MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS INNOVATION RESEARCH PROGRAM (SBIR)
SBIR 06.3 Proposal Submission Instructions

INTRODUCTION

The MDA SBIR program is implemented, administrated and managed by the MDA Office of Small and Disadvantaged Business Utilization (SADBU). If you have any questions regarding the administration of the MDA SBIR program please call 1-703-553-3414. Additional information on the MDA SBIR Program can be found on the MDA SBIR home page at http://www.winmda.com/. Information regarding the MDA mission and programs can be found at http://www.mda.mil.

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8am to 5pm EST). For technical questions about the topic during the pre-solicitation period (1 Aug 2006 through 12 Sept 2006), contact the Topic Authors listed under each topic on the http://www.dodsbir.net website before **COB** 12 Sept 2006.

As funding is limited, MDA will select and fund only those proposals considered to be superior in overall technical quality and most critical. MDA may fund more than one proposal in a specific topic area if the technical quality of the proposal is deemed superior, or it may fund no proposals in a topic area.

PHASE I GUIDELINES

MDA intends for Phase I to be only an examination of the merit of the concept or technology that still involves technical risk, with a cost not exceeding $100,000.

A list of the topics currently eligible for proposal submission is included in this section 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 e-mail address listed in your proposal is current and accurate. MDA cannot be responsible for notification to companies that change their mailing address, their e-mail address, or company official after proposal submission.

PHASE I PROPOSAL SUBMISSION

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal submission, keep in mind that Phase I should address the feasibility of a solution to the topic. Only UNCLASSIFIED proposals will be entertained. MDA accepts Phase I proposals not exceeding $100,000. The technical period of performance for the Phase I should be 6 months. MDA will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. 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.

If you plan to employ NON-U.S. Citizens in the performance of a MDA SBIR contract, please identify these individuals in your proposal as specified in Section 3.5.b (7) of the program solicitation.

It is mandatory that the ENTIRE technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report are submitted electronically through the DoD SBIR website at http://www.dodsbir.net/submission. If you have any questions or problems with the electronic proposal submission contact the DoD SBIR Helpdesk at 1-866-724-7457.

This COMPLETE electronic proposal submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site http://www.dodsbir.net/submission will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal submission must be submitted via the submission site on or before the 6 a.m.13 October 2006 deadline. Proposal submissions received after the closing date will not be processed.

PHASE II GUIDELINES

This solicitation solicits Phase I Proposals. MDA makes no commitments to any offeror for the invitation of a Phase II Proposal. Phase II is the prototype/demonstration of the technology that was found feasible in Phase I. Only those successful Phase I efforts that are **invited** to submit a Phase II proposal and FastTrack will be eligible to submit a Phase II proposal. MDA does encourage, but does not require, partnership and outside investment as part of discussions with MDA Sponsors for potential Phase II invitation.

Invitations to submit a Phase II proposal will be made by the MDA SBIR Program Manager (PM). Phase II proposals may be submitted for an amount normally not to exceed $750,000. MDA will consider making Phase II Invitations with a base program of $750K and options. The base Program and options, together, may total a maximum of $2,500K. FastTrack will be for $750K maximum, unless specified by the MDA SBIR Program Manager.

PHASE II PROPOSAL INVITATION

An SBIR Topic Sponsor (either an MDA Element MDA Project Office or MDA Functional Area Office) begins the process for a Phase II Invitation by reviewing the Phase I work of each contractor (along with the Contract Technical Monitor) and making a recommendation on what Phase I efforts should continue into Phase II. The MDA Sponsor recommendation is based on several criteria. The Phase II Prototype/Demonstration (*What is being offered at the end of Phase II?),* Phase II Benefits/Capabilities (*Why it is important?),* Phase II Program Benefit (*Why it is important to an MDA Program?)*, Phase II Partnership (*Who are the partners and what are their commitment? Funding? Facilities? Etc? This also can include Phase III partners*), and the Potential Phase II Cost. This is the basic business case for a Phase II invitation and requires communication between the MDA Program, the Phase I SBIR Offeror, and the Phase I Technical Monitor.

The MDA Program recommends the Phase II Invitation to the MDA SBIR Steering Group. The MDA SBIR Steering Group will review the Phase II invitation recommendations and make a recommendation to the MDA SBIR Selection Official based on the above criteria and the availability of funding. The MDA Selection Official has the final authority. If approved by the MDA Selection Official then a Phase II Invitation is issued.

PHASE II PROPOSAL SUBMISSION

If you have been invited to submit a Phase II proposal, please see the MDA SBIR website http://www.winmda.com/ for further instructions.

All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the MDA specified deadline or may be declined.

MDA FASTTRACK DATES AND REQUIREMENTS

The complete Fast Track application must be received by MDA 120 days from the Phase I award start date. The Phase II Proposal must be submitted within 180 days of the Phase I award start date. Any Fast Track applications or proposals not meeting these dates may be declined. All Fast Track applications and required information must have a complete electronic submission. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the MDA specified deadline or may be declined.

The information required by MDA, is the same as the information required under the DoD Fast Track described in the front part of this solicitation. Phase I interim funding is not guaranteed. If awarded, it is expected that interim funding will generally not exceed $30,000. Selection and award of a Fast Track proposal is not mandated and MDA retains the discretion not to select or fund any Fast Track proposal.

MDA SBIR PHASE II ENHANCEMENT PROGRAM

To encourage transition of SBIR into DoD Systems, MDA has a Phase II Enhancement policy. MDA's Phase II Enhancement program requirements include; up to one year extension of existing Phase II, and up to $500K matching SBIR funds. Applications are subject to review of the statement of work, the transition plan and the availability of funding. MDA will generally provide the additional Phase II enhancement funds by modifying the Phase II contract.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria <u>must be met</u> or your proposal will be REJECTED.

____1. Your technical proposal, the DoD Proposal Cover Sheet, the DoD Company Commercialization Report (required even if your firm has no prior SBIRs), and the Cost Proposal have been submitted electronically through the DoD submission site by 6 a.m. 13 October 2006.

____2. The Phase I proposed cost does not exceed $100,000.

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MDA SBIR 06.3 Topic Descriptions

MDA06-001 TITLE: Computer Network Defense (CND) Technologies

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BC(DFB) / GM(DFG)

OBJECTIVE: Develop and demonstrate innovative software solutions to the problem of Computer Network Defense (CND) in the context of Ballistic Missile Defense System (BMDS) Program Protection Plans and associated architectures.

DESCRIPTION: Computer Network Defense (CND) refers to defensive measures taken to protect and defend information, computers, and networks from disruption, denial, degradation, or destruction. Novel solutions are being sought and should focus on applications of computer network incident response, disaster prevention and recovery, intrusion prevention, accurate attack detection with low false alarms, and malicious insider detection and mitigation as they relate specifically to missile defense systems and networks.

To facilitate early and accurate detection of malicious activity, a number of new methods and ideas should be explored, including techniques to that can identify malicious activity without reliance upon signatures cataloged prior to event detection or heuristic mechanisms that depend upon a profile of “normal” system behavior. These capabilities are essential in order to defend against previously undisclosed attacks, during periods of heightened alert on the BMDS. In addition, any proposed techniques must not impact the operational network.

The sponsor is interested in alternative approaches that do not rely on existing IDS technologies, build upon work already underway to address insider threats (see reference 1-3 below) and/or approaches that significantly extend the current state of the art for IDS systems. This sponsor is also interested in identifying activities that could be characterized as precursors to a malicious attack and/or correlating separate events in near real time across a wide area network.

Research in the areas of traffic filtering, persistence, and remediation at the internal network node level is needed to provide a scalable, comprehensive protection infrastructure for internal network nodes. Solutions should mitigate increased system latency or network response times but support a human in the loop or otherwise mitigate the potential for the solution itself to negatively impact the operational network. Solutions should support the use of open system architecture standards to provide seamless interoperability of a variety of different vendor products. Proposed solutions should address their capability for integrating with agent-based systems environment supporting the cyber security manager.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of methods for Computer Network Defense (CND) application software systems that provide security solutions that contribute to Ballistic Missile Defense systems.

PHASE II: Develop and demonstrate prototype platform/software/hardware that demonstrates advancement of Computer Network Defense technologies by illustrating functional effectiveness against predetermined and/or previously unseen cyber threat sets.

PHASE III: Prepare detailed plans for and implement demonstrated capabilities on critical military and commercial applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Advanced Computer Network Defense (CND) software has application throughout commercial industries. Commercial systems that are exposed to internet and corporate intranets 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.

