production schedule, snap-together optics and compact packaging.

3) more efficient thermal management - power efficiency, thermal management in a vacuum environment and system health and status monitoring would all be beneficial additions - low mass passive cooling approaches with low cost materials for 15 minutes or more of continuous operation in a space vacuum environment,

4) extreme environment tolerance – vibration and shock tolerance of compact, hardened digital signal processing systems for system management and control, and novel approaches to nuclear radiation tolerance of optics and optical devices.

5) beam directors and beam direction concepts for improved system management, greatly improved pointing precision, system simplification and expanded field of regard.

PHASE I: Develop conceptual technology for an active sensor materials and manufacturing approach that will improve schedule, lower cost, or increase reliability of active sensors for BMDS applications. Offerors are encouraged to work with system (kill vehicle) integrator and/or their respective payload contractors to help ensure applicability of the proposed effort and to facilitate future technology transition.

PHASE II: Validate the feasibility of active sensor materials and manufacturing technologies described above by manufacturing, packaging, validation by testing and integration of prototype items for MDA element systems, subsystems, or components. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration subsystem. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end they should have working relationships with system and payload contractors. A partnership with a current or potential supplier of MDA element systems, subsystems or components is highly desirable.

PHASE III: In this phase, the contractor will apply the innovation demonstrated in the first two phases to one or more MDA element systems, subsystems, or components.

COMMERCIALIZATION: Innovations developed under this topic will benefit both DoD and commercial space and terrestrial programs. Additional applications of this technology may arise in manufacturing of semiconductor opto-electronics, IR sensor materials and devices, optical materials, scientific instrumentation, astronomy, and medical fields.

REFERENCES:

1. Nettleton, John E., Schilling, Bradley, W., Barr, Dallas N., Lei, Jonathan S., Monoblock laser for a low cost, eyesafe, microlaser range finder, Applied Optics LP, vol 39, Issue 15, pp 2428-2432.

2. Thompson, K., Description of the third-order optical aberrations of near-circular pupil optical systems without symmetry, J. Opt. Soc. Am. A 22, pp 1389-1401 (2005)

3. X. Liu, J. Wang, P. Wei, Study of the mechanisms of spectral broadening in high power semiconductor laser arrays, Proceedings - Electronic Components and Technology Conference, 2008 Proceedings 58th Electronic Components and Technology Conference, ECTC, 2008, p 1005-1010

4. J. B. McKay, Power Scaling Feasibility of Chromium-Doped II-VI Laser Sources and the Demonstration of a Chromium-Doped Zinc Selenide Face-Cooled Disk Laser, Report: AFIT/DS/ENP/02-05, Mar 2002, 177p

5. Zweben, C. Advances in photonics thermal management and packaging materials, Proceedings of the SPIE – The International Society for Optical Engineering, v 6899, 7 Feb 2008, p 689918-1-12

KEYWORDS: integrated active and passive optics, active sensor manufacturing, low power space vacuum operation, nodal aberration analysis, negative index of refraction material.

MDA09-012

TITLE: Manufacturing Process Maturation for Propulsion Technology

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: DEP, GM, TH, AB

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 3.5.b.(7) of the solicitation.

OBJECTIVE: The Manufacturing and Producibility (DEP) Directorate of the Missile Defense Agency (MDA) is seeking producibility and cost reduction improvements for low-cost, high-performance materials and components. Reliable performance in both lower and upper boost phases, as well as end game, requires innovative, mature, and reduced-cost manufacturing processes. Additional considerations are for materials and components that demonstrate innovative technologies which moderate the response of large diameter (12 inches or greater) solid rocket motors (SRM) to unplanned stimuli such as heat, bullets or high-speed fragments. Applications of interest include solid boost motors as well as solid and liquid propellant divert and attitude control systems (DACs).

DESCRIPTION: MDA propulsion systems exhibit stringent performance requirements while simultaneously exposing materials to severe operating conditions. Reduced weight and power consumption while maximizing the fast response times require innovative actuation/valve technologies to minimize the response time for fine attitude control and pointing for divert and attitude control systems. Innovative projects to reduce the weight and volume of pressure regulators with a tighter regulation range. Erosion-resistant ceramic materials cannot resist the structural loads imposed by very large temperature gradients. Department of Defense (DoD) is required by statute to have programs that utilize Insensitive Munitions (IM) technologies. The current technology used to minimize the effects of unplanned stimuli on SRMs is insufficient and new IM technologies must be developed. Current large SRMs tend to react violently when exposed to fire, bullets and fragments.

- Actuator/Valve technology: Low voltage, high power density, high performance actuators for 5 to 2000 lbf applications. Response times should range from 5 ms at 5 lbf to 15 ms above 1000 lbf. Actuation technologies should maintain response, stiffness, and precision performance characteristics at high temperatures (>500F functional capability). Additionally, MDA desires actuation technologies with reduced part counts and designs that enhance reliability and simplicity of fabrication. For valve technology, reduced part count/complexity while operating at very fast response times, typically 1 ms to 3 ms response time for opening and closing.
- High pressure regulators are used to regulate pressure for propellant feed systems for DACs systems. These regulators regulate pressure from 10 ksi to approximately 1000 psi. This solicitation requests innovative technologies to miniaturize the pressure regulator to reduce packaging weight and volume while increasing the regulated pressure tolerance to approximately 100 psi. Current technologies regulation range is approximately 400 psi (1000psi to 1400 psi).
- High temperature, ablation-resistant structural parts and components: Ablation-resistant materials such as ceramics, composites, and refractory metals for components such as liners, nozzles, and hot gas paths. DACs materials including Zr- or Hf-based materials shall be subjected to pressures up to 3000 psi and flame temperatures from 4000°F to 5000°F. SiC-based composites may be considered, but are known to be temperature limited relative to these goals. Aluminized motor materials (TaC-based) must operate at 2000 psi and at flame temperatures greater

than 6000°F. The materials must be able to tolerate large temperature gradients such as those experienced at motor initiation. A typical minimum property is a tensile strength of over 50 ksi (345 MPa).

- Structural insulation components: DACS components are attached to missile structures and electronic components that cannot tolerate high temperatures. Currently, most non-pyrolyzing insulation materials have poor mechanical properties. Optimal structural insulation materials will be dimensionally stable to high temperatures, will not pyrolyze, and will exhibit nominal 15 ksi (34.5 Mpa) strength. Structural insulators will have high fracture toughness and thermal stress resistance, and exhibit low thermal diffusivity. Materials are desired for use at 3000°F with a future temperature goal exceeding 4000°F.
- Non-Structural insulation components: New materials are desired which pyrolyze to form dense, adherent, and low thermal diffusivity char layers. Such materials are typically rubbers (such as EPDM) which are compatible with both case materials and propellant compositions. High elongations (goal: >50%) are desired to enable case-propellant structural compatibility, and chemical compatibility must also be considered.
- For IM, Define and identify concepts for IM technology improvements and new technologies for SRMs which include but are not limited to new energetic material formulations and motor case/container venting technology. Identify the possible IM benefits and outline a proof of concept test plan, which can include but are not limited to testing of new energetic materials to obtain valuable characterization data, and analog or sub-scale motor test designs and venting tests. The use of MIL STD 2105C for designing, conducting and evaluating IM test programs is highly desirable.

PHASE I: Develop a strategy to demonstrate the producibility of the proposed propulsion product including integration with an MDA system. The goal of the Phase I effort will be to demonstrate that it is feasible to increase performance, reduce cost, and/or increase production reliability of the selected component. The proposal should provide a quantifiable assessment of the feasibility and pay-off of the selected technology. Critical experiments and/or analyses to support the Phase I feasibility is desired.

PHASE II: Implement the manufacturing plan and quantify key milestones. Validate the feasibility of the material or component by demonstrating its use in the operation of manufactured items for MDA systems, subsystems, or components (such demonstration assumes adequate material and component characterization). A partnership with a potential supplier of MDA systems, subsystems, or components is highly desirable. Identify commercial applications of the technology and other DoD opportunities that benefit from the innovation.

PHASE III: Complete technology transition via successful demonstration of a new product technology. This demonstration should show near-term application to one or more MDA element systems, subsystems, or components. This demonstration should also verify the potential for enhancement of quality, reliability, performance and reduction of unit cost or total ownership cost of the proposed subject.

COMMERCIALIZATION: Manufacturing improvements in materials have direct applicability to space launch vehicles, gas turbines, and automotive technologies. Actuator technologies have wide applicability to the aerospace industry to include both aircraft and rocket technologies. Because of the wide variety of chemicals and materials involved, it is anticipated that the private sector will benefit from test procedures for aging propellants.

REFERENCES:

1. George T. Sutton, "Rocket Propulsion Elements; Introduction to the Engineering of Rockets" Seventh Edition, John Wiley and Sons, 2001.
2. Missile Defense Agency Link: <http://www.acq.osd.mil/mda/mdalink/html/mdalink.html>
3. Ballistic Missile Defense Basics: <http://www.acq.osd.mil/mda/mdalink/html/basics.html>

KEYWORDS: Divert and Attitude Control System, High Temperature Material, Insulation, Propellants, Rocket Motor

MDA09-013

TITLE: Develop and Demonstrate High Performance Infrared Focal Plane Arrays with Advanced Quantum Structures

TECHNOLOGY AREAS: 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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop next-generation high-performance infrared (IR) focal plane arrays (FPAs) by exploring advanced quantum structures and utilizing innovations in nano-engineering. The topic includes, but is not limited to the investigation and demonstration of the type-II strained-layer superlattice FPAs based on III-V materials.

DESCRIPTION: MDA is seeking innovative research proposals in the area of infrared detectors and focal plane arrays using advanced quantum structures, such as Antimony (Sb) based strained layer superlattice (SLS). SLS is a new infrared detector material that has the theoretical promise to outperform existing materials such as mercury cadmium telluride (HgCdTe) and indium antimonide (InSb). In the past few years, tremendous progress has been made in various research laboratories. Long-wavelength infrared single-element detectors with performances approaching that of HgCdTe are being achieved. SLS FPAs at 320x256 format with 30 μm pixel pitch with good performance have been successfully demonstrated.

However, in order to achieve high-performance FPAs that can provide the best system performance for missile defense, several technical issues still need to be solved by technology and engineering innovation. Novel detector architecture and structure design is one area that can be explored further. Both single- and multiple-spectral band FPAs can benefit from such improvement. Better understanding and optimization of various combinations of interface elements may also payoff greatly. In the epitaxial wafer growth area, significant improvement can be made by innovations in nano-engineering. Substantial reduction in growth defect and advances in precision control of a large space of growth parameters are critical to reduce dark current noise, improve uniformity, increase device reliability and reproducibility. Additionally, innovation is needed to enhance the substrate quality and size, including reducing micro- and macro-defect counts, improving surface quality, and doping control. Substrate crystal orientation and its impact to superlattice material growth may also be studied. It is anticipated that large diameter (up to 6-inch) wafers will be needed in the near future.

So far, successful superlattice materials are grown by molecular beam epitaxy (MBE). There is no fundamental physics-derived reason to exclude other growth methods to achieve high-quality material growth. In fact, different growth methods may offer advantages over MBE, such as lower defect density, better uniformity, larger wafer size, lower production cost, and superior manufacturability. MDA encourages alternative approaches to material growth. These include utilization of technology and engineering innovations to solve technical issues specific to superlattice growth, such as interface intermixing, strain compensation and balance, temperature optimization, stoichiometry optimization, and precursor selection.

Demonstration in material growth should have quantitative technical goals, including the following: High-resolution X-ray rocking curve with full-width-at-half-maximum of 20 arc second, and the mismatch between SLS and substrate, which can be inferred by peaks in X-ray rocking curves, of less than 300 parts per million (ppm); atomic force microscopy surface roughness near 2 angstrom; wafer macro defect (defined as defect diameter larger than 20 μm) density of less than 500 per square centimeter, and wafer micro defect (defined as defect diameter less than 20 μm) density of less than 2000 per square centimeter. In addition, these SLS materials should be processed to form single-element diodes that meet the following performance goal: At operating temperatures higher than 65 Kelvin and cutoff wavelength of 10 μm , the quantum efficiency should be larger than 60% and the dark current density should be less than 1 micro-ampere per square centimeter.

In the detector array processing and FPA fabrication area, novel ideas in etching chemical selection, etching and surface cleaning protocol, passivant selection, and passivation scheme perfection are sought. Technology innovations in this area are essential in achieving low leakage current for FPAs with small pixel size and multiple-

spectral bands. Although many passivation materials and methodologies have been experimented on Sb-based superlattice materials, the ultimate passivant and protocol is still to be discovered that offers a stable and highly effective mechanism to eliminate leakages. In addition, novel approaches are encouraged for substrate thinning or removal, detector array anti-reflection coating, hybridization, and FPA packaging.

Proposed novel ideas will be validated by device demonstrations at the FPA level. Single band or multiple bands on one FPA are desired. The FPA format should be at least 320x256, up to 2kx2k at single band, and up to 1kx1k for two-bands. The single-band small format FPA has the following performance goal: operating temperature higher than 65 Kelvin, cutoff wavelength $> 7\mu\text{m}$ (longer cutoff desired), median quantum efficiency larger than 60%, fill factor larger than 88%, median dark current density < 1 micro-ampere per square centimeter (depending on the cutoff wavelengths), responsivity operability larger than 98%, responsivity non-linearity at 10 – 90% full well depth less than 1%, noise equivalent input (NEI) operability (defined at 2X median) larger than 98%, frame rate 30 – 200 Hz, and integration time range from zero to the full-frame time. The two-band FPA has the following performance goal: Operating temperature higher than 65 Kelvin, the first spectral band covers wavelengths from $7\mu\text{m}$ to $9\mu\text{m}$, and the second spectral band covers wavelengths from $9\mu\text{m}$ to $11\mu\text{m}$, median quantum efficiency larger than 50% in each band, fill factor larger than 80%, median dark current density < 1 micro-ampere per square centimeter (depending on the cutoff wavelengths), responsivity operability larger than 95%, responsivity non-linearity at 10 – 90% full well depth less than 1%, NEI operability larger than 95%, frame rate 1 – 200 Hz, and integration time range from zero to the full-frame time.

PHASE I: Prepare and deliver feasibility study of proposed ideas. This study includes design, modeling, and experimental study. Single-element detector concept design and single pixel/small format array demonstration are strongly encouraged in Phase I.

PHASE II: Design, develop, and characterize a prototype of the proposed detector array or FPA with dramatically improved characteristics than current state of the art.

PHASE III: Develop and execute a plan to market and manufacture superlattice FPA. Assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing.

COMMERCIALIZATION: The contractor shall pursue commercialization of the various technologies and EO/IR components developed in Phase II for potential commercial uses in such diverse fields as law enforcement, rescue and recovery operations, maritime and aviation collision avoidance sensors, medical uses and homeland defense applications.

REFERENCES:

1. M. Tidrow et al., Recent Success on SLS FPAs and MDA's New Direction for Development, to be published at SPIE Defense & Security Conference Proceedings, 2009.
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3. P. Delaunay and M. Razeghi, High performance focal plane array based on type-II InAs/GaSb superlattice heterostructures, Proc. of SPIE Vol. 6900, paper 69000M, 2008
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6. E. Aifer et al, Very-long wave ternary antimonide superlattice photodiode with 21 μm cutoff, Applied Physics Letters Volume 82, Number 25 23 June 2003.

7. B. Nguyen et al, Dark current suppression in type II InAs/GaSb superlattice long wavelength infrared photodiodes with M-structure barrier, Applied Physics Letters 91, 163511, 2007.
8. E. Huang et al, Surface leakage reduction in narrow band gap type-II antimonide-based superlattice photodiodes, Applied Physics Letters, vol 94, page 053506-1, 2009

KEYWORDS: Type II strained layer superlattice (SLS), infrared focal plane array (IRFPA), Dry etching and passivation, single- and dual-band detectors and FPA, InAs/GaSb III-V materials, substrate.

MDA09-014

TITLE: Smart Infrared Focal Plane Arrays and Advanced Electronics

TECHNOLOGY AREAS: Sensors, Electronics, 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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate smart infrared focal plane array (IRFPA) that can operate robustly under ballistic missile defense environment. Explore innovative ideas in detector arrays and read out integrated circuits (ROIC) to mitigate all adverse effects, including the radiation from space.