REFERENCES:

1. [Heberlein90] L. T. Heberlein, G. V. Dias, K.N. Levitt, B. Mukherjee, J. Wood, and D. Wolber, A Network Security Monitor, Proceedings of the 1990 IEEE Symposium on Research in Security and Privacy, May, 1990.

2. Liepins92] G. E. Liepins and H. S. Vaccaro, Intrusion Detection: Its Role and Validation, Computers and Security, 1992, pp 347-355.

3. DARPA. Intrusion Detection PI Meeting February 1998¾Agenda and Presentations. (1998).

4. Puketza, Nicholas, et al. "A Software Platform for Testing Intrusion Detection Systems." IEEE Software 14, 5: 43-51.

5. Kahn, Clifford, et al. A Common ID Framework. (1998).

KEYWORDS: intrusion prevention, intrusion detection, malicious code, cyber security, computer network

MDA06-002 TITLE: Secure Computer System and Application Composition

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BC(DFB) / GM(DFG)

OBJECTIVE: The computing networks of Ballistics Missile Defense Systems (BMDS) are an important target for the enemy. One key area of critical importance to the BMDS is the ability to integrate computer systems, components and applications to perform an integrated mission implementing cooperative security policies.

DESCRIPTION: Research is required into the preservation of the security policy within a system, subsystem and application layers in complex systems. Further, research is also required into the development of tools to support automated policy reconciliation and composition across a distributed enterprise level system of systems. In order to find gaps and inconsistencies in security policy specifications across an integrated system-of-systems, information must be extracted from those security policies highlighting semantic interoperability issues that could lead to weak or limited policy enforcement. Furthermore, both formal and semi-formal modeling techniques can be applied to validate the divergence of the policies among integrated components in order to complete the reconciliation of detected interaction vulnerabilities. These methods also support the composition of security policies.

Additionally, research is required into technologies and tools that support the integration of software systems that have been developed to different security standards as well as application level certification and accreditation of these systems. Current systems rely on underlying operating systems and security kernels to provide basic security mechanisms. Integration developments layered the OS with middleware such as DBMS and browsers and custom developed applications. The Sponsor is interested in unique approaches, techniques and tools to assess the preservation and effectiveness of the underlying security controls within the overall software context. Specifically, addressing whether specific controls have been overridden or bypassed by the layered software and assessing the impact of trusted software.

Other questions to consider are:

1. Does the middleware reflect the desired controls to the user interface?
2. Does the middleware in any way obviate, obscure, or invalidate the desired controls?
3. If the middleware is trusted or privileged relative to the underlying O/S, then does it provide user interfaces that can be used to bypass the O/S controls?

Solutions must address composition problems for applications, systems or systems applicable to large-scale, dynamic, enterprise level systems in a system of system context and accommodate multiple, evolving, and flexible device management protocols. The proposed solutions should be system independent and build upon on-going research including The Department of Defense (DoD) Goal Security Architecture (DGSA).

PHASE I: Develop and conduct proof-of-concept demonstrations of advanced methods and tools that support system, subsystem and application composition. Develop methods and tools that support security policy interoperation and application level certification and accreditation in a system of system context.

PHASE II: Continue development of technology based upon based on Phase I results and demonstrate technology in a realistic environment. Identify opportunities for transition of this technology into BMDS programs.

PHASE III: Pursue partnership with traditional DOD prime-contractors since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Technology that enhances the privacy and survivability of the information infrastructure would have many applications in the commercial sector. Examples include the financial, medical, and electronic based systems.

REFERENCES:
1. THE DGSA: UNMET INFORMATION SECURITY CHALLENGES FOR OPERATING - Feustel, Mayfield, T; THE DGSA: UNMET INFORMATION SECURITY CHALLENGES FOR OPERATING.

2. Security Policies and Security Models - Goguen, Meseguer - 1982.

3. Information Flow in Non-Deterministic Systems Wittbold, Johnson - 1990.

4. A Model of Information - Sutherland – 1986.

5. Security and the Composition of Machines- Johnson, Thayer – 1988.

6. Hookup Security for Synchronous Machines- Millen – 1990.

7. A Hookup Theorem for Multilevel Security- McCullough – 1990.

8. A Formal Approach for Security Evaluation - McDermid, Shi – 1992.

KEYWORDS: composition, information security, information assurance, computer networks, security policy, security standards

MDA06-003 TITLE: Integration Framework for Heterogeneous Distributed Systems

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BC(DFB)

OBJECTIVE: Develop a framework exploiting advanced integration technologies such as grid computing, enterprise computing, web services, and semantic technologies to enable rapid integration of disparate MDA simulations, applications and systems. The framework should utilize DoD standards such as the HLA, and be able to integrate heterogeneous computing facilities (desktop machines, supercomputers, etc.) that are geographically distributed, connected through a wide area network.

DESCRIPTION: Despite many advances, the ability to rapidly compose disparate complex systems remains a major challenge in the defense community. Emerging technologies such as enterprise computing, web services, semantic technologies, and grid computing offer the potential to make transformational advances in MDA’s ability to rapidly field interoperable distributed systems for testing, analysis, and training. Effective systems must support rapid integration of heterogeneous, geographically distributed computing facilities ranging in computing capability from desktop machines to supercomputers. Heterogeneous distributed simulations require advanced time management algorithms to ensure proper synchronization of data exchanged among subsystems. These systems must scale to handle tens of thousands of entities or more. The system must be compatible with DoD standards such as the HLA and be able to operate effectively in the Global Information Grid. Client and server authentication and secure communications are essential. For many applications, “thin client” approaches may be appropriate to minimize impact on local host computing, storage, and communication resources. Current commercially available software does not support this broad range of requirements.

PHASE I: Develop a system design for a scalable, integration framework to support rapid interoperability among disparate components by exploiting one or more of the technologies described above. The system must support secure operation over heterogeneous, geographically distributed computing platforms interconnected via wide area networks. Develop a proof of concept prototype that demonstrates system capability for at least two client systems. Demonstrate how the system can be extended in future generation systems to scale to larger system configurations.

PHASE II: Develop and demonstrate the application of the integration framework to provide interoperability and scalability among a sampling of MDA applications for C2BMC, GMD and THAAD, e.g., simulations, data repositories, test facilities that use disparate date representations and computational resources.

PHASE III: Develop a robust, commercialized product of the integration framework and work with MDA/C2BMC in the training and usage of the product for selected MDA applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The system can be applied to a variety of applications where rapid integration is required, e.g., manufacturing, infrastructure simulation, and complex system modeling, to name a few.

REFERENCES:
1. I. Foster, C. Kesselman (eds.), The GRID 2: Blueprint for a New Computing Infrastructure, Elsevier, 2004.

2. Tuecke, S., I. Foster, et al. Open Grid Services Infrastructure (OGSI) Version 1.0. Open Grid Services Infrastructure Working Group (OGSI-WG), June 2003 http://xml.coverpages.rg/OGSI-SpecificationV110.pdf.

3. Extensible Modeling and Simulation Framework (XMSF), http://www.movesinstitute.org/xmsf/xmsf.html.

4. IEEE Standard 1516.1-3, Standard for Modeling and Simulation (M&S) High Level Architecture, 2000.

KEYWORDS: interoperability, modeling and simulation, grid computing, web services, enterprise computing, HLA

MDA06-004 TITLE: Track Correlation / Sensor Netting

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

ACQUISITION PROGRAM: BC(DFB) / AS(DV) / GM(DFG) / SE(DEE) / SN(DFN) / SS(DFS)

OBJECTIVE: Develop advanced, innovative, robust, real-time algorithms and software for the integration of passive or active electro-optical sensor tracks or detections with radar generated tracks or detections.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) employs optical and radar sensors in the detection, tracking, and identification of ballistic missiles and their constituent pieces. To provide a single integrated picture of the battle to the combatant commander and to the battle management algorithms, it is necessary to correlate (associate) the tracks and/or detections from the optical sensors with the tracks and/or detections from the radar sensors. Proposed advances should provide robust, reliable capability to correctly correlate reports from three or more sources (two sensors with the existing system track), 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 correlation.
2) Provide a measure of confidence with the correlation decision.
3) Identify groups of objects that form a cluster but are otherwise indistinguishable.

4) Provide as many distinct tracks as possible, using track fusion when appropriate to increase overall track accuracy.
5) Provide for cluster tracks when absolutely necessary.

It is desired that the proposed method can be implemented in either a centralized or distributed architecture.

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

PHASE I: Develop the mathematical basis for and provide a demonstration of track correlation/sensor netting concepts using simulated data.

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.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The technology is applicable to air traffic control and multi-sensor applications.

REFERENCES:
1. Bar-Shalom, Y. and Blair, W.D., Editors, Multi-target/Multi-sensor Tracking: Applications and Advances, Vol III, Artech House, Norwood, MA, 2000.

2. Cowley, D.C. and Shafai, B., “Registration in Multi-sensor Data Fusion and Tracking”, Proceedings of the American Control Conference, June 1993.

3. http://spie.org/Conferences/Programs/05/dss/conferences/index.cfm?fuseaction=5809.

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

MDA06-005 TITLE: Interceptor Communications

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

ACQUISITION PROGRAM: GM(DFB) / KI(DFK) / AS(DV) / BC(DFB)

OBJECTIVE: Develop innovative concepts to provide high speed, in-flight communications between the Ballistic Missile Defense System (BMDS) Fire Control and Interceptor/Kill Vehicles such as the Ground Missile Defense – Exoatmospheric Kill Vehicle (GMD-EKV), Kinetic Energy Interceptor (KEI), and Multiple Kill Vehicle/Carrier Vehicle (MKV/CV) in a fading channel environment. Increase probability of message delivery by In-Flight Interceptor Communication System (IFICS) under adverse conditions by utilizing innovative algorithms, implemented in software and/or firmware, to enhance system performance and reliability. Provide analysis of proposed high speed communications solutions within the framework of the Missile Defense Agency (MDA) layered architecture and prototype hardware that will demonstrate the utility of the proposed solution for missile to ground, ground to missile, and/or flight vehicle to kill vehicle communications. Signal encryption/ decryption is not a part of this topic.

DESCRIPTION: MDA is seeking innovative, high speed/ wide band communications methodologies for current systems as well as future Interceptor/Kill Vehicle systems. Near term improvements such as assessing the optimum high speed/ wide bandwidth communications solutions for overall system improvement and growth are needed. MDA is interested in both long range endo-exoatmospheric (>500 km) as well as short range exoatmospheric communications (~50 km.).

In any future MDA communication architecture, IFICS solutions will have to provide robust communications links with the ability to handle fading channels, including jamming and Nuclear Weapons Effects. In addition, there is a finite set of available RF spectrum options that can be assigned and authorized to any particular communications solution. High speed/ wide band communications system design depends heavily on and the successful bidder will consider:

1. Selection of the RF spectrum and allocation constraints.
2. Platform weight, size, and power constraints (especially on flight vehicles).
3. Link Attributes (i.e., data rate, bandwidth, range, latency, error rates, ...).
4. Channel waveform design, simulation and insertion (such as the use of Turbo Codes, different IF or RF Frequencies via upgradeable modules, support of transceiver-to-simulator RF interfaces between 70 MHz and 44 GHz, channel descriptions in Time Domain or Frequency Domain,…).
5. High altitude nuclear effects.
6. Jam and Intelligence gathering resistance.
7. Interference avoidance with and from the existing communications systems.
8. Transmission during ground and range testing as well as during wartime operations.
9. Beyond Line Of Sight (BLOS) connectivity.
10. New technology insertion alternatives and schedules.
11. Cost trades of proposed communications solutions.

The design requirements for Interceptors and Kill Vehicles are more much more demanding than for small satellites. Lower power, smaller antennas, reduced timelines, and hostile channel conditions are hallmarks of this design problem. Any proposed communications schemes must be scaleable as Missile Defense architectures grow in both geographic coverage (locations & platforms) and in hardware (number and type of interceptors or kill vehicles). Implications of frequencies and waveforms recommended such as interference potential, spectrum allocations, modulation coding, etc. must be considered for wartime and peacetime operations (e.g. integration, routine tests).

PHASE I: Contractors shall analyze, design and develop candidate communications solutions for providing high speed/ wide band connectivity to missiles and/or kill vehicles within the evolving MDA architecture. The contractor shall demonstrate the particular solutions feasibility of meeting Interceptor/Kill Vehicle high speed/ wide band communication requirements and envelope constraints. The contractor shall also identify the strengths/weaknesses associated with different solutions/ concepts. The output shall be a set of communications system and hardware trades which substantiate the proposed solution(s) and provides quantifiable metrics for comparison. Attention shall be paid to ongoing efforts within the Department of Defense (DoD) for weapons communications connectivity.

PHASE II: The contractor shall select an optimal candidate communications scheme developed in Phase I and prototype communications hardware sets or subsets that could be used for high speed/ wide band, two-way communications connectivity (half or full duplex). The proposed schemes must be selected for their optimum mix of performance/cost characteristics as listed above. Contractor shall begin coordination with MDA contractors to ensure products will be relevant to ongoing and planned projects.

PHASE III: The offeror shall work with MDA industrial partner(s) to maximize the transfer of this development to missile defense and is expected to identify a tractable Phase III project as a by-product of this overall program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Other efforts within the DoD are focused on two-way data links to weapons systems and this technology will, most likely,be transferred to those programs. The number of weapons that could ultimately use this technology would be substantial. Commercial applications would be in the cell-phone industry, airline communications, and over-the-air communications.

REFERENCES:
1. Digital Communications in Fading Channels: Modulation and Coding, R. L. Bogusch. Mission Research Corp., Report for Air Force Weapons Lab, Kirtland Air Force Base, NM, 1989.

2. DARPA Tactical Targeting and Network Technology (TTNT) program http://dtsn.darpa.mil/ixo/programdetail.asp?progid=9.

3. DARPA MIMO program, the Transformational Communications Architecture (TCA) from the National Security and Space Architecture (NSSA) office.

4. Irving, L. "Spectrum management: a balancing process", Communications Magazine (IEEE), Volume: 33 , Issue: 12, Dec 1995 Pages:44 - 46.

5. Brown, I.; Kavetsky, A.; Riccio, M.J.; Weiskopf, M.; "Spectrum. management and international filing from the acquisition program manager's perspective: current process and recent changes", MILCOM 2000. 21st Century Military Communications Conference Proceedings , Volume: 1 , 22-25 Oct. 2000, Pages:1-7.

6. MIL-STD-461, "Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference", military standard, procedure CE106.

7. DD 1494, "Application For Equipment Frequency Allocation", Department of Defense Form.

8. For more on high-altitude EMPs, see "U.S. Representative Roscoe Bartlett (R-MD) Holds Hearing on Electromagnetic Pulse and Business," House Small Business Committee Subcommittee on Government Programs and Oversight, FDCH Political Transcripts, Federal Document Clearing House, Inc., June 1, 1999; "U.S. Representative Curt Weldon (R-PA) Holds Hearing on Effect of Electromagnetic Pulse Attacks," House Armed Services Committee Subcommittee on Military Research and Development, FDCH Political Transcripts, October 7, 1999; "Hearing of the Military Research and Development Subcommittee of the House National Security Committee on Electromagnetic Pulse Threats," Federal News Service, Federal Information Systems Corporation, July 16, 1997; and Office of Technology Assessment, "The Effects of Nuclear War," May 1979.

9. Professor David Jenn, “ATMOSPHERIC NUCLEAR EFFECTS”, Naval Postgraduate School, Monterey, California.

KEYWORDS: communications architecture, jamming, nuclear effects, ground terminals, channel trades, RF data link, spectrum management, fading channel, spectrum allocation, DD 1494, CE106, NTIA, optics, spectral efficiency, dynamic link analysis

MDA06-006 TITLE: Software Defined Radio for Next-Generation Interceptor

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: AS(DV) / KI(DFK) / BC(DFB)

OBJECTIVE: To develop software defined radio to enable the development of ultracompact and rugged, software reconfigurable communications systems for integration with RF front-end MEMS technology.

DESCRIPTION: This effort is to focus on finding ways to develop an extremely compact RF/IF MEMS controllable communications sub-system. Extensive work has been done to develop common architectures for secure software defined radios, such JTRS, but most of it is focused on common architecture, modular, systems and components, and not on technology required for optimum miniaturization for atmospheric target cluttered missile defense environments. Significant advancements in the formation of integrated and hybrid device technology provide new possibilities via MEMS. The use of COTS programmable, multi-waveform software defined modems is recommended. The COTS modem base band to RF front-end will integrate with the MEMS beam forming technology including beam forming digital control. One class of solution to this effort would therefore be a communications sub-system based on miniature software reconfigurable modem/MEMS technology to provide the required system flexibility, compactness, and efficiently.

The government spec for the modem waveform and MEMS performance will be specified in future addendum. Included in the addendum is bit rate error rate performance over benign channel. Future missile defense constructs for swarms of small kill vehicles would benefit from this technology.