DESCRIPTION: IRFPAs, including detector arrays and ROICs, are critical to many missile defense sensor and weapon systems. Often these systems are placed permanently on space-based platforms, or transiently on a seeker flying in the endo- and exo-atmosphere experiencing rapidly changing radiation environment. The system performance may degrade or become unreliable under the harsh space environment not encountered on Earth or at normal laboratory settings. High-energy radiation impinged onto IRFPAs is a major source of system performance degradation. For example, displacement damages due to protons and neutrons may cause changes in photovoltaic detector carrier lifetime and mobility, and therefore lead to permanent IRFPA performance deterioration. Ionization-induced response may increase dark current count in the directly radiated pixel and nearby pixels, causing system malfunctions. These adverse radiation effects may vary with detector materials and device passivation methods, ROIC layout, and the overall IRFPA structure. Although many studies have been conducted on a few types of IRFPAs, little is known about the performance degradation of newly developed IRFPAs, not to mention any possible mitigation solutions.

Innovative and robust solutions are solicited to mitigate the adverse effect caused by space radiations. In order to achieve this, studies should be performed to fully understand the possible mechanisms that may impact the IRFPA performance in space environment. Quantitative relationships should be established between types of radiation, radiation dose, and radiation impact to the performance of detector arrays, ROICs, and infrared sensor systems as a whole. The performance parameters may include detector lifetime and mobility, detector array uniformity, dark current noise, operability, radiation damage threshold, cross talk statistics, and transient response. Both modeling study and laboratory experiment are to be conducted.

Solutions addressing every aspect of IRFPAs are solicited. For example, at the detector level, it has been found that in some material systems, better detector passivation led to greater improvement in IRFPA total-dose hardness. Similar ideas may be applied to newly developed IRFPAs, i.e., by dramatically improving detector array passivation, a radiation-hard solution may be found. This may require the development of new passivation materials that are stable and effective, novel ways to perform etching and cleaning, and different procedures to apply the passivant to the mesa surface. On the other hand, an innovative solution may also be developed that is not at all associated with traditional mesa structure and passivation. Instead, planar structures made by ion implantation or other methods may offer a good solution. In addition, it might be possible to use microlenses and unconventional optical means to reduce the effective electrical volume that is prone to radiation exposure. All solutions should consider the cryogenic cooling as the normal operating condition.

At the ROIC level, innovative ideas are solicited to intelligently remove noises associated with space radiations and other processes. ROIC design solutions should decrease the circuit complexity, increase the operational lifetime, and provide immunity against extraneous events. ROIC designs must be radiation hard to a minimum of 300kRads(Si) total dose of natural radiation and include features for mitigation of single-event upsets and latch-up. In addition, proposed ROIC solutions should be scalable to future IRFPA development trends, i.e. large format, small pixel size, and multiple spectral bands. ROIC designers should be able to collaborate with the detector and FPA community, including the vendors that are developing new detector materials or new detector structures, to achieve the best overall performance of IRFPAs. This may involve improving charge injection efficiency, offering flexibility on n-on-p or p-on-n polarities, and making various numbers of electrical contacts per pixel while keeping the fill factor at a reasonable level. Advanced features are also highly desirable, e.g., super framing, programmable spatial resolution, pixel level change detection, programmable color fields, random window addressing for high speed imaging of multiple targets, on-ROIC analog to digital converter, multiple integration modes, programmable unit cell gain, short circuit prevention, and blooming control.

Demonstration of single-band and dual-band ROICs and FPAs that incorporate radiation-hard solutions are solicited. The desired characteristics for single-band ROICs and FPAs are the following: format 1024 x 1024 or larger, pixel pitch from 15 μm to 30 μm , operating temperature 65 - 80 Kelvin, detector bias range 0 - 0.5 Volt, detector bias resolution 5 millivolts, well capacity up to 50 million electrons, read noise less than 200 electrons, dynamic range 14 bits, full frame rate 200 Hz, power consumption less than 200 mW, matching detector quantum efficiency 45 - 70%, and resistance-area product at zero bias (ROA) 1,000 ohm-cm². For dual-band ROIC demonstrations, the desired characteristics are similar to that of the single-band ROIC, except that the format should be 512 x 512 or 1024 x 1024, the expected minimum detector resistance-area product at zero bias (ROA) 100 ohm-cm² or larger, and the frame rate up to 100 Hz.

PHASE I: Prepare and deliver feasibility study. This activity includes data gathering that establishes good understanding of the problems and quantitative analysis of promising solutions or designs. A single unit cell ROIC concept design or single pixel/small format array demonstration is strongly encouraged in Phase I.

PHASE II: Design, develop, and characterize a prototype of the proposed ROIC, or detector array, or FPA with radiation-hard characteristics

PHASE III: Develop and execute a plan to market and manufacture the smart FPA or ROIC. Assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing.

COMMERCIALIZATION: The contractor will pursue commercialization of the various technologies and EO/IR components developed in Phase II for potential commercial uses in such diverse fields as commercial satellite imagery, law enforcement, rescue and recovery operations, maritime and aviation collision avoidance sensors, medical uses and homeland defense applications.

REFERENCES:

1. J. Pickel et al, Radiation effects on photonic imagers – a historical perspective, IEEE Trans. Nuclear Science, vol 50, page 671, 2003.
2. E. Huang et al, Surface leakage reduction in narrow band gap type-II antimonide-based superlattice photodiodes, Applied Physics Letters, vol 94, page 053506-1, 2009

KEYWORDS: Smart FPA, radiation-hard FPA and ROIC, large format, single and multiple spectral band.

MDA09-015

TITLE: Radar Multi-Beam Receive Arrays

TECHNOLOGY AREAS: Sensors, Electronics

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop low-cost receive-only active phased array technologies to support multiple simultaneous beam operation.

DESCRIPTION: Next generation BMD sensor systems are anticipated to be highly networked. One radar concept calls for a single (or a few) illuminator(s) and multiple receive antennas. It is desirable that the receive antennas be electronically steerable and that they support multiple simultaneous receive beams. This approach has multiple potential advantages: 1) The receive array can be more affordable than a full T/R array because the transmit circuit and T/R switches are eliminated and the thermal/cooling system is simplified, 2) the receive array can operate at 100% duty cycle, supporting multiple simultaneous and time interleaved engagements.

The receive array should support full-field of view steering. It is desirable to have multiple simultaneous arbitrary beams. However, to form N beams would likely require N copies of receive element control (amplitude/phase) and N parallel manifolds. Multiple beams in a cluster configuration can be achieved by allowing fixed element control for sub-arrayed elements and then allowing sub-arrays to be combined using N parallel manifolds (analog or digital), resulting in a sub-array mainbeam that is less than full field of view. Performance/cost trades for different combining network architectures are desired. The objective array will be quite large (on the order of tens of square meters). This SBIR will develop building block array technology that can scale to the objective size array. Polarization support (linear, circular, dual) will be application system dependent. MDA is interested in cost/complexity trades to polarization support for low-cost receive array technology. The control architecture will be designed to support open architecture principles and to be able to scale in both array size and performance (beam switching/update rates, number of beams supported...) Notional goals are shown below:

Frequency:	X-Band or S-Band
Operating Bandwidth:	20-40%
Scan capability:	Full Field of View
# Simultaneous beams:	Threshold: 4-8 clustered beams Objective: 4-8 arbitrarily steerable beams
Polarization:	TBD, cost trade
Beams switching:	TBD, cost trade

This topic is focused on developing novel, low-cost receive-only multi-beam array architectures.

PHASE I: Develop array building block architecture including derived requirements for element spacing, radiating element design and feed, receive circuit performance (noise figure, gain, phase/time control, amplitude control...), subarray manifold and array manifold, and integrated beams steering control concept. Critical components of the system should be identified and trade studies conducted resulting in selection of the best architecture and components for Phase II.

PHASE II: Model, design, fabricate and integrated sub-array building block hardware to validate achieved performance through testing and demonstration. Model performance of a full scale system and support for multiple beams using measured and subarray data to support model. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Refine prototype sub-array building block developed in Phase II for targeted MDA and commercial applications. Integrate with a radar back-end for end-to end radar receiver demonstration. Work with MDA to target potential integration into one or more BMDS systems.

COMMERCIALIZATION: The proposed technology has a number of related commercial applications in radio frequency (RF) sensors. Commercial radar systems and commercial RF communications systems all require directional antennas. The ability to support multiple simultaneous beams would increase capability of these systems dramatically.

REFERENCES:

1. Rejto, S., "Radar Open Systems Architecture and Applications," IEEE International Radar Conference, 2000, 7-12 May 2000, pp. 654-659.

KEYWORDS: Phased Array Radar, Multi-static Radar, Multi-beam, Digital beamforming, Low-Cost, Receive only arrays

MDA09-016

TITLE: Photonic Multi-Beam Receive Arrays

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Study, design, develop, and validate a photonic multi-beam RF receive array architecture that would enable multiple simultaneous receive beams with high bandwidths, would minimize interfaces for control, would provide an interface which controls the beams and provides the necessary accuracy, would provide accurate time delays to accomplish beamforming and pointing accuracy, would minimize the losses in the optical-RF paths, and would use novel packaging approaches to integrate the receive array in a cost effective manner.

DESCRIPTION: The use of photonics provides an opportunity to design a multi-beam phased array which can simultaneously form multiple beams and receive multiple signals. This topic involves the study, design, development, fabrication, and validation of the performance of a photonic multi-beam receive arrays for phased array antennas. There are a number of challenges in the development of a photonic multiple beam (simultaneous) antenna including maintaining beam pointing accuracy and gain over a minimum scan range of +/- 60 degrees, minimizing the interfaces in the design, providing an antenna control interface which minimizes the number of inputs and provides the necessary control for all beams and minimizes latency, and provides a design which minimizes the optical and RF losses through the system. The effort should consider a design which would insure that fabrication maintains the necessary time delays to maintain the required pointing accuracy throughout the scan area, an input pointing command structure which provides the required pointing accuracy anywhere in the scan area, and a design which minimizes the required system calibration. In addition, the design would provide opto-electronic interconnects which can be readily integrated into the system and minimize the SW&P, and use novel packaging concepts which reduce the system SW&P and provide a producible design. The antenna should be tunable over two octaves including coverage in the X-Band, and provide at least 10 simultaneous antenna beams. The antenna sizes of interest range from 40,000 to 400,000 elements.

There is also interest in the development of subsystems and functions for the photonics multi-beam receive phased array which would improve/extend the performance, simplify implementation, or reduce costs; and can be readily integrated into a packaged photonics multi-beam receive phased array system.

PHASE I: Study and develop a conceptual design of a photonic multi-beam receive array which can be evaluated with modeling and simulation (M&S), and use the M&S to evaluate the extension of the design for simultaneous beams. The integrated packaged system including the SW&P and interfaces shall also be considered. The development of a subsystem or function shall include a conceptual design of a complete photonic multi-beam phased array system with emphasis on the subsystem or function. Offerors are encouraged to work with a system or prime contractor during early phases of the program to facilitate future technology transition.

PHASE II: Complete the design of the photonic multi-beam receive array and fabricate the design in a breadboard or brassboard which can be used to validate the system design to allow the design to be transitioned to a prototype with an integrated packaged system in a follow-on phase. As recommended in the Phase I, to facilitate technology transition to a Phase III effort the contractor should have a working relationship with system or prime contractors. A

partnership with a current or potential supplier of MDA element systems, subsystems or components is highly desirable.

PHASE III: In this phase, the contractor will apply the innovation demonstrated in the first two phases to one or more MDA element systems, subsystems, or components.

COMMERCIALIZATION: Innovations developed under this topic will benefit both DoD and a range of commercial applications. Additional applications of this technology include commercial communications, air traffic control, and a range of aerospace applications.

REFERENCES:

1. H. Jasik, J. L. Volakis, R. C. Johnson, "Antenna Engineering Handbook," MCGRAW-HILL, 2007.
2. R. J. Mailloux, "Phased Array Antenna Handbook - Second Edition," Artech House Publishers, 2005.
3. M.W. Beranek, "Fiber optic interconnect and optoelectronic packaging challenges for future generation avionics," Proceedings of SPIE, vol. 6478, 2007.
4. B. Jung, J. Shin, and B. Kim, "Optical True-Time-Delay for Two-Dimensional X-Band Phased Array Antenna," IEEE PHOTONICS TECHNOLOGY LETTERS, VOL. 19, NO. 12, pp. 877-879, JUNE 15, 2007.
5. Y. Han and J. Lee, "Multiple-element photonic microwave true-time-delay beamforming incorporating a tunable chirped fiber Bragg grating with symmetrical bending technique," OPTICS LETTERS, Vol. 32, No. 12, pp. 1704-1706, June 15, 2007.
6. H. Zmuda and E. Toughlian, "Photonic Aspects of Modern Radar," Norwell, MA, Artech House, 1994.

KEYWORDS: Antenna, beamformer, opto-electronic interconnects, true time delay, Phased-Array, Photonics, Receive only arrays

MDA09-017

TITLE: Innovative Waveforms and Related Signal Processing for Missile Defense Radars

TECHNOLOGY AREAS: Sensors, Electronics

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop innovative waveforms and related signal processing algorithms that will improve the capability of missile defense radars in target detection, discrimination, and tracking as well as reducing vulnerability to jamming and other countermeasures.

DESCRIPTION: Earlier missile defense radars used linear frequency modulated (LFM) waveforms, with narrow band versions used for search and broadband versions used for tracking and discrimination. These waveforms are subject to jamming and do not provide the capabilities in tracking and discrimination available with more advanced waveforms. The need for improved detection, tracking, and discrimination for missile defense radars as well as crowding of the electromagnetic spectrum increases the need for innovative radar waveforms and related improved signal processing. The use of widely displaced radars to improve volumetric coverage and angular resolution, in particular, will require orthogonal waveforms if the radars operate in the same bands. Wideband waveforms are required to improve range resolution, while methods for measuring target polarization signatures using polarimetric waveforms will improve target discrimination. In addition, noise and chaotic waveforms provide some degree of stealth besides being inherently orthogonal. Waveforms must be robust with respect to determination of both range

and Doppler for missile targets. Because of the lack of scarce electromagnetic spectrum, the cellphone industry has lead in the development of innovative orthogonal waveforms allowing multiple access to cellphone communications channels as well as some degree of security. Adaptive waveforms have the potential for improving radar discrimination by adapting to radar returns. These waveforms have the potential for improving the radar range-Doppler ambiguity function by adaptively removing ambiguous peaks from the vicinity of the target return in range-Doppler space. It is likely that all radar functions can be improved by using waveforms that have the capability to adapt to fluctuating target and environmental scenarios. The availability of sophisticated wideband digital receiver excitors (DREX) makes feasible the generation of innovative waveforms that can be rapidly adapted to changing scenarios.

PHASE I: Develop innovative waveforms and related innovative signal processing to improve the detection, discrimination and tracking functions for missile defense radars. Show by modeling and simulation that these functions are improved. Show by simulation that these waveforms improve the range-Doppler ambiguity function for targets and scenarios relevant to missile defense.

PHASE II: Test waveforms and signal processing algorithms developed in Phase I against real targets using real radar data. Demonstrate improved performance in detection, discrimination, and tracking. Show that these waveforms decrease the vulnerability of missile defense radars to jamming and other countermeasures.

PHASE III: Work with the Missile Defense Agency to identify potential applications within the Ballistic Missile Defense System. Contact commercial entities to determine the applicability of waveforms developed during this effort to such applications as wireless communications and weather radar.

COMMERCIALIZATION: The demand for electromagnetic spectrum for civilian applications such as wireless communications and air traffic control and weather radars has created a need for waveforms that will make maximum use of spectrum while providing for improved communications and radar performance. The results of this effort will provide the basis for improving the performance of commercial radio frequency systems.

REFERENCES:

1. Proceedings of the 4th International Conference on Waveform Diversity and Design, Orlando, FL, 9 – 13 February 2009. See also the proceedings of earlier conferences in this series held in Pisa, Italy in 2007, Lihue, Hawaii in 2006, and Edinburgh, UK in 2004, <http://www.waveformdiversity.org/>
2. Principles of Waveform Diversity & Design, V. Amuso, S. Blunt, E. Mokole, R. Schneible, and M. Wicks, editors, Scitech Publishing Co, Raleigh, NC, 2009.

KEYWORDS: Orthogonal waveforms, adaptive waveforms, ambiguity function, waveform diversity, waveform design, radar discrimination, radar tracking

MDA09-018

TITLE: Clutter Suppression and Debris Mitigation Techniques and Algorithms for Missile Defense Radars

TECHNOLOGY AREAS: 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 3.5.b.(7) of the solicitation.

OBJECTIVE: This topic seeks proposals for innovative, clutter and debris suppression concepts and approaches which will enhance the ability of radar systems to perform detection, tracking, and discrimination in a missile defense context. Traditional clutter in radar signals comes from undesired background reflections. Radar clutter in the missile defense context may also come from objects associated with the attacking missile. (See references.) Any proposed approach should offer a new idea for robust mitigation of one or more types of intentional or non-

intentional clutter and debris that are anticipated. Purely algorithmic approaches are of primary interest, although it would be acceptable for an algorithm to be coupled with an incremental and low-cost modification to existing MDA radar assets. To this end, any proposal should clearly indicate the radar system specifications required to make the proposed suppression/mitigation technique viable.

DESCRIPTION: Missile Defense System performance is heavily dependent on data from dispersed and disparate radars and other sensors. Accurate radar data is needed, no matter what the environment. It is anticipated that the environment around a ballistic missile complex will include intentional and non-intentional clutter as well as a large number of small debris fragments. This clutter and debris can decrease the ability of a missile defense radar to detect, track, and discriminate objects of interest. Algorithms that mitigate the effects of these intentional and/or non-intentional clutter and debris backgrounds while maintaining all required radar data on objects of interest are desired.

A proposed algorithm may focus on one or more types of clutter or debris and may take advantage of the capabilities of any or all missile defense radars. Efficient, highly reliable algorithms will be required to maintain clutter and debris suppression performance under a variety of conditions. Proposed approaches that minimize radar resource utilization while providing maximum clutter/debris suppression capability are desired.

PHASE I: Develop a proof of principle demonstration for the proposed clutter/debris suppression technique using simulated data. Perform sufficient analysis and testing to ascertain the capabilities and performance of the technique to a first order. Recommend a plan for further development of the algorithm to optimize its functionality and allow it to run on a real-time system with a minimum allocation of computational assets.

PHASE II: Perform further development of the algorithm in order to enhance its functionality and run it against a wide variety of clutter/debris cases using realistic environmental data, to include realistic processing speeds in complex scenarios.

PHASE III: Integrate the technique into the Ballistic Missile Defense System in coordination with BMDS Systems Engineering and the relevant Program Office.

COMMERCIALIZATION: This product can be used to support clutter/debris suppression in the aerospace sector, to include air traffic control, weather radar and aircraft collision avoidance.

REFERENCES:

1. Purdy, Blankenship, Muehe, Stern, Rader, and Williamson, Radar Signal Processing, Lincoln Laboratory Journal, Volume 12, Number 2, 2000, pp. 297-320.
2. Radar System with adaptive clutter suppression, United States Patent 5539412, 04/29/1994, Howard B. Mendelson.
3. Planning a Ballistic Missile Defense System of Systems, Rand National Defense Research Institute www.rand.org/publications/IP/IP181/.
4. Haykin, Simon, "Adaptive Filter Theory, Third Edition", Prentice-Hall, 1996
5. Skolnik, Merrill, "Radar Handbook, Second Edition," McGraw-Hill, 1990.
6. "Orbital Debris Evolutionary Models," NASA Orbital Debris Program Office www.orbitaldebris.jsc.nasa.gov/model/evolmodel.html
7. Method and Device for the Detection and Track of Targets in High Clutter, US Patent #7,154,433 B1, 12/26/2006, J. Michael Madewell.
8. Method and Device for the Detection and Track of Targets in High Clutter, US Patent #6,809,682 B1, 10/26/2004, J. Michael Madewell.

KEYWORDS: clutter, chuff, debris, debris mitigation, clutter suppression, fragments, discrimination, radar, algorithms

MDA09-019

TITLE: Innovative Low-Cost Encrypted Mobile Ground Systems

TECHNOLOGY AREAS: Information Systems, Sensors, Space Platforms

ACQUISITION PROGRAM: GBI (alternative STSS)

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 3.5.b.(7) of the solicitation.

OBJECTIVE: The objective of this effort is to create an innovative field deployable for L/S-Band ground systems at significantly reduced cost. The mobile ground system (MGS) approach should be SGLS compatible, easily upgradeable to accommodate the K-band downlinks, allow interoperability with the AFSCN, and employ government furnished Type-1 cryptographic equipment.

DESCRIPTION: There are a increasing number of microsatellite research and development (R&D) missions within the Department of Defense (DoD) which are critical for development of critical Information Systems, Sensors, and Electronics technologies that require a dedicated ground system to achieve maximum mission payoff while maintaining minimum interference with existing ground segment architectures – the Calibrated Orbiting Objects Project (COOP, formerly known as the Microsatellite Target System (MTS)) is a good example of such a mission.

This effort requires developing algorithms to enable a net-centric distributed processing prototype system to fully exploit the strength of spatially distributed sensors in combating the effects of clutter and sensor noise effects. One of the challenging aspects to this problem is the correct association of bearings-only measurements to tracks in the database. Since bearings-only measurements lack range or intensity information (or have large uncertainties), there is significant ambiguity in associating such measurements to tracks in the system, especially when fusing data from multiple sensor types. Correctly associating these measurements is essential to maintaining track on a target.

Subordinate issues must furthermore be addressed for mission success:

1. Extend the 2D assignment to a multiple hypothesis data association algorithm so that ambiguities can be carried longer in hopes of resolving them with subsequently collected measurements.
2. Recognize that a partially obscured target is more likely to stay obscured for at least some period of time. In other words, the obscuration state of an target is time-correlated which can be exploited to improve tracking of the target.

Given the research needed to deliver a theatre level data fusion capability to the local commander, proposers are further encouraged to suggest methods for fusing multi domain information from an array of identical or similar ground systems (e.g. Joint Tactical Ground Station (JTAGS)) to support the DoD policies regarding data sharing among information capabilities, services, processes, and personnel interconnected with the Global Information Grid (GIG). In addition, offerors should present potential software solutions for communicating with several research and development satellites. These solutions should specifically the interface challenges associated with command and control of multiple satellites.

Flight programs currently struggle for priority on the Air Force Satellite Control Network (AFSCN) with operational systems. A low cost mobile ground system (MGS) would provide these missions with a dedicated ground system (or systems) allowing the Department to demonstrate technologies in a relevant environment without upsetting the primary ground architecture. Furthermore, transportability will allow for deployment at the integration facility, where telecom system testing can be accomplished more efficiently, and enable demonstrations to test operations over different CONUS and OCONUS theaters.

Proposers should specifically seek creative and innovative options for reducing system level cost by combining existing hardware and software with a new generation of low cost components emphasizing the importance of Horizontal Integration. The proposal should address the system level impacts and integration issues. For example, to what degree can new components be integrated with existing systems? Proposers should specifically propose the accommodation of a Space Ground Link System (SGLS) satellite command and control (C2) link and both high data rate and low data rate K-band downlinks (~100Mbps, ~2Mbps), recognizing that the all associated equipment will not be affordable under a typical Phase II SBIR.

The proposal shall address the use of a multi spiral approach to achieving Initial Operational capability (IOC) and Final Operational Capability (FOC). IOC shall include at least SGLS command and control functions for tasking a single satellite in Low Earth Orbit (LEO). FOC shall include at least SGLS C2 and both high data rate and low data rate K-band downlinks for a single Geosynchronous Earth Orbit (GEO) satellite.

PHASE I: Phase I work should culminate in a CDR-level design including the fabrication of any engineering hardware/software needed to validate key concepts. Phase I should also result in a clear technology development plan, schedule, budget, performance specification, and requirements documentation.

PHASE II: Phase II work will ideally result in IOC of the MGS ready for deployment. Systems predicted to cost in excess of the Phase II ceiling are considered responsive to the solicitation. In this event, the proposer should strive to develop the components critical to achieve operational status. Field testing of the system should not be considered in the cost proposal.

PHASE III: This phase I-III sequence is designed for direct insertion into actual MDA experiments in phase III as part of ongoing capabilities based test plans. Phase II will therefore be directed to support some specific phase III program within which it will be inserted.

COMMERCIALIZATION: A successful development and demonstration of this technology will result in a continued use by the Air Force, the Department of Defense (DoD), academia (i.e. the Unniversity Nanosat Program), and the commercial space community.

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KEYWORDS: Low-cost, Air Force Satellite Control Network (AFSCN), Space Ground Link System (SGLS), Field Deployable, Mobile, Transportable, Ground System

MDA09-020

TITLE: Payload Thermal Management Technology

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: STSS (GBI, MKV alternates)

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Reduce jitter, mass, and/or power for electro-optical (EO) space payloads by improving performance of components of the cryogenic and ambient thermal management systems. These performance improvements may consist of (in no priority order): a reduction in weight of or power consumption of the cooling system; an improvement in heat transfer to, within and/or from the system; enabling the transfer of cooling across a gimbal, a flexible joint, and/or to multiple payloads from a single refrigerator; an ability of the cooling system to rebalance loads vs. temperatures over system life; a reduction in the jitter induced by the cooling system.

DESCRIPTION: Next generation missile midcourse tracking infrared sensing systems will require improvements in component level technology that reduce payload jitter, mass, and power budgets through improved thermal management of cooling loads and rejected heat. The issues associated with gimballed sensor and laser communications systems are of particular interest. Specific areas of interest are: application of improved heat conduction materials (e.g. composites with anisotropic conductance or conductances greatly above those of pure elements) to cooler or heat transport components (e.g. thermal control devices for high density microcircuits & laser diodes) capable of $700\text{W}/\text{cm}^2$ across $<30\text{K}$ gradients; pumped or wicked cryogenic cooling load transfer devices capable of transferring significant (2-10 W at 35K, 60-150W at 300K) cooling loads across a two axis gimbal, flexible joint, or to multiple locations on a spacecraft; cryocooler component improvements, and the control electronics associated with any active devices. All devices must be capable of 10 years operation in a space environment, including a minimum of 300Krad total dose of radiation (ionizing and proton[UU1]).

Some notional system within which the improved component will operate must be described. The nominal rejection sink of a usual payload is at 250-325 K and the minimal continuous duty lifetime is 10 years. Two axis gimbals operate across 0-359 degrees in azimuth and 0-90 degrees in elevation. High heat flux microcircuits of interest are the radiation hardened versions of various Field Programmable Gate Arrays (FPGAs) and variants of the Power PC CPU. Proposals concerned with waste heat rejection from or cooling load transfer to refrigerated components must describe how the thermodynamic system notionally proposed supports the specific application cooling needs. Showing how the component improvement would benefit currently available designs for space EO payload either as efficiency improvements or as reductions in payload budgets must be discussed in the proposal.

Reducing size (up to an upper linear dimension limit of 2 meters) or component intrinsic mass of just the thermal unit is not a primary objective of this topic; instead, payload mass savings in excess of 10 kg is a prime mass objective.

The overall performance of space sensor systems is very sensitive to the thermal design of the primary thermal insulation technology. The industry standard for thermal insulation technology has been multilayer insulation (MLI) whose performance is highly dependent on how MLI blankets are fabricated, assembled, and installed. Moreover, the performance is also dependent on the shape and geometry of the insulated structure because MLI is susceptible to thermal shorting when compressed or stretched around hard/sharp corners. Large errors in thermal modeling with costly surprises are being discovered late in the sensor integration. In addition, the cost and schedule of the sensor integration time are also key payload issues.

An alternative to MLI is required while maintaining consistent and repeatable thermal performance. Any proposed alternative must resolve a number of key payload thermal issues while meeting all system requirements for space sensor systems. A major requirement for any insulation scheme is the effective thermal conductivity and resultant e^* value under thermal vacuum conditions. The insulation scheme should exhibit a maximum thermal conductivity of $0.005\text{ W}/\text{m}\cdot\text{K}$ while having a maximum e^* value of 0.02 when compared to an equivalent 30-layer MLI blanket.

In addition to thermal performance, an alternative must also achieve an improvement in both fabrication and system integrations costs. MLI is extremely labor intensive and costly to fabricate and install. Once installed, any maintenance or repair tasks that require removal or opening of an MLI blanket are dramatically elongated due to the replacement and/or reinstallation of the MLI. A minimum improvement of 30% on labor and 20% on fabrication costs would be required for alternative scheme to be considered for qualification. And if possible, the alternative approach should provide an overall weight savings.

MLI is also a major source of sensor contamination. Water must be outgassed before any sensor cool-downs are attempted. Water is absorbed in the Dacron mesh that is used to divide the MLI layers. Edges of MLI blankets must also be sealed with vents designed to prevent fiber shedding from the interlaced Dacron layers. Any alternative insulation scheme would need to exhibit outgassing materials, quantities, and rates which are compatible with space sensor needs while minimizing contamination. As for pressure decay rates and effects on venting over launch, any alternative scheme must meet or surpass the NASA CARS manual specification of 8.28 psi/min.

PHASE I: Phase I SBIR efforts should concentrate on the development of the fundamental concepts for increased efficiency or reduced mass, jitter, or power input of space EO payloads or their supported spacecraft. This could include demonstration of a process or fundamental physical principle in a format that illustrates how this technology can be further developed and utilized in a space payload simulated in ground testing conditions. This phase should make plans to further develop and exploit this technology in Phase II. Offerors are most strongly encouraged to work with system, payload, and/or refrigeration contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Phase II SBIR efforts should take the innovation of Phase I and design/develop/construct a breadboard device to demonstrate the innovation. This device may not be optimized to flight levels, but should demonstrate the potential of the prototype device to meet actual operational specifications. Demonstration of the potential improvements in efficiency or mass reduction of space payloads should be included in the effort using commercially-available high-heat-flux parts. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system, payload, and/or refrigeration contractors.

PHASE III: Typical MDA military space applications for cryogenic sensing systems relate to infrared sensing, cryogen management, electronics cooling, and superconductivity; laser communications are similarly being transitioned into MDA payloads. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS). Other potential Phase III opportunities to transfer this technology include the Advanced Infrared Satellite System (AIRSS) and block upgrades to other Ballistic Missile Defense Systems.

COMMERCIALIZATION: The applications of this technology could potentially be far reaching with large market potential due to the increased efficiency and to a lesser extent the expected reduction in mass. Applications of this technology include NASA, civil, and the commercial sector for space based and airborne uses such as missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. Other potential applications include CMOS (complimentary metal-oxide semiconductor) cooling for workstations and personal computers.

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KEYWORDS: cryocooler, cryogenic, Infrared Sensors, laser communications, electronics cooling

MDA09-021

TITLE: Improvements in Spacecraft Assembly, Integration and Test

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: Space Tracking and Surveillance System

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Significantly reduce the cost and time required for the Assembly, Integration, and Test (AI&T) of future MDA Space Systems.

DESCRIPTION: Space Systems are unique in that they are very expensive, low volume procurements, often requiring a significant amount of hand touch labor. Further, they must be mission ready and perform in highly adverse environments. Space systems typically spend a significant amount of resources testing component mission hardware and software, performing assembly and integration of key assemblies and subsystems, and performing subsystem and system level verification and validation testing. This assembly, integration and test (AI&T) process is time consuming, very labor intensive, and represents one of the largest cost and schedule aspects in the procurement of any space program. The AI&T process historically focuses on discrete subsystems, adopting a "building block" approach to assemble and test the payload and spacecraft. This "building block" approach does not optimize or look for efficiencies in context of the entire spacecraft AI&T process. In addition, AI&T requires custom Special Test Equipment (STE) that is typically redesigned at each level of the integration process to accommodate higher level test requirements. Similarly, flight software is validated through a long and arduous process through various software and hardware emulation schemes before it is optimized for the flight processors and validated for operational use.

The review of available literature concerning AI&T clearly demonstrates the lack of research or guidance in this area to create system level methodologies, processes, efficiencies or optimization of workflow. With a few exceptions, available information focuses on reporting of test results from past AI&T efforts and occasionally "Lessons Learned". The focus is on what was done, not on methodologies and processes to plan and execute synergistic AI&T efforts that look beyond the "building blocks" approach to the spacecraft as a whole. In addition, program specific information about US Systems is export controlled due to applicability to space and is not readily available for review by the community. Even the leading systems engineering handbooks overlook the development and execution of the assembly, integration and test process. They focus on development of the design and test requirements for verification and validation.