PHASE I: Provide an architecture for compact, flexible communications based on multiwavefrom secure software programmable modem technology. The offeror must demonstrate the ability to achieve a significant advantage in compactness over existing SDR approaches, and must deal with the issues of fabrication, packaging, testing, reliability, radiation tolerance, and qualification for MDA applications. A concise architecture definition backed up by analyses and simulations are a necessary prerequisite to Phase II.

PHASE II: The Phase 2 program will construct a prototype software re-configurable radio for integration with an existing RF MEMS front-end, with supporting simulation of the overall architecture to demonstrate feasibility of an integrated MEMS-based software-defined communication system.

PHASE III: Full ground and potential on-orbit testing of prototypes. Partnerships with other companies doing both government and commercial work are sought to exploit the unique reprogrammability features that this architecture will demonstrate.

PRIVATE SECTOR COMMERCIAL POTENTIAL: As 3G cellular telephony is pursuing compact and flexible, low-cost solutions for communications, breakthroughs in this program can potentially have a significant impact on a large (multi-billion dollar), cost-competitive infrastructure.

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KEYWORDS: microelectromechancial systems, software definable radio, RF Mems, space qualification, radiation-hardening, microminiature RF components, electronics packaging

MDA06-007 TITLE: Automated Battle Management / Planning Aids

TECHNOLOGY AREAS: Information Systems, Space Platforms

ACQUISITION PROGRAM: BC(DFB) / AS(DV) / GM(DFG) / SE(DEE) / SN(DFN)

OBJECTIVE: To develop advanced, innovative, robust, real-time algorithms and software that support coordinated, layered missile defense through the use of optimized interceptor to target assignments.

DESCRIPTION: With the addition of emerging weapon systems, to include boost intercept capability (airborne laser or kinetic interceptor), upgraded SM-3 missiles, multiple kill vehicle systems, and terminal defense systems, the Ballistic Missile Defense System (BMDS) will have the capability for layered defense. To maximize the potential performance enhancements of these new weapons 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. For single kill vehicle systems this will require determination of the number of each interceptor type to allocate to any threat, or for multiple kill vehicle systems, the derivation of the optimum assignment of kill vehicles to individual objects within a threat cluster. This is inherently a constrained, M-on-N assignment problem. This topic will require advanced optimization or assignment techniques. Furthermore, to support any evolving defense structure, the proposed method should work in either a centralized or distributed architecture.

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

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

Second, the fire control needs to determine how best to employ the missiles allocated for negation of a threat launch, given that there might be multiple objects associated with each missile launch. This optimization should, where possible, exploit launch timing flexibility and any scope for trajectory shaping to control engagement geometry, and 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.

Third, the multiple kill vehicle system will have a carrier vehicle and several smaller kill vehicles. The carrier vehicle determines how to assign M kill vehicles to negate objects found in one or several clusters. The number of objects in each cluster will be known to a limited accuracy. The carrier vehicle needs to determine when to release the kill vehicles and the desired trajectories for kill vehicle flight. Several factors influence (constrain) this optimization. The assignment should consider the uncertainty of objects within the cluster and the uncertainty in perceived lethality of the known objects in the cluster. This assignment should consider how the employment of multiple kill vehicles on a particular target will increase the success of target negation due to intercept angle, intercept velocity or other similar factors. In general, the assignment and trajectory should increase the lethal effectiveness of the kill vehicles. In the case of large targets, the assignment and trajectory should results in coordinated attack to intercept the entire target.

PHASE I: Develop the mathematical basis for and provide a demonstration of advanced allocation methods that will enable robust engagement planning for various weapon systems, battle managers and fire controls with different capabilities. Guidance will be provided on representative scenarios for concept evaluation. Concepts can be demonstrated on related problems of commensurate difficulty.

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.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The technology is applicable to any allocation/optimization application that operates on components of differing capabilities.

REFERENCES:
1. Report of the American Physical Society Study Group, Boost Phase Intercept Systems for National. Missile Defense, Scientific and Technical Issues, July 2003.

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3. Paschal N., Strickland B., Lianos D., Miniature Kill Vehicle Program, 11th Annual AIAA/BMDO. Technology Conference, Monterey, CA, August 2002.

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KEYWORDS: Optimization, Adaptive Scheduling, Allocation, Engagement Planning, interceptor, Ballistic Missile Defense Systems (BMDS)

MDA06-008 TITLE: Advanced Sensor Registration Health and Status Monitoring Technology Components

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: BC(DFB) / GM(DFG)

OBJECTIVE: Develop and integrate robust algorithms, displays, user interfaces, network interfaces, and hardware necessary to receive, process, and display information from BMDS sensors in order to assess registration health and status.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) is being designed to integrate information from a variety of BMDS sensors to provide the war fighter the capability to plan and execute the BMD battle in a manner that leverages available resources. Many of the core functions that allow shared sensor data to be appropriately leveraged (e.g. correlation, cueing, advanced engagement support, and fusion) depend heavily on local sensor registration (i.e. measurement/track bias removal and consistent bias residual covariance inflation). The goal of this research topic is to develop capabilities to remotely assess the sensor registration status of a sensor using the BMDS sensor network which can provide real-time sensor data from cooperating targets selected to support the sensor registration process. Algorithms, displays, user interfaces, network interfaces, and hardware which enable real-time and historical database assessments of sensors would enhance BMDS performance by directing the appropriate element Fire Control & Communications (FCC) to take corrective actions when sensor registration performance problems are detected. It is extremely important that sensor registration solution minimize the generation of false reports of improper sensor registration while concurrently optimizing detection of registration problems. In Phases II and II, providers of SRHSM solutions are expected to work closely with BMDS users to design, develop and optimize displays and human-the-loop interfaces. Advanced sensor registration and compliance monitoring solutions are desired which have the capability to process track
reports as currently provided by the BMDS network and measurement reports that may be provided by the BMDS network in the future. Sensor registration and performance tolerance compliance monitoring functions, at a minimum, should provide bias and track covariance consistency test functionality with and without accurate registration targets of opportunity being available.

PHASE I: Develop and conduct proof-of-principle demonstrations of advanced sensor registration health and status monitoring algorithms using simulation and available BMDS radar measurement and track file databases.

PHASE II: Update, refine, and test advanced sensor registration health and status monitoring algorithms based on Phase I results. Support and help conduct real-time tracking experiments which demonstrate the ability of sensor registration health and status technology to work in a real-time/multi-sensor networked environment. Perform algorithm, display, and user interface development/test which directly supports a transition to operations.

PHASE III: Integrate sensor registration health and status monitoring technology into the BMDS system. Demonstrate capabilities of the monitoring system, i.e. functionality, displays and user interface to support real-time and historical data based sensor registration situational awareness. Partnership with DOD prime-contractors and commercial entities, i.e. sensor, displays, hardware, and networking, will be pursued to provide an operational capability supporting the BMDS sensor network.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The technology is applicable to air traffic control as well as remote sensor and process monitoring applications.

REFERENCES:
1. Y. Bar-Shalom and W.D. Blair, Editors, Multi-Target/Multi-Sensor Tracking: Applications and Advances, Vol. III, Artech House, Norwood, MA, 2000.

2. R.Y. Novoselov, et. al., “Mitigating the Effects of Residual Biases with Schmidt-Kalman Filtering, Numerica Corporation, Fusion 2005 paper.

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KEYWORDS: Sensor Calibration, Sensor Registration; Sensor Monitoring, Sensor Bias Estimation, Sensor Covariance Consistency

MDA06-009 TITLE: Optimization of Sensor Management/Sensor Registration

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: AS(DV) / BC(DFB)

OBJECTIVE: To develop techniques for the real time tasking of diverse and distributed sensor resources to optimize the collection of threat data in a multi-target environment to meet competing requirements for accurate tracking and discrimination in order to support weapon assignment.

DESCRIPTION: As the BMDS evolves to incorporate new or enhanced sensors and weapon systems to contend with increasingly complex ballistic missile threats, the control and tasking of sensor systems will become increasingly difficult requiring the operators to be supported by sophisticated planning and real time scheduling tools. The available range of spatially separated EO/IR and radar sensors, each with its own temporally and geometrically constrained view of the battlespace, will have increasing demands placed upon them as the need for collection of target discrimination information expands to cope with countermeasures.

Proposals for the development of innovative optimization techniques/algorithms for the scheduling of sensors are invited. These may be based on techniques using dynamic programming or approximations thereto, stochastic programming or otherwise. The proposed scheme should allow for the need for dynamic reallocation of sensors in response to changing threat priorities and complexity, and arising from changes to sensor availability.