The Missile Defense Agency seeks to advance the state of the art in the Assembly, Integration and test of Space Systems to reduce the cost and time required to acquire these systems. The focus of this topic is on space-based systems with particular emphasis on space-based optical systems. Special areas of interest in this topic are: AI&T workflow management, test simulation, and improved software integration and test.

The first area of emphasis seeks proposals for tools to implement processes and methodologies to improve the identification of synergistic requirements of assemblies and subsystems based on verification and validation

requirements, effective planning of resources (including utilization of special test equipment (STE) and test facilities), effective scheduling of interrelated processes, and overall work flow management to streamline assembly, integration and test processes.

The second area of emphasis seeks proposals for test simulators/stimulators for use during ground test and verification. Proposals in this area should address either (1) developing tools and hardware simulators to support alignment and calibration of optical system far-field line of sight to microradian accuracy and stability, or (2) the development of high fidelity visible / infrared target sources (stimulators). The target sources should radiate in the visible through Long Wavebands. Knowledge of and the ability to control the radiance of these sources in each wavelength band is critical.

The third area of emphasis seeks proposals for improve software integration and test tools and methods. These tools should support simulation-based testing at the various stages of development including design, embedded software development, prototype integration, full system integration testing, and training. The proposed architectures should support pure simulation, software-in-the-loop simulation, man-in-the-loop simulation, and hardware-in-the-loop simulation allowing for maximum reuse of payload simulation and testing assets in all modes of operation. To facilitate a scalable and efficient integration testing process, the system should enable simulation-based test projects to be executed in non-real-time on a general purpose operating system (GPOS) based platform for low-cost test development, verification and validation; and in real-time on a real-time operating system (RTOS) based computer platform for hardware-in-the-loop and man-in-the-loop testing. To assist with obsolescence avoidance, the payload simulator architecture should leverage an open-source RTOS, where possible.

PHASE I: Clearly identify which aspect of this topic you are proposing to address and state the objectives/goals of the proposed Phase I & II efforts. Based on proposed objectives/goals, develop self-imposed requirements to meet these objectives. The offeror shall develop conceptual designs of the hardware, process tools, or software based on their self-imposed requirements and preliminary modeling, simulation and analysis. The offeror shall perform sufficient design, development, analysis and/or testing to verify the objectives and self-imposed requirements can be met. Phase I should also result in a clear technology development plan, schedule, budget, requirements documentation, and CONOPs. Offerors are strongly encouraged to work with system and payload contractors to help ensure applicability of their efforts and begin work towards technology transition. Although not required, offeror's are highly encouraged to perform hardware or software risk reduction activities to verify critical aspects of their efforts.

PHASE II: Mature and demonstrate the conceptual design developed in Phase I. Tasks shall include, but are not limited to, development of a critical design and a detailed demonstration of key technical parameters that can be accomplished, leading to a detailed performance analysis of the technology. The Phase II work will ideally produce hardware, process tools, or software that can be used to demonstrate the viability of the concept. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system and/or payload contractors.

PHASE III: The offeror is expected to work with other industry partners and DOD offices to modify and improve the design of the Phase II proof of concept prototypes, process tools or software to meet individual system applications. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS).

COMMERCIALIZATION: The successful development and demonstration of this technology is expected to result in continued use by MDA, other DOD organizations, NASA, and commercial spacecraft developers.

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KEYWORDS: low cost, spacecraft, software validation, electro optical, sensor, calibration, characterization, optical signature, payload, hardware in the loop, integration, and test

MDA09-022

TITLE: Large Format Space Focal Plane Array Technologies

TECHNOLOGY AREAS: Materials/Processes, Sensors, Space Platforms

ACQUISITION PROGRAM: STSS

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 3.5.b.(7) of the solicitation.

OBJECTIVE: The overall objective of this effort is to develop innovative solutions to support the growth, processing, fabrication and integration of large format (>25cm²) focal plane arrays (FPAs) for space sensing.

DESCRIPTION: The Missile Defense Agency (MDA) is interested in technology developments in support of advanced space sensor systems. Space-based sensors operate in low background environments where radiation hardness is key to mission operation. Sensor bands from the visible through long wavelength infrared (IR)

wavelengths are of interest. Large format infrared focal plane arrays based on mercury cadmium telluride (MCT) have been demonstrated at $>25 \text{ cm}^2$. However, to-date, several significant challenges to their manufacture exist. The Ballistic Missile Defense System (BMDS) requires reliable, high performance, high sensitivity and low noise space-based sensors which are affordable and producible. Specific technology areas of interest include:

Detector materials and processing techniques -- both bulk cadmium zinc telluride (CZT) substrates and MCT epitaxial materials for SWIR-LWIR leading to high quality, low damage occurrence, improved through-put and improved yield. The current infrared industrial base relies on a single source of CZT substrates. CZT substrates $>49 \text{ cm}^2$ with high purity, excellent crystallinity, and excellent surface finish are needed to support large format detectors. It is in the interest of MDA to develop a second source of CZT substrates to reduce reliance, increase availability and reduce substrate costs. There is a continued interest in developing additional methods of epitaxial detector growth that can meet or exceed the quality produced by current methods such as Molecular Beam Epitaxy and Liquid Phase Epitaxy, over the large formats of interest and have lower capital expense, predictable repeatability and higher thru-put. Quality metrics include: capable of single wafer sizes $\geq 12"$, Group II-VI compound semiconductor materials (including mercury) as thin as $5 \mu\text{m}$ and as thick as $200 \mu\text{m}$, with less than 2% non-uniformity in both composition and thickness. In addition, innovative technologies in substrate cleaning and reclamation processes, detector processing including diode formation, etching and surface clean-up, low-loss hybridization techniques including both temporary and permanent and bump bond architectures. As optical components, the final polishing and A/R coating methods must produce uniform surfaces that are also optically flat so that the component can be integrated into a sensor system. Current methods have been developed for much smaller arrays; there is a strong desire for innovative techniques that can be applied to these large areas. FPA polishing, planarization and radiation hard anti-reflective coatings/surface finishing techniques are of interest;

Characterization -- tools and non-destructive characterization techniques that can readily assess step-wise processed material for damage, thereby reducing the likelihood of a less than ideal wafer entering the MCT growth and processing stage. New methods and/or new application of mature methods are of interest especially those that have both submicron resolution and can provide data collection mapped over $>49 \text{ cm}^2$ in a timely ($\ll 8 \text{ hrs}$) manner. Wafer mapping techniques for determining composition, crystallinity, purity, etch pit density, micro and macro defect density and electro-optic properties are of high value;

Design, Integration and Testing -- innovative approaches to Read Out Integrated Circuit (ROIC) design, fabrication, testing and integration are of interest. ROIC designs typically constitute a significant portion of the non-recurring cost of FPA development. Methods of addressing functional design and design re-use could significantly reduce this cost. ROIC and FPA testing are also significant cost drivers. Methods of streamlining the test process while retaining the ability to extract decision quality information is enabling for megapixel arrays. Currently the definitive pass/fail test for an FPA is after hybridization. Hybridization of large arrays is problematic due to the extreme size. Ideally all pixels will be interconnected and the pressure needed is quite high (several hundreds of pounds). Non-uniform pressure can cause slip of the two subcomponent bump bonds or cracking of the arrays. Methods to reduce loss are expected to increase overall FPA yields.

All proposed efforts must have/retain the intrinsic FPA capability of operation in a space/nuclear radiation environment, resulting in FPA performance sufficient for strategic systems to meet the requirements of BMDS; and offer system performance advantages over current sensor capabilities/approaches. Any proposal submitted must focus on one specific area: the material (substrate and epitaxial), detector processing, detector characterization, hybridization, substrate removal A/R coatings, ROIC design, and FPA fabrication and test. An offeror may submit multiple proposals with unique approaches in one area, or in interrelated areas. Note that strained layer superlattice (SLS) detector material development is covered in another topic in this MDA solicitation and is not within the scope of this topic.

PHASE I: Identify and investigate unique process designs, novel characterization techniques, and/or production process changes or additions suitable for FPA component fabrication that will result in significant improvement in the FPA size, while retaining performance and operational lifetimes. A deliverable or proof-of-concept design available to the government for additional characterization is highly desirable. Offerors are strongly encouraged to work with infrared component contractors to help ensure applicability of their efforts and begin work towards technology transition, either by license or service.

PHASE II: Using the resulting process, designs, techniques, architectures, and/or process changes or additions developed in Phase I, verify these changes in a prototype fashion, on or off a product line to demonstrate the feasibility and efficacy of the technique. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end they should have working relationships with, and support from, infrared component contractors.

PHASE III: Either solely, or in partnership with a suitable production foundry, implement, test and verify in full scale the Phase II demonstration item as an economically viable production technique. Demonstration would include, but not be limited to, demonstration in a real product line with the resulting FPA testable in a system level test-bed against system performance criteria. This demonstration should show near term application to BMDS systems, subsystems, or components.

COMMERCIALIZATION: Innovations developed under this topic will benefit both DoD and commercial space and terrestrial programs. Possible uses for these products and techniques include surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. Enhancements to imaging quality and higher product yields show significant potential for increased applications.

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KEYWORDS: infrared detectors; infrared focal plane arrays, radiation hardening, advanced sensor concepts

MDA09-023

TITLE: Enhanced Spacecraft Survivability

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: Space Tracking and Surveillance System (STSS)

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop (design, fabricate and demonstrate) innovative approaches to enhance the survivability of MDA Space Systems to spacecraft anomalies occurring from either natural or manmade events.

DESCRIPTION: Survivability and resiliency to anomalies is critical in the design and analysis of MDA space systems. The Missile Defense Agency seeks innovative solutions to enhance the survivability of spacecraft to effects from natural and/or manmade origins. Special areas of interest in this topic are: environmental monitoring sensors, sensor protection, and techniques to allow operation through an anomaly and/or fast recovery. Space

qualification requirements as well as the necessity of minimizing the size, weight, and power consumption of all spacecraft components must be part of the design trade for any successful proposal. The intent of this topic is not the development of generic radiation hard electronics and sensors. Other topics within this solicitation explicitly seek those solutions, however any solutions developed for this topic must meet a ten year life and a minimum of 300 Krad radiation requirements.

The first area of emphasis seeks proposals to develop sensors and sensor algorithms to detect, characterize (i.e., provide attribution), and report, in near real time, mission critical space environmental events or effects occurring from natural and/or manmade origins that could potentially inhibit performance of the Ballistic Missile Defense System.

The second area of emphasis seeks proposals to develop innovative mechanisms or algorithms to enhance the survivability of optical sensors from natural and/or manmade events or effects.

The third area of emphasis seeks proposals to allow for continued operations through anomalies and/or the fast recovery of the system afterward. The anomalies can include but are not limited to; the effect of abnormal electromagnetic and particle irradiance that may affect the spacecraft sensors and/or onboard electronics, spacecraft power generation capability or thermal behavior of the space vehicle, space vehicle to ground communication, debris impact (mechanical damage), and/or other effects. Natural effects may also include stressing radiance perturbations on infrared sensors that may impact the ability of a sensor to detect and track small dim targets.

PHASE I: Develop a preliminary design for the proposed component or algorithm. Modeling, Simulation, and Analysis (MS&A) of the design must be presented to demonstrate the offeror understands the physical principles, performance potential, scaling laws, etc. MS&A results must clearly demonstrate how near-term goals will be met, at a minimum. Proof of concept hardware or software development and test is highly desirable. Proof of concept demonstration may be subscale or specific risk reduction activities associated with critical components, algorithms or technologies. Test results (if performed) should be used in conjunction with MS&A results to verify scaling laws and feasibility. Phase I will include the development of plans to further develop/exploit this technology in Phase II. Offerors are strongly encouraged to work with system, spacecraft, and/or payload contractors to help ensure applicability of their efforts and begin work towards technology transition. No specific contact information will be provided by the topic authors.

PHASE II: Complete critical design of prototype component or algorithms including all supporting MS&A. Fabricate a prototype or engineering demonstration unit (EDU) and perform characterization testing within the financial and schedule constraints of the program to show level of performance achieved compared to stated government goals. In addition, environmental testing, especially radiation testing, is highly encouraged in this phase. The final report shall include comparisons between MS&A and test results, including identification of performance differences or anomalies and reasons for the deviation from MS&A predictions. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system, spacecraft, and/or payload contractors.

PHASE III: The offeror is expected to work with other industry partners and DOD offices to modify and improve the design of the Phase II proof of concept prototypes to meet individual system applications. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS).

COMMERCIALIZATION: The successful development and demonstration of this technology is expected to result in continued use by MDA, other DOD organizations, NASA, and commercial spacecraft developers.

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WEB SITES:

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KEYWORDS: space environment, threat protection, natural environment, atmospheric correction, limb radiance

MDA09-024 **TITLE:** Space Component Miniaturization

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: Space Tracking and Surveillance System (STSS - MDA/SS)

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 3.5.b.(7) of the solicitation.

OBJECTIVE: The objective of this SBIR topic is to design, develop and test miniaturized, lightweight, space qualified components to support future MDA space missions. Although this is a broad topic area, this year we are placing special emphasis on telescopes, optics and mirrors. Offerors may also propose other highly innovative component miniaturization efforts for consideration under this topic. Please contact the topic authors to discuss innovations outside the focus area.

DESCRIPTION: The Space Tracking and Surveillance System (STSS) is the MDA passive mid-course tracking system. Future STSS satellites will greatly benefit from the development of lightweight, low cost, athermal telescope solutions. One of the challenges of producing telescopes is the lead time required for current approaches and materials. Innovative design and fabrication approaches are solicited that will significantly reduce manufacturing and delivery times, produce low cost components and assemblies, and low part count system designs. Designs must be capable of cryogenic operations (~150-220 degree K), be an athermal design (minimal degradation in performance over specified delta temperature at a selected operating temperature), have sufficient mechanical strength and stiffness to survive launch without performance degradation, be utilized in either a gimbaled or fix-body architectures, and support application of broadband (visible through long wavelength infrared) optical coatings. In addition to telescopes, other optics and mirrors are also of interest that would support future STSS satellite development. Offerors may also propose other highly innovative component miniaturization efforts for consideration under this topic. Please contact the topic authors to discuss innovations outside the focus area.

In addition, all components proposed in this area must address space qualifiability. The following space environmental parameters listed in Table 1 below should be used as guidance. Table 2 contains basic parameters of interest for telescopes.

Table 1: Space Environmental Parameters

SPACE ENVIROMENT PARAMETER	NEAR TERM GOAL	FAR TERM GOAL
Vacuum Operations	Yes	Same
Shelf Life – years	5	Same
On-orbit Service Life – years	10	15
Radiation Hardness (Proton – nominal 63 MeV)	300 kRad	1MRad
Radiation Hardness (Ionizing)	300 kRad	1 MRad
Operating Temperature Range	54 to 32°C	Same
Survival Temperature Range	-60 to 71°C	Same

Table 2: Telescope Performance Goals

PARAMETER	NEAR TERM GOAL	FAR TERM GOAL
Nominal Clear Aperture, cm	30	50

Field of View (FOV), degrees	1	2
f/#	f/3 – f/6	Same
Operating temperature (OP Temp) of Primary/Secondary (deg K)	185 – 220	150 – 185
Delta T about selected Op temp for Athermal Design (deg K)	+/- 2	+/- 5
Wavefront RMS (@632.8nm, OP Temp and 0-g)	Lambda/10	Lambda/20
Mirror Finish (RMS), Angstroms	50	< 20
Areal Density (Primary), kg/m**2	15	10

PHASE I: Develop a preliminary design for the proposed component. Modeling, Simulation, and Analysis (MS&A) of the design must be presented to demonstrate the offeror understands the physical principles, performance potential, scaling laws, etc. MS&A results must clearly demonstrate how near-term goals will be met, at a minimum. Proof of concept hardware development and test is highly desirable. Proof of concept demonstration may be subscale or specific risk reduction activities associated with critical components or technologies. Test results (if performed) should be used in conjunction with MS&A results to verify scaling laws and feasibility. Phase I will include the development of plans to further develop/exploit this technology in Phase II. Offerors are strongly encouraged to work with system, spacecraft, and/or payload contractors to help ensure applicability of their efforts and begin work towards technology transition. No specific contact information will be provided by the topic authors.

PHASE II: Complete critical design of prototype component including all supporting MS&A. Fabricate a prototype or engineering demonstration unit (EDU) and perform characterization testing within the financial and schedule constraints of the program to show level of performance achieved compared to stated government goals. In addition, environmental testing, especially radiation testing, is highly encouraged in this phase. The final report shall include comparisons between MS&A and test results, including identification of performance differences or anomalies and reasons for the deviation from MS&A predictions. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system, spacecraft, and/or payload contractors.

PHASE III: The offeror is expected to work with other industry partners and DOD offices to modify and improve the design of the Phase II proof of concept prototypes to meet individual system applications. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS).

COMMERCIALIZATION: Commercial imaging satellites would greatly benefit from space qualifiable telescopes, optics and mirrors sought in this solicitation. Low cost and low part count combined with rapid fabrication techniques would mean real cost savings to commercial imaging systems in terms of initial cost and assembly, integration and test expenses. In addition, the smaller variants of these systems could be utilized for space-to-space and space-to-ground laser communication systems, rapid response ISR missions, or utilization in a number of NASA remote sensing or environmental missions.

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KEYWORDS: Space Components, Spacecraft Components, athermal telescopes, optics, mirrors

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Sensors, Electronics, 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 3.5.b.(7) of the solicitation.

OBJECTIVE: Identify design architectures and methodologies for developing monolithic, heterogeneous processors (MHP) to support data processing from sensors in space systems.

DESCRIPTION: The Missile Defense Agency is seeking proposals for research directed toward the development of radiation hardened, monolithic, heterogeneous processors for space surveillance systems. Many space systems generate copious amounts of sensor data at high data rates. The extraction of information from such data streams requires high speed data reduction. Parallel processing may be required to keep pace with the data stream, and that processing often requires application of sophisticated digital filtering algorithms. The results of the signal processing then require aggregation and additional processing to produce actionable information to be used either on the satellite or downloaded to the war fighter. The availability of nano-scale semiconductor process enables the development of integrated circuits incorporating an array of processing elements on the same chip. The tight integration of processor arrays permits enhancement of processing speed and reduction of delays associated with transferring data from one processor to the next. Although much of the work in multi-processors has been oriented toward homogeneous arrays, there is potentially great benefit in using heterogeneous arrays (e.g., digital signal processors/ general purpose processors; vector processors/scalar processors; etc.). By being optimized for processing and aggregating sensor data, heterogeneous arrays offer significant opportunities for greatly increased throughput bandwidth while reducing size, weight, and power.

The MHP project should address the following: (a) the development of a heterogeneous multi-processor array with a minimum of four parallel processing channels suitable for digital filtering or other signal conditioning algorithms; (b) the development of on-chip general processing element(s) for aggregation of data from each of the processing channels; (c) provisions for radiation hardening to the space environment (total dose hardness > 300 krad(Si), no single event latch-up, no single event functional interrupts, and error management for single event upset from heavy ions or protons); and (d) issues related to memory management, data synchronization, and inter-processor communication and control functions.

PHASE I: The contractor shall develop an architecture for a MHP array per above requirements. Effectiveness shall be demonstrated via simulation. The approach to design, fabricate, and test a radiation hardened MHP shall be devised. The effort should be coordinated with developers of space systems.

PHASE II: The contractor shall design, fabricate and test the MHP array architecture developed in the Phase I activity. Testing shall include electrical verification of performance, processing data from simulated sensor outputs, and the demonstration of the radiation hardness.

PHASE III: The offeror is expected to work with other industry partners and DOD offices to modify and improve the design of the Phase II proof of concept prototypes to meet individual missile defense system applications. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS).

COMMERCIALIZATION: Commercial satellite, telecommunications, multi-media set-top boxes, and personal mobile computing.

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KEYWORDS: Heterogeneous processor, radiation hardened, integrated circuit

MDA09-026 TITLE: Resource Optimization for Battle Management

TECHNOLOGY AREAS: Information Systems, Space Platforms, Human Systems, Weapons

OBJECTIVE: To develop advanced, innovative, robust, real-time sensor/interceptor to target assignment algorithms and software within a coordinated, layered missile defense environment.

DESCRIPTION: With the addition of emerging weapon systems, to include multiple sensors and weapons, the Ballistic Missile Defense System (BMDS) will have the capability for layered defense. A significant amount of work has been directed toward the mid-course engagement scenario. Less development has been focused on the challenging ascent phase in the target trajectory. To engage during ascent, severe time and information constraints exist upon which to allocate resources and support decision making. To maximize the potential performance enhancements of these weapons and sensors and of the associated battle management and fire control systems supporting them, it is necessary to extend the ability of assignment algorithms and decision theory. This topic will require advanced optimization or assignment techniques. Furthermore, to support any evolving defense structure, the ultimate goal of the technology is a distributed architecture; however, the offered solution may work in a centralized architecture.

This topic can be divided into two functional areas. While the basic techniques developed will likely have applicability to both areas, the areas have different constraints and requirements on processor capability and timeliness. Therefore, it is appropriate that proposals address one of the two areas explicitly.

First, the battle manager needs to allocate sensor and weapon systems to threat launch events. This decision might be based on perceived threat inventory, the threat missile, and ground asset being attacked. This decision should depend on the capabilities of the weapon systems employed.

Second, the fire control needs to optimally determine how best to employ the sensors and missiles allocated for negation of a threat launch, given that there might be multiple objects associated with each missile launch. This optimization should, where appropriate, be capable of recognizing the opportunities for exploiting shoot-look-shoot engagements so as to maximize the probability of lethal object destruction. It should have the capability to adapt in real time to updated kill assessment and discrimination status information.

To appropriately scope this effort, the proposed solution may address either sensors or weapons or both, and should not address countermeasures or debris. Multiple solutions may be required for different problem sizes. The proposed technology may consider techniques to optimize the solution over time or to measure confidence in the solution, but not at the cost of over simplifying the problem.

PHASE I: Provide a proof of principle of the suggested approach for allocation methods that will enable robust engagement resource allocation for multiple sensors, weapon systems, battle managers, and fire controls with different capabilities. Emphasis should be on techniques suitable for addressing the ascent phase engagement scenario.

PHASE II: Develop/update the technology based on Phase 1 to provide a demonstration of the technology in a realistic environment using realistic data, to include realistic processing speeds in complex scenarios.

PHASE III: Integrate the technology into the BMDS system in coordination with BMDS System Engineering and the Element Program Office. Partnership with traditional DoD prime contractors will be pursued since the government applications will receive immediate benefit from a successful program.

COMMERCIALIZATION: The technology is applicable to any allocation/optimization application that operates on components of differing capabilities.

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2. Bertsekas, D.P., Dynamic Programming and Optimal Control, Athena Scientific, Belmont, MA, 2001.
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KEYWORDS: Optimization, Adaptive Scheduling, Allocation, Engagement Sensor, interceptor, Ballistic Missile Defense Systems (BMDS), Operations Research, Dynamic Programming

MDA09-027

TITLE: Track Correlation

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Space Platforms

OBJECTIVE: Develop advanced, innovative, robust, real-time algorithms and software for the creation, handover and integration of sensor tracks originating from a variety of disparate sensors.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) employs a variety of disparate sensors in the detection, tracking, and identification of ballistic missiles and their constituent parts. A significant amount of work has been directed toward the mid-course engagement scenario. Less development has been focused on the challenging ascent phase in the target trajectory. To engage during ascent, severe time and information constraints exist upon which to allocate resources and support decision making. In order for the BMDS to engage tracks effectively, it is critical that tracks originating from disparate sources are correlated in an accurate and timely manner. This ensures that the correct tracks are engaged, thereby minimizing the wastage of interceptors. Current approaches continue to present challenges in accomplishing these functions in a timely and accurate manner. Proposed approaches should provide robust, reliable capability to unambiguously correlate reports from multiple sources, or identify when the reports represent new tracks. The proposed approach should have the following properties:

- 1) Use metric data, features, or other data that provides for accurate and timely correlation.
- 2) Provide a measure of confidence with the correlation decision and manage ambiguities applicable to the ballistic missile defense problem.
- 3) Promote track continuity and minimize the number of false tracks.
- 4) Provide for cluster tracks when absolutely necessary.
- 5) May assume a clear scene consisting only of potential threat objects.

- The final product will need to operate in a distributed manner, with multiple interacting decision nodes. The algorithms could assume a centralized architecture as a first step.

- May assume perfect discrimination initially, but the method should support later extension to uncertain discrimination.

Proposals that offer improvements to track correlation subroutines, such as bias estimation, or that enable distributed operations will be considered.

PHASE I: Develop the mathematical basis and provide a proposed methodology and demonstration of track correlation/sensor netting concepts using simulated data. Emphasis should be directed toward techniques suitable for addressing requirements in the ascent phase of engagement.

PHASE II: Develop/update the technology based on Phase 1 to provide a demonstration of the technology in a realistic environment using realistic data, to include realistic processing speeds in complex scenarios.

PHASE III: Integrate the technology into the BMDS system in coordination with BMDS System Engineering and the Element Program Office. Partnership with traditional DoD prime contractors will be pursued since the government applications will receive immediate benefit from a successful program.

COMMERCIALIZATION: The technology is applicable to air traffic control and multi-sensor applications.

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3. Blackman, S., and Popoli, R., Design and Analysis of Modern Tracking Systems, Artech House, 1999

KEYWORDS: Track correlation, Sensor Fusion, Data Fusion, Multi-sensor

MDA09-028

TITLE: Discrimination

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

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 3.5.b.(7) of the solicitation.

OBJECTIVE: This topic seeks innovative techniques to enable ballistic missile object discrimination through analysis of radar and/or optical sensor data. Areas of exploration include algorithms, models, and system-level (multi-sensor) approaches, which can deal with ambiguity, and can be integrated with existing track correlation mechanisms. Solutions must be capable of accurately and reliably supporting acquisition, track, discrimination, and engagement of threatening objects across a spectrum of threat classes and environments. New ideas for features that can help discriminate objects are needed.

DESCRIPTION: Ballistic Missile Defense System (BMDS) performance is heavily dependent on data from dispersed and disparate radars and other types of sensors. The challenge today is developing the algorithms that will increase the accuracy in separating lethal objects from non-lethal objects in a complex and challenging environment. For example, countermeasures, including debris and decoys, can make this a very difficult problem. Techniques currently proposed for accomplishing discrimination include the use of physics-based characteristics as well as metric information to ultimately discriminate objects. New ideas are specifically sought for discriminating characteristics that might be detected at long range. Innovative techniques should improve effectiveness of interceptor usage by increasing the probability of correct identification of target objects. Fusion of data at several hierarchical levels may be required. Any new sensor (other than mentioned above) which could enable a proposed discrimination technique, should be identified in the proposal.

Technical issues that must be addressed include: sufficiently accounting for, or eliminating, uncertainty in both threat evolution and sensor feature measurements; reliance on a priori information; data throughput limitations between sensor platforms; processing speed and capacity; data latency and gap handling; target feature exploitation; and, countermeasure identification and negation.

PHASE I: Develop and conduct proof-of-principle studies and/or demonstrations of discrimination concepts/algorithms that are easily adaptable to a wide range of sensors using simulated sensor data.

PHASE II: Update/develop algorithm(s) based on Phase I results and demonstrate technology in a realistic environment using data from multiple sensor (as applicable) sources. Demonstrate ability of the algorithm(s) to work in real-time in a high clutter and/or countermeasure environment.

PHASE III: Integrate algorithms into the BMDS and demonstrate the improved total capability of the updated system. Partnership with traditional DOD prime-contractors will be pursued as government applications of this technology will produce near term benefits from a successful program.

COMMERCIALIZATION: The technology is applicable to air traffic control, weather radar applications areas of transportation and shipping, e-commerce and robotics industries.

REFERENCES:

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KEYWORDS: Discrimination, statistical inference, Bayesian network, algorithms, feature extraction

MDA09-029

TITLE: Radiation Hardened End-to-End Communication Links

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

OBJECTIVE: Increase transmission rate of future Ballistic Missile Defense (BMDS) end-to-end interceptor communication links operating through adverse conditions. A reconfigurable modem solution is sought, allowing a common communication system design suitable for cross-platform application. Channel impairments of interest include both signal fading caused by ionospheric scintillation, induced by high altitude nuclear weapons detonation, and electronic counter-measures (ECM).

DESCRIPTION: MDA's strategic communication links are required to successfully operate under nuclear disturbed propagation conditions. The standard model for these fading channels is specified by the Defense Threat Reduction Agency (DTRA), as described in (Bogusch, 1989). In order to provide cost effective high data rate communications capable of reliably sustaining video transmission rates during and after exposure to a nuclear environment, reconfigurable modem solutions will need to take advantage of advanced modulation and coding techniques. Of particular interest are wideband multi-carrier systems using Turbo-codes or a related advanced forward error-correction code (FEC), which may lead to significant improvements to link performance.

Specific emphasis should be placed on:

1. Channel waveform design, with emphasis on selection of an advanced modulation and FEC method.
2. Use of rapid prototyping for evaluation of candidate waveforms. The computational demands of advanced FEC decoders and the increased dimensionality of the test space due to nuclear environment testing limits the utility of the traditional MATLAB simulation or other software-only simulation performance assessment. Therefore, the rapid prototyping platform must be selected with sufficient computational throughput to allow full characterization of candidate waveforms.
3. Modeling of the nuclear and ECM environment with sufficient fidelity for use in conjunction with a prototype system.

PHASE I: Contractors shall propose and analyze candidate communication link solutions for providing scintillation hardened connectivity to missiles and/or kill vehicles within the evolving MDA architecture. The analysis should identify the strengths and weaknesses of the proposed solutions. Candidate comparisons should emphasize preliminary link performance metrics and quantifiable measures of system complexity. The contractor shall identify a rapid prototyping platform with sufficient computational throughput for characterizing the performance of the candidate waveforms in a joint nuclear and ECM environment. A test plan, including a testing timeline, shall be provided demonstrating how the final waveform design will be selected from the Phase I candidates.

PHASE II: The contractor shall implement each of the candidate waveforms from Phase I using the prototyping platform. The test plan developed during Phase I will be executed using the rapid prototyping system. The testing will result in a full characterization of the performance of each candidate waveform in a joint nuclear and ECM environment. A final waveform design will be selected based on this evaluation. Contractor shall begin coordination with MDA contractors to ensure products will be relevant to ongoing and planned projects.

PHASE III: The contractor shall work with MDA industrial partner(s) to maximize the transfer of this development effort to missile defense and to identify a tractable Phase III project that can become a by-product of this overall program.

COMMERCIALIZATION: Other efforts within the DoD are focused on two-way data links to weapons systems and this technology has the potential to be transferred to those programs. Commercial applications would include the cell-phone industry, airline communications, and other over-the-air communications.

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KEYWORDS: Communication system, electronic counter-measures, high altitude nuclear effects, RF data link, fading channels

MDA09-030 TITLE: Information Assurance

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: DOS

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop tools and technologies for discovering, monitoring, defending and/or remediating insider threats to software and firmware across the full system life cycle.

DESCRIPTION: Product engineering has evolved into product and process engineering in which manufacturability, producibility, maintainability, usability - and other so-called "-ilities" - are considered during the design, acquisition and deployment of a product. Integrated product and process development (IPPD) strives to include all life-cycle aspects of a hardware/software system early in its design. One technical requirement that is not currently met in IPPD could be termed "protectibility". Can a proposed design be protected in the face of malware or exploitable code-based flaws? If so, can the system be properly manufactured, produced, fielded, maintained, and used? How can an engineer ensure that a system can be protected against malware during the entire manufacturing and deployment lifecycle?

To address this critical problem, the Missile Defense Agency (MDA) is seeking development of innovative tools and techniques that can effectively safeguard their systems against the threat of malware/exploits injected during the manufacturing phase. The main objective of this solicitation is to improve the protectibility of a weapon system by developing technologies that can observe, identify, and guard systems against insider threats. These threats can be posed in the production of that system or after it is deployed where replacement parts could also manifest malicious code. The resulting tools will provide a new level of rigor in the manufacturing process maintaining seamless production while ensuring that systems will be operating threat-free throughout the system lifecycle.

PHASE I: Develop a proof-of concept design, feasibility assessment, and demonstration for threat-free manufacturing tools and technologies. Results from the design and assessment will be documented for Phase II.

PHASE II: Based on the Phase I design and assessment, develop a prototype technology and demonstrate the efficacy of the Phase I results.