In proposing schemes recognition should be made of the following features:

1. Some sensor tasks will benefit from simultaneous observation from different platforms.
2. Depending on the objective, required observations may differ in character from short single looks, through frequent revisits to sustained periods of continuous observation.
3. For some sensors the slew and reacquisition time can be significant and constrain the ability to observe objects with large angular separation.
4. Priorities for sensor tasking must reflect the need to provide fire control solutions for weapon systems appropriate to each layer in the BMDS architecture.
5. The fidelity of track and discrimination information required will vary with time to match key decision points in an engagement.
6. Sensor resources will be required post interceptor launch to support tracking, in flight target update of threat state vectors and discrimination state and to provide kill assessment.

Proposed schemes should clearly identify how the performance improvement resulting from extending at any time the algorithm’s future planning horizon (‘far sightedness’) is achieved at the expense of increased to computational complexity to allow trade-offs of performance against processing load.

PHASE I: Develop a mathematical basis for the proposed approach, augmented as appropriate by coding or analysis sufficient to demonstrate its computational tractability and ability to handle the features 1-6 listed above.

PHASE II: Implement the algorithm(s) and integrate with simulation framework to allow their testing and evaluation in realistic scenarios.

PHASE III: If successful, this work has the potential to be incorporated into the BMDS C2BMC function; a task which would form the basis of Phase 3 work would probably be achieved through partnership with a DOD prime contractor.

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1. Kreucher et al. - Efficient Method of non-Myopic Sensor Management for Multi-target tracking. 43rd IEEE Conference on Decision and Control. December 2004.

2 D.P. Bertsekas. - Nonlinear Programming Second Edition. Athena Scientific. 1999.

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KEYWORDS: optimization, sensor management, resource allocation

MDA06-010 TITLE: Sensor Data Fusion

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: GM(DFG) / AS(DV) / AB(DFA) / BC(DFB)

OBJECTIVE: This topic seeks to apply innovative discrimination concepts to the fusion of sensor (feature) and contextual scenario information through the development of robust algorithms, software, and/or hardware necessary to collect, process, and fuse information from multiple sources (radars either at the same or different frequencies as well as EO/IR sensor assets). This topic further seeks to enhance the BMDS by forming a single integrated picture of the battlespace and assisting the warfighter in making decisions based on the evolving battlespace environment, with optimal discrimination and inference capabilities for threat identification being presented to the warfighter. 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.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) performance is heavily dependent upon data from dispersed and disparate radars and other types of sensors. Timely and accurate fusion of data collected from a variety of radars and/or other sensors that acquire information from multiple perspectives and/or different frequencies can provide for a more accurate picture of the adversary threat cloud than any single radar or group of radars operating independently. The goal of the data fusion process is to operate on a combination of sensor measurements, features, track states, and object type and identification likelihoods to produce a highly accurate integrated picture of the battlespace. Innovative techniques applied to the BMDS realm which are grounded in advanced mathematical decision theory and/or probabilistic inferencing algorithms as well as software, and/or hardware that enable this synergistic fusion and interpretation of data from disparate BMDS radars and/or other sensors should enhance system acquisition, tracking and discrimination of threat objects in a cluttered environment and provide enhanced battlespace awareness. Fusion of data at several levels may be required. Technical issues that must be addressed include: sufficiently accounting for uncertainty in both threat genealogy and sensor feature measurements, over-reliance on apriori information, spatial and temporal registration of radars, data throughput within and between sensor platforms, processing speed and capacity, data latency and gap handling, target feature exploitation, and sensor calibration. Of additional interest are methods for fusing multi-sensor data for 3-dimensional imaging for discrimination purposes. This includes multiple radar data, as well as on-board IR sensor data and active LADAR device data. Further fusion of data with other radar or a-priori data wouldalso be useful.

PHASE I: Develop and conduct proof-of-principle demonstrations of advanced sensor data fusion concepts using simulated sensor data.

PHASE II: Update/develop technology (algorithms, software, hardware, or a combination thereof) based on Phase I results and demonstrate technology in a realistic environment using data from multiple Radar assets sources. Demonstrate ability of technology to work in real-time in a high clutter environment.

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

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The technology is applicable to air traffic control and weather radar applications.

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KEYWORDS: Inferencing Algorithms, Decision Theory, Sensor Fusion, Data Fusion, Sensor Integration, Signal Processing, Algorithm, Multi-Sensor, 3-D Imaging

MDA06-011 TITLE: <u>Near-Pixel Signal Processing to Improve Next-Generation Interceptor</u>

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: DV (AS) / GM(DFG) / KI(DFK) MP(DEP)

OBJECTIVE: Develop an IR smart sensor chip assembly where each pixel contains a high performance pre-amplifier and several memory cells, allowing read out integrated circuit (ROIC) advanced real-time signal processing capability to improve sensor efficiency.

DESCRIPTION: The Missile Defense Agency (MDA/DV) and the Air Force Research Laboratory (AFRL/VS) are investigating novel real-time signal processing technologies under their Hyper Temporal Imaging program. Under this program, AFRL has demonstrated several methods of constructing sensors that are a paradigm shift from those produced today, with significant performance improvements for surveillance applications when on sensor signal processing is introduced. Signal processing can take many mathematical forms: mean, Fourier analysis, and many others, all of which could be programmable at the readout multiplexer level. To perform such processing, each pixel in the ROIC needs limited memory space to store enough data for first order processing with newly acquired information before alerting the on-board processor. With just rudimentary signal processing, one can ignore repetitive information and concentrate on dynamic scene changes, which will allow data compression and alleviate the computational problems associated with processing large format images.

Most surveillance sensors make use of large format infrared focal plane arrays to construct images of interest. Modern focal planes for infrared imagers are fabricated by hybridizing a two-dimensional array of photodiodes to silicon based ROIC. Several versions of silicon based ROIC are available but most are designed around the premise that lowest noise and highest pixel density can be obtained with a charge integration scheme. The charge from the photodiode is accumulated during the integration cycle. The accumulated charge on these capacitors is read serially and the charge, once read in a given integration time is dumped. With this technique, image intensity is a function of integration time and as the integration time is decreased the sensor array loses sensitivity. In addition, this approach limits the temporal content available for analysis to the maximum available frame rate and the minimum available integration time. Although great sensitivity can be achieved with a small and simple charge storage circuit, the development of smart sensor technology requires that a higher temporal and/or spectral content become available at the pixel level.

An alternative readout technique, which can maintain the needed temporal and/or spectral content for fast processing, is to couple each detector pixel directly to a resistive trans-impedance amplifier (RTIA). For a given number of photons impinging on the detector, the detector responds with a given output current. The output current is amplified directly from the pixel to produce an output voltage which depends only on the number of impinging photons. In this case, the output voltage becomes independent of the frame rate while bandwidth and dynamic range of each individual pixel can be dramatically increased. Such a trans-impedance amplifier coupled detector functions for cases of both photon-rich and photon-starved environments. Some potential trade-offs of a RTIA is a reduced signal-to-noise ratio due to an increased noise floor, along with the need for a larger pixel size. Innovative pre-amplifier, pixel cell designs, and ROIC signal processing techniques are sought.

PHASE I: Design, develop and fabricate a single IR detector with near-pixel processing and RITA integrated. Demonstrate the functionality of the integrated single device.

PHASE II: Fabricate a 32 x 32 IR detector array integrated with near-pixel processor and RITA that can demonstrate the functionality of the device as applied to a simple target scene.

PHASE III: Develop and execute a plan to manufacture a ROIC developed in phase II, and assist the MDA in transitioning this technology to the appropriate BMDS prime contractor(s) for the engineering integration and testing of advanced IR sensors.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The contractor will pursue commercialization of this technology for potential commercial uses in such diverse fields as law enforcement, homeland defense, rescue and recovery operations, maritime & aviation collision avoidance sensors and medical uses.

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3. “ CCD / CMOS Hybrid FPA for Low Light Level Imaging”, Liu et al.
http://www.fairchildimaging.com/main/documents/CCD_CMOS_Hybrid_FPA_for_Low_Light_Level_Imaging.pdf.

KEYWORDS: Near-pixel processing, Transimpedence amplifier (current-voltage converter) and signal processor/processing, Read-out-integrated (ROIC), IR detector

MDA06-013 TITLE: Active and Passive EO/IR Sensors

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: AS(DV) / GM(DFG) / TH(DFT)

OBJECTIVE: To develop active and passive electro-optical (EO) and infrared (IR) sensor technology for ballistic missile defense applications such as target detection, tracking and discrimination.