PHASE III: Integrate threat free manufacturing technology into a critical system component and demonstrate the application to one or more MDA element systems or subsystems, and the technology's utility against malicious threats. When complete, an analysis will be conducted to evaluate the ability of the technologies/techniques to protect against malicious threats in a real-world situation.

COMMERCIALIZATION: Malicious threat detection and remediation technology has application throughout commercial industries. Commercial systems that are exposed to malicious insider threats would benefit greatly from this development. In addition to military and homeland defense, banking, finance, e-commerce, and medical industries would have a high demand for such systems.

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KEYWORDS: information security, information assurance, computer security, malware, malicious insider, threat, weapons system life cycle, firmware, manufacturing and producibility

MDA09-031

TITLE: Effects of Hardbody-Plume Interactions on Radar Returns

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

ACQUISITION PROGRAM: MDA/AB

OBJECTIVE: Codes currently exist to separately model the radar signatures of hardbodies and plumes, but none consider the potential interactive effects of the hardbody and plume. The major objective of this SBIR is to develop the capability of determining the conditions under which the apparent hardbody radar signature may be significantly changed due to the presence of the plume.

DESCRIPTION: The radar signature of a threat missile hardbody provides threat characterization information to enable a rapid response. However, the absorptive properties of plumes could act to reduce the apparent hardbody radar cross section (RCS) in some cases, and the reflective properties of plumes could act to increase the hardbody RCS in others. A need thus exists for a more advanced model of hardbody radar signatures with attached plumes, in order to distinguish these signatures from the radar returns from non-boosting hardbodies. The prediction of hardbody radar signatures has been of fundamental interest for many years, with method-of-moment (MoM) techniques being particularly successful. Substantial progress in computing incoherent plume signatures, produced by the turbulent structure of the plume, has more recently been achieved. It is well known that abrupt changes in the shape of the hardbody and its surface slope, as typically occur near the base of a missile, can dominate its radar signature depending on the radar frequency and aspect angle. The coherent (time averaged) structure of a plume can both absorb and reflect radar energy. How these plume properties affect the coherent hardbody RCS signature, especially when influenced by the missile base shape, is unknown. It is currently known, from many flight tests, that there are discrepancies between measured hardbody RCS during boost phase and modeled hardbody RCS. This effort will first explore the potential for hardbody-plume interactions to affect the overall coherent signature, and

then determine computational approaches that can best predict the combined signature. One approach could involve the use of MoM techniques with the capability of incorporating the plume electrical properties. Alternate approaches and methodologies, such as finite-difference-time-domain (FDTD), may also be considered.

PHASE I: Identify numerical techniques capable of separately computing missile hardbody and plume RCS. Determine an approach for simultaneously computing the coherent RCS of a hardbody and its plume. Develop and test this approach for a simple hardbody shape and attached plume configuration, with plume electrical properties representative of either a solid or liquid hydrocarbon propellant. Quantify differences between the combined plume and hardbody RCS and that of the hardbody alone for at least one set of flight and radar parameters.

PHASE II: Continue development of the approach utilized in Phase I to simultaneously treat the coherent RCS of a missile hardbody and its plume, or consider other promising approaches. Incoherent plume RCS effects may be introduced if considered to be important. Develop a user-oriented code to implement the approach to be followed. Compute the combined RCS of the hardbody and plume for solid and liquid propellant threat missiles over a range of flight conditions, radar frequencies and aspect angles. Compare computational results with available flight data for: (1) a hardbody with an attached plume and, (2) for a hardbody alone. These results will determine the extent to which the combined coherent hardbody/plume RCS differs substantially from that of the hardbody alone. Prepare the final version of the code for delivery to the MDA user community, together with all documentation.

PHASE III: Integrate this updated hardbody-plume modeling capability into ballistic missile defense threat analysis, and demonstrate enhanced capability to characterize threats with RCS via comparison with threat RCS data obtained from boost phase measurements at relevant radar frequencies. The extension of this enhanced modeling capability to terminal phase re-entry vehicle-wake RCS will also be explored.

COMMERCIALIZATION: Enhanced hardbody-plume RCS modeling capability would be extendable to commercial rocket launches as an independent method of determining engine burnout and staging events and tracking when several objects are in the radar field of view. Commercial uses of this modeling will be explored as part of Phase II of this effort.

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

KEYWORDS: Hardbody-Plume, Method of Moment (MoM), Finite-Difference-Time Domain (FDTD)

MDA09-032

TITLE: Advanced Radiation Transport Models for Next Generation Rocket Exhaust Flowfield Processes

TECHNOLOGY AREAS: Air Platform, Information Systems, Sensors, Battlespace, Space Platforms

ACQUISITION PROGRAM: MDA/DES

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 3.5.b.(7) of the solicitation.

OBJECTIVE: A wide array of physical and chemical mechanisms resulting from the operation of rocket engines or motors may yield prominent radiometric signature properties that may be leveraged, and must be understood, for

missile defense applications. However, many of these characteristics have not been adequately considered by the currently available plume flowfield and signature modeling architecture, and those that have been explored were treated empirically and reside within specialized modeling tools. The objective of this effort is to investigate the development of first-principles radiation transport algorithms to predict the influence of these rocket exhaust phenomena on the total in-band, spectral and spatial intensity features for use in the next-generation propulsion related modeling framework which supports the development of ballistic missile defense system (BMDS) algorithms that may exploit such features.

DESCRIPTION: The accurate modeling of rocket exhaust plume flowfield and radiometric signature characteristics must begin with a detailed description of the processes that occur from the injector face or solid propellant grain surface through the nozzle geometry as well as a comprehensive database of physical and chemical reactions that occur as the exhaust constituents interact with other exhaust constituents or the surrounding atmosphere. Recent MDA sponsored modeling efforts that have focused on upgrading plume flowfield and signature predictive tools have improved the current capability from beyond the simple 1-D treatments of the rocket nozzle exit plane and limited chemical reaction databases to incorporating full 3-D volume surfaces as startline conditions and the flexibility to include increasing levels of fidelity for describing chemical reactions for both bulk and trace species. However, while the flowfield models have the capability to include much of this detailed combustion and interaction chemistry, phenomenology models to properly account for the radiometric signatures produced by these processes are considerably less mature. Moreover, modeling efforts that have attempted to address some of these rocket exhaust processes (such as condensation initiation, growth and extended trail development or solar heating of particulate ejecta for high altitude plumes) were focused as specialized models, were largely empirically driven and/or did not address the inherent coupling of those radiometric processes on the local flowfield properties.

This effort will concentrate on developing first-principles models to predict the influence of these detailed rocket exhaust phenomena on the total in-band, spectral and spatial intensity characteristics of the plume. These processes may include, but are not limited to: solar and earthshine scattering and heating from unburned liquid propellant droplets and solid-phase particulates; heating to and reflection from target vehicle geometries due to an expanding or recirculating plume; condensation onset and cluster size estimation; and delayed release of emission from optically thick regions of the plume due to photon trapping effects. These processes may be present in both low and high altitude environments, and are closely related to (and have influence on) the surrounding plume properties. As such, accurate simulation of the gas-dynamic and thermodynamic characteristics should be performed in concert with the radiation transport, and thus algorithms developed under this effort should seamlessly interface within the next-generation plume flowfield and signature modeling architecture.

PHASE I: Select one pertinent rocket exhaust phenomenological process and identify first-principles requirements for development of a model. Provide an assessment to encompass, but not be limited to, the spectrum and methodology for the proposed model. A detailed investigation should also be conducted to determine state-of-art phenomena modeling (theoretical and/or computational) and identification of the most robust methodology. Determine portion(s) of electromagnetic spectrum where emission from selected process would be present. Develop an algorithm for predicting radiometric signatures and demonstrate against a unit case or analytical solution as appropriate. Outline an approach for integrating this algorithm with next-generation plume flowfield models at low altitudes or high altitudes as appropriate, as well as the next-generation radiation transport tool FLITES .

PHASE II: Integrate the algorithm from Phase I into the current MDA plume flowfield modeling capability and verify it against the Phase I unit solution. Demonstrate coupling between radiometric processes and local flowfield properties. Validate the integrated modeling suite against available plume signature data (multiple band regions where available). Deliver the technical and software user documentation, software, model demonstrations and validation results for MDA use. Maximum practical use of existing plume flowfield modeling software is desired to reduce development and validation costs.

PHASE III: Demonstrate the applicability of the new integrated plume flowfield/signature modeling tool against multiple cases of both steady and transient nature. Perform system trade studies in diverse electromagnetic spectral regions to estimate signatures from this phenomenology in sensor bands identified for current or follow-on BMDS assets.

COMMERCIALIZATION: Updated and improved plume flowfield and signature models for broader phenomena in rocket exhaust plumes allows greater flexibility to rocket propulsion companies to utilize passive signature measurements as a non-intrusive diagnostic tool during subsystem development and testing, such as for vehicle performance metrics, combustion efficiency or environmental contamination. In addition, this technology can apply to commercial satellite companies looking at plume contamination as well as space situational awareness characterization.

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3. Crow, D., C. Coker, B. Smith, and W. Keen, "Fast Line-of-sight Imagery for Target and Exhaust-plume Signatures (FLITES) Scene Generation Program", SPIE Defense and Security Symposium 2006, Technologies for Synthetic Environments, Hardware-in-the-Loop Testing XI, April 2006.

KEYWORDS: plumes; signatures; radiation transport; modeling and simulation; rocket combustion; high altitude; low altitude; condensation; plume-body interaction; solar heating; earthshine; photon trapping

MDA09-033 TITLE: Plume EO-RCS Data Fusion

TECHNOLOGY AREAS: Air Platform, Information Systems, Sensors, Battlespace, Space Platforms

ACQUISITION PROGRAM: MDA/DES

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 3.5.b.(7) of the solicitation.

OBJECTIVE: The Missile Defense Agency is interested in innovations in modeling missile exhaust plumes which utilize all available phenomenology. Low Altitude (0-60 km) missile exhaust plumes can be observed simultaneously by various Electro-Optical (EO) and Radar sensors. The objective of this topic is to combine both data sources to improve MDA next generation plume modeling fidelity. This improvement is based on the model capturing and fusing both sets of observables.

DESCRIPTION: EO sensors operate in the visible and IR regions of the electromagnetic spectrum. EO sensors and radars are sensitive to different features in the missile exhaust. For example, IR sensors measure the temperature of the plume and the radiating molecular species while the Doppler radar spectrum is sensitive to the velocity field and plasma properties of the plume. Recent MDA missile exhaust plume model development has focused on incorporating three dimensional (3-D) effects such as multiple nozzle flowfields, angle of attack, and jet vanes on the predicted flowfields. The fidelity of the resulting simulations needs to be tested on the most fundamental level possible. Plume Radar Cross-Sections (RCS) are sensitive to the velocity field of the exhaust and thus complement radiometric data that are sensitive to the temperature of the radiating species observed. The current MDA plume RCS model, PARCS+, is restricted to axisymmetric flowfields so that one area of research could focus on approximate models of 3-D effects in plume radar cross-sections. Of particular interest are 3-D effects that shift the Doppler spectrum of the plume from the missile body return.

One area of interest is incorporating three dimensional (3-D) effects considering the impact of jet vanes on both IR radiance maps and the plume incoherent RCS. One jet vane design would be studied as a minimum.

A second area of interest is development of first-principle models of the appropriate plasma chemistry for solid propellants, hydrocarbon propellants, and amine propellants. One propellant class shall be selected as a minimum. The focus will be on afterburning plumes in the 0-60 km altitude region. Axisymmetric and/or 3-D flowfields shall

be included as appropriate. The study shall include visible and/or IR sensors as appropriate for candidate emitters. The role of CH(A) in chemi-ionization processes occurring in hydrocarbon propellant missile exhausts. Since CH(A) also emits in the visible, the study would consider both visible and plume radar cross section data and development of a model capable of predicting both provided that CH(A) is important for plasma generation and visible emission. Current MDA plume models assume a nominal mole fraction of CH(A) so that development of a CH(A) model would improve MDA modeling capabilities.

PHASE I: Develop a proof-of-concept EO/RF fused-data algorithm. Identify first-principles requirements for development of a plasma chemistry model or a 3-D plume radar cross-section model as it relates to the proposed innovation. Provide an assessment to encompass, but not be limited to, the spectrum and methodology for the proposed model. Determine portion(s) of electromagnetic spectrum where emission from the selected process would be present. Identify candidate data sets for comparison to model predictions. Demonstrate the plasma chemistry model using a simplified flowfield such as a uniform cylinder. Alternatively, demonstrate the contribution of one 3-D effect on the plume radar cross-section.

PHASE II: Integrate the model from Phase I effort into current plume flowfield modeling capability. Demonstrate coupling between radiometric process and local flowfield properties. Validate integrated modeling suite against available plume signature data (visible/IR and radar). Deliver the technical and software user documentation, software, model demonstrations and validation for MDA use. Maximum practical use of existing plume flowfield modeling software is desired to reduce development and validation costs.

PHASE III: Demonstrate applicability of a new integrated plume chemistry modeling tool or an approximate 3-D modeling tool against multiple cases of both steady and transient nature. Perform system trade studies in diverse electromagnetic spectral regions to estimate signatures from phenomenology in sensor bands and radars identified for current or follow-on BMDS assets.

COMMERCIALIZATION: Updated and improved plume flowfield and signature models for broader phenomena in rocket exhaust plumes allows greater flexibility to rocket propulsion companies to utilize passive signature measurements as a non-intrusive diagnostic tool during subsystem development and testing, such as for vehicle performance metrics, combustion efficiency or environmental contamination. Improved plume flowfield plasma properties will support key rocket test ranges with improved safety margins for design and verification of flight termination systems.

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1. Simmons, F.S. Rocket Exhaust Plume Phenomenology, AIAA, Reston, VA, 2000.
2. G. Sutton and O. Biblarz. Rocket Propulsion Elements, Seventh Edition, Wiley Interscience, 2001.
3. Crow, D., C. Coker, B. Smith, and W. Keen, "Fast Line-of-sight Imagery for Target and Exhaust-plume Signatures (FLITES) Scene Generation Program", SPIE Defense and Security Symposium 2006, Technologies for Synthetic Environments, Hardware-in-the-Loop Testing XI, April 2006.

KEYWORDS: plumes; signatures; radiation transport; modeling and simulation; rocket combustion; low altitude; plasma chemistry

MDA09-034

TITLE: Terahertz Signature Modeling for Kill Assessment and Warhead Materials Identification

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace

OBJECTIVE: Develop techniques and tools for high-fidelity, first-principle, chemistry and physics-based modeling of sub mm (Thz) absorption and emission spectra resulting from missile intercept debris fields for threat warhead materials such as nuclear material.

DESCRIPTION: One goal of kill assessment post missile intercept is to determine the presence and type of warhead materials that might have been within the target Re-entry Vehicle. Current post intercept warhead identification techniques generally focus on the atomic line spectra immediately after impact and disassembly. Being atomic line spectral, the wavelengths are sub micron and characterize "warm" emissions. As the debris field expands and cools, molecular vibration states enable distinguishable absorption and emission spectra. If there are nuclear materials present, nuclear oxides and hydrides will have molecular vibration states distinctly separated (lower frequency) from all other metal oxides and hydrides and hydrocarbons. Sub mm radar illuminating the expanding debris cloud will actively interrogate molecular rotational states and yield highly distinct signatures from both nuclear molecular rotation absorption and emission spectra to characterize the presence and type of nuclear materials. The benefit of performing kill-assessment on "cold-cloud" or on a debris cloud that is no longer significantly radiating due to its temperature above background, is primarily the vastly longer time duration than that for spectroscopy on high temperature (rapidly cooling) atomic line emission spectra.

PHASE I: Develop and demonstrate an approach for modeling sub mm absorption and emission spectra resulting from missile intercept debris fields using high-fidelity, first-principle, chemistry and physics-based tools. Such tools must capture both the warhead material spectra and account for background debris effects due to non-warhead material dispersed due to the impact. Additionally, the results should be used to perform an initial assessment of the feasibility of doing THz warhead typing exploitation for the Ballistic Missile Defense System.

PHASE II: Using the approaches developed and demonstrated in Phase I, prepare the high-fidelity, first-principle, physics-based tools and use these tools to generate sub mm signature predictions for a range of interceptor, targets, geometries, and closing velocities. These numerical results will be used to define system implementation options, complement empirical results in the development and validation of fast-running intercept damage and debris algorithms.

PHASE III: Expand tools to address sub mm signatures from other missile defense phenomenology such as boosting rockets.

COMMERCIALIZATION: Terahertz spectroscopy or imaging has the potential to be useful in a wide range of applications including space surveillance plasma diagnostics and atmospheric monitoring.

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1. Herzberg, G., Spectra of Diatomic Molecules, , Vol 1, New York, Van Nostrand Reinhold Publishing, 1967.
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KEYWORDS: Kill Assessment, terahertz, Debris, modeling

MDA09-035 TITLE: Creation of a Global UV-VIS-IR Ocean Background Model That is a Function of Time, Location and Sea State

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace

ACQUISITION PROGRAM: MDA/DES

OBJECTIVE: Develop advanced software algorithms and use them to create a high fidelity time-variable ocean background model for battlespace sensor and system trade studies in the ultraviolet, visible and infrared wavebands.

DESCRIPTION: Next generation ballistic missile warning, defense and surveillance systems need to anticipate, through modeling and simulation, the background ultraviolet (UV), visible (VIS) and infrared (IR) radiation of the

battlespace environment. This objective requires prior knowledge of the environmental radiance conditions, including those conditions relevant to viewing geometries that intercept the Earth's surface, for the development of optimal sensors and detection approaches. Much work has been done to create atmosphere, terrain and cloud background models (see references below). However, existing terrain models emphasize the "hard earth" rather than the ocean surfaces. The ocean surface temperature varies with location, time of year, and over multi-year cycles. Temperature variations, and associated biotic activity variations, result in signature variations as observed by airborne and orbiting sensors. The Sea State condition, such as calm-glassy or very rough, can also affect the observed signature in UV-VIS-IR wavelengths if the sea surface is visible (i.e., not obscured by clouds). In order to construct a high fidelity terrain model on a global scale, the temperature and physical state of the dominate surface type (i.e., ocean) must be modeled in a manner that is consistent with "hard earth" terrain models. What is needed is a new model for the time-variable UV, VIS and IR radiance of ocean surfaces on a global and regional scale that accurately models the physical aspects of the oceans that influence their temporally- and spatially-variable radiance. To gain the full advantage of the new ocean surface model, and to meet missile warning/defense surveillance needs, the new model must be capable of being efficiently and seamlessly integrated into a MDA scene generation tool that models other aspects of the missile defense battlespace environment. Proposals are therefore sought for both developing an innovative capability to improve ocean surface simulations, and integrating the new model into state-of-the-art background radiation codes, such as the Air Force SAMM2 and FLITES codes and Navy SSGM code (see references). Proposed advances should address issues related to determining the state of the ocean surface from UV, VIS and IR imagery, using arbitrary spatial resolution that is commensurate with (but not limited to) airborne and satellite imagery, and producing simulations as seen by UV, VIS and IR sensors through radiative transfer modeling. SAMM2, FLITES and/or SSGM should serve as a baseline for implementation. Other key features should address computational speed for operational implementation, computer platform flexibility, ease of subsequent model upgrades, and error/uncertainty estimates in simulating airborne and satellite imagery. Validation should be accomplished through imagery provided by UV/VIS/IR airborne and satellite sensors.

PHASE I: Define a robust physics-based ocean terrain model. Define an architecture detailing how the new model can be efficiently, seamlessly and consistently integrated as a component into an existing computer modeling environment such as SAMM2, FLITES or SSGM, or define how these existing computer environments can be integrated into a new architecture that supports the new ocean model. Demonstrate the primary algorithms to be used for UV/VIS/IR remotely-sensed ocean scenes, and prototype a robust and viable computer code that uses one or more of the primary algorithms for simulating ocean UV/VIS/IR imagery. Create a plan for validating the simulations.

PHASE II: Advance the approach developed in Phase I into a fully implemented time- and spatially-variable UV/VIS/IR ocean radiance simulation capability that is integrated into SAMM2, FLITES or SSGM. Demonstrate the feasibility of the software for real world airborne and satellite mission scenarios in coordination with government personnel. Provide error/uncertainty estimates of the UV, VIS and IR imagery simulation capability using well-defined statistical measures. Validate the code and simulations.

PHASE III: Advance the software developed in Phase II into an enterprise level product. Establish and maintain a full support Help Desk to provide technical and administrative support to users. Establish and maintain a testing and verification system. Establish and maintain a defect tracking system. Produce and maintain a full and complete Validation Report. Address technical deficiencies, evolving requirements and new capabilities in coordination with Government personnel.

COMMERCIALIZATION: Military application: The technology will provide a system trade capability for UV/VIS/IR imagery that will enhance sensor capability and intelligence mission planning surveillance. Commercial application: Results from this work will apply to weather forecasting and future NASA earth science missions.

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KEYWORDS: radiance transport, terrain models, ocean models, infrared, surveillance, missile warning

MDA09-036

TITLE: High Power Fiber Laser Technology and Beam Combining

TECHNOLOGY AREAS: Air Platform, Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: Airborne Laser and Advanced Sensors and Interceptors

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop innovative concepts and technologies for high powered fiber laser technologies for use in MDA high energy laser systems, extending the reliability and power handling capability beyond current state of the art. Techniques should concentrate on high efficiency configurations compatible with thermal management constraints and robust scaling to multi kilo watt power levels.

DESCRIPTION: High Energy Lasers (HELs) are required for a number of BMDS applications including long range sensing, communications, and missile defense. One type of laser of interest is the semiconductor diode pumped fiber laser.

This topic seeks proposals for demonstration of concepts and hardware which would enable high-brightness, high-power scaling of fiber lasers/amplifiers.

Semiconductor diode-pumped fiber lasers offer many attractive features for these military applications, including efficiency, reliability, and ruggedness. To maximize the ruggedness and reliability in military environments, high efficiency, polarization preserving pump combiners are needed to transmit the light from high brightness diode pumps to the pump cladding of fiber lasers. The ideal pump combiner minimizes the loss in brightness between multiple pump diodes and the gain fiber and preserves the signal polarization. Couplers are needed that are compatible with polarization-maintaining (PM) large mode area (LMA) fibers. These fibers are typically low numerical aperture and may not be strictly single mode, making them sensitive to external stresses and deformations. In addition, couplers for air- or glass-clad fibers are needed for power handling and reliability. In addition, for many military applications these fiber lasers must be scaled to high power levels while maintaining high brightness and beam quality, so that they can be propagated over militarily-significant distances. Thus, the outputs from multiple fiber lasers must be combined while maintaining the output beam brightness and quality. One beam combining approach is to coherently couple the beams in a Master Oscillator Power Amplifier architecture.

Since Master Oscillators have been readily available at 1064nm, that is what has been commonly used for Yb-doped fibers. However, there may be greater system efficiencies from MOPA operation at other wavelengths, e.g., 1030 nm. For operation in the mid-infrared spectral region, it may be possible to develop all-fiber laser systems that are based on various glassy semiconductors such as chalcogenide and zblan (mixture of Zr, Ba, La, Al, and Sodium Fluoride) as well as sapphire. Various ceramics such as either single-crystal or polycrystalline yttrium aluminum garnet (YAG) may also offer attractive features for fiber cores and the associated cladding(s). Laser dopants for the fiber core may include thulium, holmium, praseodymium, and terbium, among others,

PHASE I: Phase I should consider exploration of new fiber materials, dopants and fiber design and fiber combining constructs are required to address better lasing efficiency, reduced nonlinear effects, and improved single-fiber power handlings constructs are to be explored. Investigate innovative concepts and technologies for fiber laser source beam combining, to substantially increase laser power. Techniques should concentrate on high efficiency and good beam quality in configurations compatible with thermal management constraints and robust scaling to high power.

Beam Combining: Select design for prototype approach and define testing methodology for demonstrating feasibility of near diffraction limited operation of an array of fiber laser/amplifiers containing at least seven modules in all fiber architecture. Phase I should concentrate in generating a design and completing the analysis of the selected approach.

The metrics for the Phase I concept are:

- (1) detailed design and experiment to demonstrate beam combination of seven laser/amplifier modules at a combined power of greater than 50W, a combined beam quality better than 1.5 times the diffraction limit, and high wall plug efficiency of the entire system (goal approaching 20%),
- (2) Initial design of a multi-kW fiber laser/amplifier combined system with a beam quality of less than 1.5 times diffraction limited, and wall plug efficiency exceeding 20%. Modeling and simulation are encouraged to guide the development of the HEL beam combination technique in all phases of the effort.

Pump Combiners: Select design for prototype approach and define testing methodology for demonstrating feasibility of all-fiber pump combiner compatible with current Polarization Maintaining-Large Mode Area (PM-LMA) fibers and high brightness laser diode pump sources in the 975nm region. Designs for pumping Ytterbium (Yb) operating at ~ 1 micron wavelength and Thulium(Tm) operating at ~ 2.0 micron wavelength are sought, with emphasis on Yb. Criteria for the design include polarization maintenance for the signal throughput, power handling capability, and packaging free of organics or other power limiting materials. Designs compatible with air-clad, high NA fibers or glass-clad gain fibers are also of interest. Phase I should concentrate on generating a design capable of handling high power and completing the analysis/demonstration of the selected approach.

The metrics for the Phase I concept are:

- (1) detailed design and experiment to demonstrate combination of six pump modules into one double clad PM output fiber at a combined power of greater than 500W and high polarization extinction ratio, (goal of greater than 20dB for the PM feed through). Perform complete testing at 500W or greater, including overall loss characterization, polarization performance, fusion splicability to LMA fibers, and assessment of power handling capability.
- (2) Initial design of a multi-kW fiber laser/amplifier compatible combiner. Modeling and simulation are encouraged to guide the development of a multi-kW fiber pump combiner in all phases of the effort.

Alternate Fiber Materials: The behavior of materials for use in infrared fibers shall be explored and materials processing techniques shall be developed for fabricating optical fiber that enable significant improvement in the operation of lasers operating in the 1 to 5 micron wavelength range.

PHASE II: Phase II should include brassboard demonstrations of several of the key interest areas including:

Beam Combining: (1) Conduct a concept validation experiment to demonstrate beam combination of at least seven laser/amplifier modules, at a combined power level goal of over 700W (e.g. individual modules at greater than 100W), good beam quality, better than 1.5 times diffraction limited, and high wall plug efficiency greater than 20%, (2) Conduct detailed design of a 100kW class array of fiber laser/amplifiers with good beam quality (goal of better than 1.5 times diffraction limited) and high wall plug efficiency (goal approaching 30%). (3) Deliver packaged hardware to AFRL/RDLAF for performance verification.

Pump Combiners: Conduct a concept validation experiment to demonstrate packaged prototype coupler for combination of at least six fiber coupled pump diodes and one PM LMA MOPA capable of coupling greater than 1kW of pump power into a double clad fiber, based on the Phase I design and tests. Perform complete testing, including loss characterization, polarization performance and assessment of power handling capability. Perform reliability testing to assess component lifetime and serviceability in a military environment. Deliver packaged hardware to AFRL/RDLAF for performance verification.

Alternate Fiber Materials: The proposed material and/or the relevant material processes shall be further developed for fabricating a doped fiber core plus compatible cladding layers, and the material's properties and its usefulness for commercial and military applications shall be fully demonstrated for verifying the potential to exceed state-of-the-art fiber-laser power at the selected lasing wavelength. All necessary manufacturing processes for commercialization of the material and/or product shall be developed as well. Fiber samples shall be delivered to AFRL/RXPS for performance verification periodically throughout the Phase II effort.

Perform reliability testing to assess component lifetime and serviceability in a BMDS environment. Prototype experiment hardware will be characterized in a Government designated facility.

PHASE III: Compact, conveniently packaged, and scalable laser systems would be valuable for active ranging, tracking, and characterizing targets. If scaled to high average powers, they could also be attractive as weapons for targets at long ranges. The Phase III effort will focus on work with MDA prime contractors and subsystem integrators to incorporate the fiber laser technology demonstrated here into sensor, weapon, and targeting systems for MDA Directed Energy, interceptor, and platform remote sensing application along with potential use in long distance free space laser communications.

COMMERCIALIZATION: Components for high power fiber lasers have significant potential markets in both commercial and military systems. A high power, high efficiency pump combiner based fiber amplifier laser system with diffraction limited beam quality will be capable of adding value to land, air and space based directed energy platforms to defend against nuclear, biological and chemicals weapons of mass destruction. High energy fiber lasers are also high value sources for material processing in automotive, aircraft and other large manufacturing industries. They can also be used for decommissioning of nuclear and other hazardous manufacturing plants. High brightness fiber lasers constructed at greater than the 10 kW level with near diffraction limited beam quality and 20% wall plug efficiency will be the Phase III goal in partnership with automotive and aerospace industries.

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KEYWORDS: High power fiber lasers, fiber pump combiner, fiber amplifiers, coherent beam combining, Fiber Lasers, High Energy Lasers

MDA09-037 TITLE: High Energy Laser Technology Innovations for BMDS Directed Energy, Tracking, and Illumination

TECHNOLOGY AREAS: Air Platform, Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: Airborne Laser and Other MDA Active Tracking Programs

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Identify and develop new laser materials, laser subsystems, and supporting technologies to enable high power solid state lasers for Missile Defense directed energy and laser ranging/tracking applications.

DESCRIPTION: Advanced Laser Technology applications can contribute to two important future Ballistic Missile Defense (BMD) System capabilities. The first is laser ranging and laser illuminator transmitters and integral optics required for precision tracking of threatening targets at long range, and illumination of threatening targets for discrimination, and imaging. An example of an active sensor application includes laser ranging which uses a time of flight principle by sending a laser pulse(s) in a narrow beam towards the object and measuring the time taken by the pulse to be reflected off the target(s) and returned to the sender. High power lasers and amplifiers that are compact, in terms of size, weight, and power, are needed. These lasers may need to be used in conjunction with passive infrared and/or visible sensors requiring complementary high precision optics. Brightness, beam quality and peak power at high pulse repetition frequencies (PRF) are critical for long range (100's to 1000's of kilometers) BMDS engagement scenarios.

The second capability is far-term laser weapon applications in which the laser transmitter and optical system provides high energy laser (HEL) output beams capable of damaging threatening targets to the extent of preventing

them from completing their mission. Technologies improving the current state of the art in innovative laser technologies providing compact sources in the 100's of kilowatts to megawatt ranges are desired.

Among innovations sought are for:

Laser Illuminator Technology Needs

Laser Transmitters are needed consisting of advanced diode pumped solid state laser source and amplifiers for transmitter systems (examples: Mono-Block, Fiber Lasers, or other Advanced Laser Architectures). These include, light-weight, small volume, robust, highly efficient lasers with good beam quality. Some characteristics of these improved capabilities needed include:

- Pulsed and Agile Waveforms with much greater than 100 milliJoule/pulse at repetition rates of 100 to 1000 pps, with pulse lengths less than 10 nanoseconds
- Wall plug efficiency greater than 15%
- Beam quality less than 1.5 time the diffraction limit
- Weight less than 10 kg, and Volume of approximately a liter

Laser Illuminator technology improvements to light up distant targets supporting acquisition and tracking include:

-- Advanced diode pumped laser illuminators (e.g., Nd:YAG, cryo-cooled Yb:YAG, or other advanced laser concepts) for light-weight, small volume, robust, highly efficient lasers with good beam quality capable of providing:

- Waveform with much greater than 100 mJ/pulse at Rep Rates greater than 1000s of pps with pulse lengths < 15 nsec
- Wall plug efficiency much greater than 15%
- Beam Quality less than 1.5 time the diffraction limit
- Average Power to Mass Ratio greater than 12 W/kg
- Average Power to Volume Ratio greater than 10 W/liter

High Energy Laser Technology Needs: Advanced High Energy Lasers innovations are needed in technology which is highly energy efficient, light-weight and compact, and which is scalable to high power operation with 10s to 100s of kilowatts, both repetitive-pulsed (RP) and continuous wave (CW) output are desired.

These include technologies in materials, more efficient diode pump sources, beam quality and real time diagnostics to enable:

- Advanced diode pumped solid state lasers
- Advanced diode pumped Alkali lasers (DPAL)
- Advanced Chemical Oxygen Iodine Laser innovations (COIL) reducing size, weight, power
- Other advanced laser concepts

Advanced in-situ diagnostics, modeling and simulation, as well as, Hardware in the Loop technologies to support the development, test, and demonstration of the above technologies are also of interest.