DESCRIPTION: Key functions of a missile defense interceptor are to detect, track and discriminate threat objects. Discrimination relies on the use of sensors that perform a variety of remote measurements such as IR emission, target temperature, shape, dynamics, range and range resolved shape. Ladars with their near microradian cross range resolution (suitable for resolving closely spaced objects) are ideal as an adjunct to a passive IR sensor. And, because ladars operate in a different part of the lectromagnetic spectrum, it is difficult and costly to develop countermeasures that simultaneously defeat both active and passive EO/IR sensors. In a dual-mode (active and passive) sensor system the passive IR sensor is the primary sensor. It acquires the threat after receiving a target position update from a ground-based radar or surveillance satellite. The IR sensor establishes an initial track of the threat, performs preliminary discrimination, and provides a line of sight to the ladar for objects it cannot discriminate. The ladar measurements are fused with the IR sensor data to increase the total number of features available to the discrimination algorithm. The major goal of a dual-mode sensor system is to improve discrimination at the longest possible range.

This topic solicits novel ideas and concepts that may form the basis of useful new products and development programs of benefit to the Missile Defense Agency. Of particular interest are new approaches to the development of both active and passive EO/IR sensors and components (such as fast steering mirrors, shock and vibration mitigation structures, 2-D ladar detector arrays, and highefficiency, high-power lasers) with features that include lightweight, small size, long range (hundreds of kilometers), fast response time, high angular and line-ofsight resolution, and better than the state-of-the-art performance. The innovative concepts, components and technologies to be developed under this topic include laser radars (ladar), infrared sensors, dual-mode active and passive sensor fusion and system integration. Components of greatest interest are fast steering mirrors, shock and vibration mitigation systems, and low-cost, compact, high-power pulsed lasers and 2-D imaging ladar receivers.

Fast steering mirror control technologies provide Field-of-Regard (FOR) and field-of-view scan mirror control and sensing techniques—specifically, fullaperture, servo-controlled, 2-axis FOR mirror with a closed-loop bandwidth of at least 100 Hz, elevation (vertical) range of 0-45 degrees (arbitrary origin), azimuth (horizontal) range of +/- 5 degrees, and < 10 micro-radian precision is desired; a small (1-2cm), servo-controlled, 2-axis laser pointing mirror with a closed-loop bandwidth of at least 10 kHz, +/- 5 degrees range in both axes, and < 1 microradian precision is desired – non-mechanical approaches will be also be considered.

Shock and vibration mitigation techniques (active/passive) may rely on smart structures which incorporate both sensing and PZT-like reaction to cancel shock/vibration, or other passive/active techniques which retain the optical system rigidity and pointing knowledge. Innovative ideas regarding low-cost, compact, high-power density, highefficiency pulsed lasers and associated components and thermal management technologies along with large format, 2-D ladar receiver arrays, and associated ROICs with sub-nanosecond response time are also solicited. To date, the detectors of choice have been avalanche photodiode arrays. Solicitations are sought that address new concepts that use on-chip integrated all-optical amplification, and detection that can simultaneously provide high sensitivity, low noise, high gain (>100), high fill factor (>75%), high bandwidth (>10 GHz), and high-speed gating (>500 MHZ).

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

PHASE II: Design, develop, and characterize a prototype of the active, passive, or dual-mode sensor 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.

PRIVATE SECTOR COMMERCIAL POTENTIAL: 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.

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KEYWORDS: Discrimination, IR Detectors, Laser, Ladar, Active Sensors, Passive IR Sensor, Remote Sensing, Mirror Control, Sensor Fusion, 2-D Detector Arrays

MDA06-014 TITLE: <u>Radar Debris Algorithms and Models for Discrimination</u>

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: GM(DFG) / AS(DV) / AB(DFA) / BC(DFB)

OBJECTIVE: Develop radar algorithms to screen debris and small fragments from objects of interest in a ballistic missile defense threat complex. Develop a statistical model of radar debris fragments with realistic phase and amplitude variations for large scale Monte Carlo testing of discrimination algorithms and architectures. Emphasis is on L- and S-band BMDS midcourse radars.

DESCRIPTION: A large number of small debris fragments are present in a typical ballistic missile threat complex. These fragments may include pieces of spent solid fuel, bits of deployment hardware, and debris from staging events. These fragments will exist even in simple threats that employ no deliberate countermeasures. Such fragments are highly variable in shape and motion. A pre-screener is desired that will greatly reduce the number of these objects that need to be considered by a classifier, while exhibiting extremely low leakage (i.e. the prescreener should never dismiss an RV as a debris fragment). Since RCS statistics alone may not be sufficiently reliable, another physical feature is sought to perform this prescreening function.

Debris Test Models for Discrimination Algorithms: Debris fragments will exist even in simple threats that employ no deliberate countermeasures. Current threat intelligence provides probability distributions on the physical size and RCS, probable tumble rates, etc. for fragments of various origins, but a statistical model is needed that provides highly realistic radar debris signatures for exercising coherent and wideband radar algorithms in Monte Carlo simulation to assure adequate rejection of debris by algorithms for identifying the threatening RV.

PHASE I: Develop and demonstrate an innovative physics-based radar screening algorithm to eliminate most deployment debris fragments from consideration by a classifier, with extremely low leakage. Prove the fundamental physical principle by means of theory and elementary demonstrations. Develop a technique for generating high-fidelity coherent and wideband radar signatures representative of the debris present in a ballistic missile threat. A successful signature generator design will match known statistics for RCS amplitude but also provide phase returns representative of real debris. The ideal model would be continuously upgradeable to reflect refinements in knowledge of the distributions of debris RCS, size, and motion.

PHASE II: Demonstrate the effectiveness of the debris pre-screener using available measured radar data and simulated data via Monte Carlo analysis. Prepare an algorithm for high-fidelity testing and spiral improvement for insertion into BMD midcourse ballistic missile defense radar processors. Calibrate the model based on measured debris data. Demonstrate the correctness of the statistical debris model under broader conditions of radar frequency, PRF, etc. Code the model for validation and insertion into standard BMD testbeds for use in large scale Monte-Carlo testing.

PHASE III: Integrate Debris Prescreening Algorithms into BMD midcourse ballistic missile defense radars and demonstrate the total capability of the updated system. Partnership with traditional DOD prime-contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The algorithms and processing techniques developed under this effort will potentially be useful in characterizing the condition and motion states of satellites, spacecraft and space debris. The models developed in this program will have broad applicability for simulating ballistic debris environments with direct impact on space flight safety, an area of significant concern to numerous government agencies and the commercial space launch industry.

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KEYWORDS: debris, fragments, discrimination, radar, algorithms, model

MDA06-015 TITLE: Enhanced Low Observables Algorithms

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

ACQUISITION PROGRAM: AS(DV) / BC(DFB) / SS(DFS)

OBJECTIVE: Use optimal mathematical methods to create robust clutter rejection algorithms for SBIRS-like (Space Based Infrared Satellite), STSS-like (Space Tracking and Surveillance System), and SBSS-like (Space Based Space Surveillance) sensors. Exploit classical and modern filter methods to extract unresolved moving targets from space, earthlimb, and terrestrial clutter. Apply methods to aerospace trades for future space-based platforms, such as SBIRS-like, SBSS-like, and STSS-like satellites.

DESCRIPTION: A Missile Defense requirement is to find, fix, track, and identify ballistic and flying objects and to extract and discriminate such objects from cluttered environments. It is therefore crucial to locate and track dim and unresolved ballistic and flying objects for all-threat sensing. The capability need extends to small, distant, and dim objects that may be obscured by natural and manmade infrared clutter that arise from atmospheric and manmade structures. Sample atmospheric structures that may obscure ballistic and flying objects include clouds, terrain features, aurora, stratospheric warmings, temperature inversions, and polar mesospheric clouds. This topic aims to exploit and demonstrate sophisticated mathematical capabilities for optimally suppressing clutter to sensor noise levels. The capabilities should consider staring and scanning sensors for both geostationary and low-earth orbits. The proposed research methods will be evaluated based upon the potential capabilities to accurately and robustly find, fix, track, and identify ballistic and flying objects in highly stressing cluttered environments.

PHASE I: The contractor will identify the optimal mathematical methods for finding, fixing, tracking, and identifying ballistic and flying objects in the presence of natural and manmade infrared clutter. Real-world clutter sources, such as clouds, terrain and celestial sources, aurora, stratospheric warmings, temperature inversions, and polar mesospheric clouds will be considered. Robust algorithms will provide for staring and scanning sensors for both geostationary and low-earth orbits. Methods will take into account real-world sensor limitations, specifications, and artifact. Optimal methods will reduce clutter to sensor noise levels. The contractor will also develop a validation plan for this effort.

PHASE II: The contractor will develop robust algorithms and a toolkit for finding, fixing, tracking, and identifying ballistic and flying objects in the presence of natural and manmade infrared clutter. The contractor will validate the algorithms and create tools for effective data visualization that support the MD clutter suppression mission. The algorithms should include staring and scanning sensor configurations for both geostationary and low-earth orbits. The contractor will validate the algorithms with simulated or real-world data.

PHASE III: Transition the clutter rejection toolkit to computer codes for DoD and commercial space and remote sensing applications of aero and terrestrial objects. Provide optimal design tools for DoD and commercial space sensors by means of comprehensive algorithms that classify objects by track and type.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This work could be applied to surveillance and identification of small dim terrestrial and flying objects. Can be used for identification and discrimination applications in remote sensing applications including agricultural surveys, traffic control, and search and rescue missions.

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KEYWORDS: missile defense, clutter, algorithms, SBIRS, STSS, SBSS

MDA06-016 TITLE: Multiband Infrared (IR) Seeker

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: AS(DV) / GM(DFG) / TH(DFT)

OBJECTIVE: Develop a large format multiband IR Focal Plane Array (IRFPA) capable of being integrated into a kill vehicle interceptor for target/decoy discrimination by providing spectrally resolved IR signatures from which temperature estimates of the objects may also be obtained.

DESCRIPTION: Multiband IR sensors are critical to target discrimination. Current seeker systems use several individual IR FPAs and beam splitters to achieve multiband performance. Conventional multispectral IR sensors use spectral filters, which usually are bulky and have time delays. This SBIR solicits novel concepts in making multiband IR sensors that are reliable, compact, near simultaneous in reading the spectral characteristics of the incident radiation, low of mass and power consumption, and require minimum optical alignment and signal processing. The emphasis is on multiband IR sensors with 4 to 7 adjacent bands in the Long Wave Infrared (LWIR) and Very Long Wave Infrared (VLWIR); either using one FPA with internal bandgap engineered multiple bands, or external filters.

The key benefit of a large format FPA is a larger field-of-view. The large format FPA should meet the following characteristics: Array size of 512x512 or larger, low cost, high performance (large D*) with co-located band detectors (with a minimum 2-color capability in the MWIR/LWIR, or LWIR/LWIR, or LWIR/VLWIR bands), associated readout integrated circuits (ROICs) with up to 40 million carrier charge capacity unit cell. A large format simultaneous/samepixel multicolor or multiband FPA with high pixel uniformity, small pixel size (~ 25 micrometer), reduced readout noise, improved resolution, and operability would improve interceptor's ability to acquire, track, and discriminate objects.

PHASE I: Research and develop a conceptual design meeting the above listed design features. Determine the expected performance through an extensive seeker level analysis/modeling effort. Identify technical risks and develop a risk mitigation plan.

PHASE II: Design, develop, and characterize a prototype multiband, large format IRFPA and demonstrate its functionality. Investigate private sector applications and commercialization of the multiband IRFPA.

PHASE III: Develop a manufacturing process for the multiband IRFPA and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for engineering integration and testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The contractor will pursue commercialization of the multiband IRFPA and associated component technologies in such diverse fields as medical diagnostics and imaging, environmental monitoring of pollutants, agriculture, and monitoring of manufacturing processes.

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

MDA06-017 TITLE: Advanced Space Power Technologies

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Space Platforms

ACQUISITION PROGRAM: SS(DFS) / GM(DFG) / AS(DV)

OBJECTIVE: Develop advanced space power technologies for MDA Kinetic Kill Vehicle (KKV) and satellite applications.

DESCRIPTION: A space based Electrical Power Subsystem (EPS) enables spacecraft operations by supplying electrical power to other spacecraft subsystems and the spacecraft payload through a combination of several functions that include energy conversion, storage, management, and distribution. In performance of these functions, the EPS typically consumes more than one third of the spacecraft mass budget. In addition, the components of the EPS often determine the expected lifetime of the spacecraft. The goal of this topic is to develop advanced space power technologies that improve overall EPS performance as measured by EPS system mass, volume, overall efficiency, and lifetime. Specifically, improvements are sought in technologies that perform the 3 EPS functions: energy storage, Power Management and Distribution (PMAD), and energy conversion. Power system technologies that perform these functions and are of interest are listed in order of priority below:

Batteries: The currently preferred space battery is Nickel-Hydrogen due to better performance than Nickel-Cadmium (specific energy density and lifetime), a large lifetime testing database, and significant on-orbit operational data. Battery technology development is sought on concepts that exhibit performance levels exceeding the current State-of-the-Art (SOA) in terms of specific energy density (W-hr/kg), volumetric energy density (W-hr/l), cycle life, and calendar life. Lithium-Ion battery technology has shown significant increases in energy density (volumetric and gravimetric) over currently used space batteries and is of interest. The operational lifetime for the batteries is expected to be 10 yrs in MEO.

PMAD: Development of PMAD system and component concepts that reduce mass, volume, and operate at high efficiency is desired. Increases in PMAD component efficiency have a ripple effect that can reduce the quantity of batteries and solar cells required by a space system while reducing thermal control issues. Strategies for reducing PMAD mass and increasing efficiency may involve increased frequency devices, higher bus voltage, distributed power electronics, and increased radiation hardening. Reliability of components should support a 10 yr mission.

Solar Cells: The current SOA space solar cells are approximately 28.5% efficient, are GaAs based, and consist of 3 junctions. Development of technologies that exhibit performance levels exceeding the current SOA in terms of AM0 efficiency (or W/m2), specific power (W/kg), and stowed volume (kW/m3) at reduced cost ($/W) are sought. Since these metrics are based on endof-life power, reduction of degradation caused by space environmental factors is also desired. Expected mission lifetime is 10 yrs in a MEO environment.

Proposals should seek to address one of the 3 EPS technologies listed above in relation to one of the two stated MDA applications (KKV or satellite) in sufficient detail to allow the evaluation team to ascertain the potential benefits and risks associated with their incorporation into DOD systems. Should the proposing firm desire to propose solutions to multiple EPS components and/or geared toward both MDA applications, a proposal for each application specific technology should be submitted. Proposing firms are strongly encouraged to work with MDA satellite and KKV payload and system contractors during each phase to understand the EPS requirements, to help ensure applicability of their efforts, and to begin work towards technology transition. Concepts proposed shall be applicable to either satellites and kill vehicles; concepts shall not prevent space-basing of kill vehicles.

PHASE I: Design and develop a representative prototype for the proposed EPS technology. The prototype will be tested to characterize performance and to assist in developing a Phase II design strategy. Prototypes should be functionally tested in operationally driven modes and in representative environments. The contractor will identify key technical challenges and establish a plan to address and overcome those challenges. The contractor will also develop a Phase II program plan, including (but not limited to) a development and integration strategy, potential flight demonstration opportunities, program schedule, and estimated costs.

PHASE II: Using the lessons learned from fabricating and testing the prototype in phase I, design and fabricate a prototype concept that can be integrated in an MDA system. The prototype will be tested in accordance with MDA/GM/AS/SS operational and environmental parameters. 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 payload contractors.

PHASE III: The technologies developed as a result of the Phase II contract(s) will be applicable to many other military and commercial applications that can benefit from the enhanced capabilities, as well as mass and cost savings associated with this technology. MDA/GM/AS/SS and other MDA programs could efficiently procure EPS components for their systems via the phase III.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial potential for increased performance space EPS components is very high. Commercial satellite providers are a significant fraction of the space market and are continually looking for ways to reduce system mass, decrease costs, and increase spacecraft reliability and lifetime. DOD industrial vendors for KKV systems will also benefit.

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KEYWORDS: Electrical Power, Space Power, Power Generation, Power Storage, Power Management & Distribution, Photovoltaics, Solar Cells, Space Based Battery

MDA06-018 TITLE: Highly Integrated/Symbiotic Structures

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

ACQUISITION PROGRAM: SS(DFS) / GM(DFG) / AS(DV)

OBJECTIVE: Develop structures, with embedded functionality, for MDA kill vehicle and satellite applications. The objective is to go beyond the standard connotation of a multi-functional structure, but to a true merging of structure and additional capability.