PHASE I: Develop key component technologies for advanced BMDS laser systems, laser materials and subsystems that will improve the performance, operational suitability, and cost of active sensors and directed energy solutions for BMDS applications. Demonstrate in Phase I through modeling, analysis, and proof of principle experiments that the proposed approach is viable for further investigation in Phase II. Proposers are highly encouraged to work with system integrators and/or their respective payload contractors to help ensure applicability of the proposed effort and to facilitate future technology transition.

PHASE II: Validate the feasibility of the proposed concept developed in Phase I by development and demonstration of a key components brassboard and the execution of supporting laboratory/field experiments to demonstrate technology viability. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration subsystem. The goal the Phase II effort is to demonstrate technology viability and the offeror should have working relationships with system and payload contractors. A partnership with a current or potential supplier of MDA element systems, subsystems or components is highly desirable.

PHASE III: In this phase, the contractor will apply the innovations demonstrated in the first two phases to one or more MDA element systems, subsystems, or components. The objective of the Phase III is to demonstrate the scalability of the developed technology, transition the component technology to the MDA system integrator or

payload contractor, mature it for operational insertion, and demonstrate the technology in an operational level environment.

COMMERCIALIZATION: High powered laser components have numerous commercial and other DoD applications in material processing and welding, remote sensing both terrestrial and space, satellite communications, power beaming, and weather sensing applications. Numerous military other applications for the technology also apply outside of MDA in areas of tracking, designation, directed energy, demilitarization of munitions, and IED destruction.

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KEYWORDS: Directed Energy, High Energy Laser, Laser Illuminator, Chemical Iodine Laser, Diode Pumped Alkali Laser, Laser Diode Pumps, Laser Amplifier.

MDA09-038 TITLE: Improved High Speed and High Dynamic Range Photon Counting Sensors for Active Imaging

TECHNOLOGY AREAS: Air Platform, Sensors, Space Platforms

ACQUISITION PROGRAM: Airborne Laser

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Investigate advanced materials for new low noise photodiode sensor technology to develop large format (128X128 pixels), high frame-rate (10-kHz) linear mode sensor arrays with photon-counting sensitivity levels and high reliability for ABL (Airborne Laser) and other BMDS laser imaging applications.

DESCRIPTION: High speed, wide dynamic range imaging sensors are critical for discrimination, target tracking, wave front sensing and adaptive optics. These sensors are critical to development of wavefront sensors, laser imaging capabilities for pointing and tracking objects, and other future MDA applications. Developments of this technology would eventually lead to the development of camera systems to be used across the BMDS as well as ABL.

The nature of the application in imaging wavefronts for adaptive optics applications, measuring atmospheric distortion and blooming, imaging remote distant objects at high pulse rate and other critical aspects represent major sensor challenges. These are, imaging at very high frame rates and very low noise for photon counting performance. To achieve the desired results, for advanced sensor frame rates in the kilohertz range are required to match the pulse rate of new laser systems as well as the phenomenology to be analyzed. Likewise, the laser energy returned from a

distant target or through the atmosphere from a reference object may only be a few photons requiring high sensitivity and very low noise.

For laser ranging and imaging applications, linear mode operation is needed to preserve information about amplitude, phase, and polarization to be used in various tracking and adaptive optics applications.

Laser Detector Arrays: High bandwidth, high quantum efficiency, low noise laser detector array

- Pixel arrays > 128 by 128 are desired
- Detector/ROIC Bandwidth ~ 1 GHz
- Quantum efficiency > 75% at wavelengths from 0.5 μm to 1.6 μm
- Dark count rate per pixel much less than $1\text{E}4$ (10^4) electrons/sec.
- Operation at non-cryogenic temperatures desired
- Linear response to input signal photons desired

PHASE I: Develop overall system design for a high frame rate, high bandwidth, low noise, linear mode photon counting FPA associated with active tracking and wavefront sensing, laser ranging, laser imaging and laser scoring. Apply the latest process and material technology to address major improvements for low noise detectors systems in the 0.5 to 2 micrometer wavelength region. The goal for the array is to be at least 128 X 128 pixels with a 30 micron pitch (256 by 256 goal). In parallel, develop the design for a high speed low noise ROIC that can be integrated with the FPA to produce low noise (photon counting) performance over a wide number of BMDS operational conditions. Dark current, read noise, and radiation effects should also be considered on both detector and ROIC design. Perform modeling and simulation of the detector design, ROIC, and signal processing to achieve projected performance. Perform critical experiments to demonstrate photodiode light sensitivity, bandwidth and performance at a range of operating temperatures and conditions.

PHASE II: Based on the Phase I design and experiments, develop and demonstrate a prototype sensor system that integrates the novel detector design, ROIC, and associated signal processing. Demonstrate operation over a wide range of BMDS operating conditions including solar, laser, and plume backgrounds. It is highly encouraged that the proposer work with MDA system developer and integration contractors to configure the sensor and subsystem to work with various MDA laser illumination, ranging, and tracking applications for Airborne Laser and other programs. Demonstrate the high speed photon counting sensor brassboard in a relevant application experiment at a government or MDA contractor facility.

PHASE III: The Phase III effort will be to improve the speed, resolution (pixels), and noise performance of the photon counting array and readout to support transition into ongoing ABL and other MDA sensor and laser programs.

COMMERCIALIZATION: The application for photon counting high speed sensors is increasing in the nuclear medicine, forensic engineering, laser processing and welding, optical computing, and gene sequencing areas. Future areas include image processing for collision avoidance, biometrics for man-machine interaction, and optical switching and routing for telecommunications and computing.

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KEYWORDS: Sensors, Wavefront Sensing and Tracking, pattern analysis, read out integrated circuit, adaptive optics, laser imaging

MDA09-039

TITLE: High Energy Laser and Laser Illumination Optics Improvements

TECHNOLOGY AREAS: Air Platform, Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: Airborne Laser and other MDA High Energy Laser Programs

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 3.5.b.(7) of the solicitation.

OBJECTIVE: There is a need to improve and harden the optical systems, coatings and components needed for high power laser systems under development for various BMDS directed energy and laser tracking/illumination systems. This topic addresses key optical components needed to support, maintain and improve the ability to insert advanced laser systems into Airborne Laser and other MDA element applications.

DESCRIPTION: MDA High Energy Laser (HEL) and High Power Laser systems have numerous critical needs in optical technology over a wide range of operating and lifetime conditions. These optical system range in size, operating environment, and mechanical requirements over a large range. These systems can be categorized into two main groups.

Advanced Large Optical Systems

- Large integrated optical systems for acquiring, tracking and focusing high energy beams on high velocity targets at long ranges.
- Large aperture, light-weight optical telescope capable of handling high energy laser beams, aperture diameter > 6 m
- HEL wavelengths from 0.5 μm to 1.6 μm
- Target range > 500 km
- Pointing and tracking angular precision < 1 μrad

Agile Scanning Optical Systems

- Wide field of regard (FOR) optical systems with rapid scanning optical system capable of precisely pointing laser optical beams at point targets at long range.
- Field of Regard ranging from 2 deg x 2 deg to 20 deg by 20 deg
- Optical beam scanning at rates of greater than 1 deg/msec
- Accurate pointing to < 10 μrad

Many of the issues relate to optical coatings for multiple wavelengths. There is a ongoing need to improve coatings that are required to accommodate several different wavelength regions and several high power laser wavelengths. Specific areas of improvement are reproducibility of coating, robustness of coating, resistance to laser damage and ultra-low absorption.

Other issues involve operation over wide temperature ranges. There is a need to develop and demonstrate Athermal Refractive Optics for Use in HEL Beam Control Systems. There is a need to develop and characterize athermal glass (zero thermal lensing coefficient, TLC) and use it to produce refractive elements (phase correctors, lenses, etc.) for use in mega-watt class LASER (Wavelength: 1.0 to 1.315 μm) beam paths. (Bandwidth of other wavelengths in beampath 0.9-3.6 μm)

Since systems must operate over a long period with minimum or no ability to access the optical path there is a requirement to develop and test improved protective measures for coatings/substrates required to operate in contaminated environment: This would develop them and then test their respective capability (Wavelengths of interest: 0.9-3.6 μm ; megawatt class laser at 1.315 μm)

Access is extremely limited through many of the HEL beam steering systems optical path. Another requirement is to develop Fiber-Based Remote Monitoring Methods for DE Systems: Small unobtrusive sensors are needed for radiation scatter, thermal monitor imaging, in situ particulate and gas contaminants measurements, etc. This sensor might use small fibers to bring optical signals to equipment bays where IR cameras and other sensors could monitor them sequentially to determine when contamination from dust and other materials had reached a point of potential system damage. (Wavelengths of interest: 0.9-3.6 μ m). This capability would then be used for dust (firefly) generation prevention: Characterize how dust is generated inside the benches and the beam train (Helium filled and vacuum beam train). Develop internal coatings to minimize erosion as a partial source of contaminants in the beam train.

Finally to point and steer the mirror advance inertial reference sensors are needed to relay the pointing angles and rates relative to the platform inertial coordinate system. Miniature Compact, light weight, high accuracy, low drift rate IRUs for airborne applications with much higher bandwidth and smaller sizes than current fiber optic or MEMS gyros can provide. Investigations into new chip scale atomic gyros and other novel monolithic devices may provide a robust, lightweight sensor to improve optical system control and pointing accuracy.

PHASE I: Develop concepts and approaches to address advanced optical system capabilities to improve the operational survival of high power laser and tracking optics for ABL and other MDA optical system applications. Demonstrate through concept experiments in the Phase I effort the efficacy of the propose approach. Model and simulate the capability to be developed in Phase II and provide a design and development plan.

PHASE II: Develop the capability to harden, monitor, clean, and control large and high speed optical systems for directed energy, tracking, and interceptor applications. Demonstrate capability to accommodate various levels of optical system degradation while maintain useful levels of system capability. Develop and conduct prototype demonstrations of brassboard coatings, diagnostics, and dust/debris removal for in-situ restoration and monitoring of system status. Provide demonstration if appropriate of advance miniature optical system angular and position sensing technologies.

PHASE III: Design and build a full scale prototype, with a complete diagnostic suite for measuring its properties in a laboratory environment. Perform chemical compatibility and lifetime tests on the prototype to demonstrate its ability to support ABL and other MDA laser system requirements. Provide a detailed evaluation report.

COMMERCIALIZATION: The improvements in optical surfaces, coating technologies, and monitoring could have significant impact in the high energy laser for materials applications, semiconductor processing, laser lithography, eye surgery systems, and optics for science and metrology.

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KEYWORDS: High Energy Laser, Tracking Optics, Optical Coating, Laser Damage, Inertial Reference Unit, Contamination

MDA09-040 TITLE: High Powered Laser Diodes for Pump Sources and other BMDS applications

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: Airborne Laser and other MDA High Powered Laser and Interceptor laser progr

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop advanced Near Infrared (NIR) and Mid Wave IR laser diode arrays supporting MDA directed energy and high power laser application.

DESCRIPTION: High brightness CW and high peak power pulsed laser diode arrays are key technologies toward numerous BMDS directed energy, laser illumination, laser ranging, free space communication and sensor applications. Advanced diode laser arrays suitable as laser pump sources for solid state, chemical, fiber, and hybrid (Diode Pumped External Cavity Surface Emitting Laser (DPAL)) applications are needed. This topic addresses the need for novel 1D and 2D surface emitting laser diode arrays. The packaging, optical coupling, electrical current handling, low failure rate and temperature stability of novel surface emitting arrays provide key advantages for many operational laser systems. For MDA applications these array of pump and source diodes need to be highly efficient, light-weight, low volume, robust with excellent output beam quality and narrow line widths suitable for pumping advanced solid state, or hybrid lasers.

Vertical cavity surface emitting lasers (VCSEL) and Grating Outcoupled surface emitting laser (GCSELS) and Vertical External Cavity Surface Emitting Lasers (VECSEL) are examples of high optical coupling efficiency sources to provide pump and oscillator sources. In some cases high powered narrow frequency arrays could provide the ability to replace fiber amplifiers and are key for DPAL operation and pumping atomic precision navigation, timing and detection quantum systems.

These diodes are classes of semiconductor laser diodes that emit perpendicular to the plane of the semiconductor junction. The material processes for fabrication of both of them are similar. As compared with edge-emitting laser diodes, these surface emitting systems have a number of advantages including superior wavelength stability, a reduced wavelength-temperature dependence, improved reliability, lower manufacturing costs, and higher temperature operation. Primary interest for VCSELS is enabling high-power, high-brightness arrays that may be used for pumping high-power fiber lasers and high energy/power slab lasers, especially Yb, Er, Ho, and Tm doped laser materials. Potential projects of interest among many are the development of materials and processing techniques that enable designs that utilize edge oxide regions to improve carrier and optical confinement and designs that increase efficiency by optimizing tunneling between quantum wells. Primary interest for VECSELS is in

enabling laser sources for various applications with laser emission at wavelengths corresponding to the various atmospheric transmission bands at wavelengths between 0.5 and 5.0 microns.

Of various potential projects, one example is the development of materials and processes for III-antimonide semiconductors for devices that operate in the neighborhood of a wavelength of 2 microns and infrared tracking beacons/target simulator/sensor stimulator arrays with wavelengths from 1 to 5 microns and high speed-high linear dynamic range.

Directed energy development of kilowatt class mid-IR fiber lasers and amplifiers based upon Thulium or Holmium doped fibers is in its nascent stage. The critical component for all high power amplifiers is a narrow spectral linewidth source. At 2-microns very few lasers are available. One of the goals of this topic is to develop laser diode technology at 2-micron wavelength. The goal is a methodology to fabricate laser devices that can reliably operate in continuous wave (CW) mode at 100's of milliwatts powers and be single transverse mode with a narrow spectral linewidth of less than 10 MHz.

Semiconductor distributed feedback (DFB) or distributed Bragg reflector lasers (DBR) at wavelengths of 1550nm and less are extremely successful in power, compactness, efficiency, and reliability. And they have the advantage of modulated pulsed operation in addition to CW. Mode-locked laser diodes are also possible based on the same semiconductor material. At 2-microns, laser diodes have been shown but their availability, power, and reliability require continued research and development.

This architecture is a critical enabling component for realizing kilowatt-class, mid-IR rare-earth doped fiber amplifiers.

PHASE I: The contractor shall develop the necessary epitaxial and materials processing technique(s) and demonstrate the ability to fabricate the proposed device design. Research the epitaxial semiconductor growth of laser material, design free-running CW and high peak powered pulsed operating laser diodes, investigate temperature performance and initial reliability over MDA typical environment operating ranges. Evaluate laser diode performance with linear direct modulation. Evaluate life time predictions based on preliminary radiation testing for typical orbital environments. (300krad gamma; 63MeV proton). Demonstrate Injection Locking to achieve narrow linewidth and spectral coherence, demonstrate novel techniques to lock to pump wavelength over broad temperature ranges.

Proposers are highly encouraged to work with system integrators and/or their respective payload contractors to help ensure applicability of the proposed effort and to facilitate future technology transition.

PHASE II: Based on Phase I, optimize laser material, develop technologies for the development of narrow linewidth operation, characterize the laser for performance parameters, and continue reliability investigations. Validate the feasibility of the proposed concept from Phase I by development and demonstration of a key component brassboard and supporting laboratory/field experiments to demonstrate technology viability. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration subsystem. The goal of the Phase II effort is to demonstrate technology viability and the offeror should have working relationships with system and payload contractors. A partnership with a current or potential supplier of MDA element systems, subsystems or components is highly desirable.

PHASE III: In this phase, the contractor will apply the innovation demonstrated in the first two phases to one or more MDA element systems, subsystems, or components.

COMMERCIALIZATION: Commercial applications include Laser Machining, Laser Surgery, Sensing, Communications. Pulsed thulium fiber lasers for drilling or mid-IR optical parametric oscillator are also possible. Medical applications include uses in urology, angioplasty, and tissue welding. Other applications include spectroscopy and free-space point to point communication systems.

Other non MDA military applications include directed energy applications include; high power amplifiers for coherent beam combination, IR counter-measures, laser radar, laser range finders, and laser illuminator transmitters. Applications also include pump sources for optically pumped semiconductor lasers, imaging, and target designation.

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KEYWORDS: Diode laser, Semiconductor laser, Vertical cavity surface emitting laser, injection locked laser diode array, Directed Energy, High Energy Laser, Laser Illuminator, Chemical Iodine Laser, Diode Pumped Alkali Laser, Laser Diode