DESCRIPTION: The typical process of "strapping" sub-systems onto a structural backbone maybe insufficient for the requirements of several MDA satellite and kill vehicle systems. These systems require revolutionary improvements in mass, cost, and volumetric efficiency in order to better perform their missions. In order to meet these objectives, several MDA programs are earnestly looking to reap the benefits of a highly integrated/symbiotic structural approach. Such an approach will provide dramatic reductions in mass, complexity, and cost, while resulting in improved system level performance.

The goal of this topic is to develop high-performance structural systems that incorporate functions of interest to the MDA. All proposals must present a structural system capable of employment on a highly Gloaded system. Such a system must be extremely stiff in order to comply with the system-level requirements for high resonant frequency and stability during maneuvers. As such, preference will be given to those proposals that pursue developments that incorporate composites, or other high-performance structural materials. Additionally, maximum benefit may be gained by merging previously separate subsystems into load-bearing structures; a key example would be to make the propulsion system (i.e. the propellant tanks or lines) integral, conformal and/or load-bearing.

A major objective of this topic is to integrate, or embed, formerly disparate functions within the structure itself. The following is a set of functions or attributes of interest:

Radiation Shielding: This is a key requirement for both satellite and kill vehicle applications. Proposed radiation shielding approaches should address prompt radiation from a space-based nuclear blast, total ionizing dose, and Electro-Magnetic Interference (EMI). Solutions for prompt radiation should address the structure’s ability to reduce the fluence levels of x-rays and 14MeV neutrons. Total ionizing dose for the system is anticipated to be over 17,000 rad(Si) per year, for a 10-year mission life. EMI solutions should describe methods for connecting separate electrically conductive structural components in order to create something akin to a Faraday cage.

Communication on Structure: Antennas, transmitters, and receivers can be massive and bulky for potential kill vehicle applications. Additionally, not incorporating these components within the structure will act counter to the goal of a high resonant frequency. Proposals addressing this area should be relevant to current kill vehicle communication performance requirements, frequencies and protocols.

Structural Lens/Window for Optics: The goal of this sub-topic is to develop lenses and windows that do not require extensive strain relief. Areas of interest include lenses and windows for seeker heads and laser communication. Solutions for this area should address current limitations on the material system to include frequency range, image distortion as a function of strain level, and yield and ultimate stresses.

Structural Health Monitoring (SHM): SHM can be enabling for many missions; allowing for the real-time assessment of damage and system capability, as well as supplying situational awareness information to decision-making authorities. Such a capability will allow the DOD to rapidly determine if a system is capable of performing a specific mission, as well as ascertain information on anomalies in the surrounding environment. Many methodologies are of interest including those utilizing wave propagation, or strain or temperature mapping. Proposals addressing this area should include types and sizes of damage/anomalies discernable, power and mass requirements, and computations required to translate raw data into actionable information.

Thermal Management: The integration of the thermal management function into the structure of the kill vehicle or satellite has many system-level advantages, to include reductions in mass, cost, and complexity. Additionally, BMDS systems will reap benefits in terms of higher resonant frequency, quicker assembly time, and increased volumetric efficiency if thermal management is no longer a function that is “strapped” onto the system’s structure. Proposals addressing this attribute should describe the proposed method’s scalability and suitability to a range of orbital parameters, heat loads, and mission cycles in order to increase the chances for transition onto BMDS systems.

Embedded routing: This attribute covers a wide range of satellite and kill vehicle routing requirements, to include, but not limited to, electrical harnessing, DACS pressurization and fuel lines, and cryo-cooling lines. The goal of this attribute is to dramatically decrease system-level complexity by migrating satellite and kill vehicle wiring/plumbing into the structure itself. Proposals focusing on this aspect should address applicability to mass production techniques.

Proposals should NOT seek to address all the above capabilities. Proposals should seek to address one or two of the above capabilities in sufficient detail to allow the evaluation team to ascertain the potential benefits and risks associated with their incorporation into the structure and transition into DOD systems. Concepts proposed shall be applicable to both satellites and kill vehicles; concepts shall not prevent spacebasing of kill vehicles.

PHASE I: Design and develop an Engineering Development Unit (EDU) for the proposed structural concept. The EDU will be tested to characterize performance and to assist in developing a Phase II design strategy. Proposed concepts should be functionally tested in a satellite or kill vehicle-type environment that includes, but is not limited to vibration, thermal vacuum, stress, as well as characterizing the function proposed. Offerors are strongly encouraged to work with MDA system contractors to understand the system requirements, to help ensure applicability of their efforts, and to begin work towards technology transition. The contractor will identify key technical challenges and establish a plan to address and overcome those challenges. The contractor will also develop a Phase II program plan, including (but not limited to) a development and integration strategy, potential flight demonstration opportunities, program schedule, and estimated costs.

PHASE II: Utilizing the lessons learned from manufacturing and testing the EDU in phase I, design and fabricate a prototype structural concept to integrate on an satellite or kill vehicle. The prototype will be tested in accordance with MDA parameters. The contractor should keep in mind the goal of transition of this innovation for the Phase III effort, to which end they should have working relationships with, and support from, relevant BMDS system and payload contractors.

PHASE III: The technologies developed as a result of the Phase II contract(s) will be applicable to many other military and commercial applications that can benefit from the enhanced capabilities, as well as mass, complexity, and cost savings associated with this technology. MDA/GM and other MDA programs could efficiently procure tailored structural components for their systems via the phase III.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial potential for Highly Integrated/Symbiotic Structures is immense. Not only will the capabilities described above find wide appeal in the commercial sector, but the technology developed in this program will allow for the implantation of other functions within the structure. Vast market potential exists in the aviation, automobile, and infrastructure industries.

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KEYWORDS: Symbiotic Structures, Highly Integrated Structures, Multifunctional Structures, Kill vehicles, Satellites, Radiation Shielding, Communications, Optics, Health Monitoring, Composite Materials

MDA06-019 TITLE: High Sensitivity Coherent Optical Receiver/Detector

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: SS(DFS)

OBJECTIVE: Develop an advanced high capacity space qualifiable very high sensitivity coherent optical receiver/detector.

DESCRIPTION: MDA is investigating the potential application of laser communication. Total system size, weight, and power is strongly driven by the optical detector/receiver sensitivity. Improvements in sensitivity provide very large system weight savings. Currently fielded optical communications systems are primarily based on direct detection on-off-keyed (DD OOK) modulation formats. Optical coherent systems can provide a greater than 2X improvement in receiver sensitivity. Target performance goals include the following: 1. Primary data rate of 10 Gb/s per optical wavelength with an option for 40 Gb/s per wavelength; 2. Wavelength division multiplexing capability of >400 Gb/s; 3. Sensitivity of better than 40 photons/bit at a bit error rate of 10E-9 (without forward error correction); 4. Bit error rate of better than 10E-12 with forward error correction; and 5. Greater than 300 kRad radiation tolerance. Additionally, it is beneficial for the technology to support UAV, free space last mile, and terrestrial fiber applications. The primary target wavelength band is 1530-1610nm to leverage telecommunication technology. Wavelength bands in the 1.06um and 1.3um will be considered if significant performance benefits can be gained. Enhancements to physical layer security and link availability are a plus. Tolerance to unintentional and intentional jammers is a strong plus.

PHASE I: Establish design feasibility for a very high efficiency space qualifiable high sensitivity. coherent optical transmit/receive modem. Provide preliminary modeling of the module performance including receiver sensitivity characteristics, data rate capacity, jammer resistance, etc. Laboratory validation of key parameters is a plus.

PHASE II: Fabricate and demonstrate (to Air Force/Contractor agreed parameters) a prototype high sensitivity coherent optical transmit/receive modem.

DUAL USE COMMERCIALIZATION: Terrestrial communication systems at data rates above are moving to coherent modulation formats. The technology developed in this topic may be very applicable to terrestrial communication applications.

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KEYWORDS: lasercom, high sensitivity, coherent optical communication, free space optical communication

MDA06-020 TITLE: Improved Laser Diodes for Space Laser Communications

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: SS(DFS)

OBJECTIVE: Develop long-life, high reliability laser diodes to support Laser Communications in the space environment.

DESCRIPTION: The MDA is investigating the use of laser communications to support high speed, broadband communications for future satellite programs. A key concern is long-term reliability of laser diodes in the space environment. There are two primary areas of concern. The first is operation of the diodes in hard vacuum and the second is degradation/failure of the diodes due to long-term exposure to radiation. Anecdotal evidence indicates that current diodes may have a significantly shorter life expectancy in vacuum than when operated in atmosphere. There is also limited information on radiation testing of current state-of-the-art diodes. Potential missions will require the diodes to continue operating at > 70% of beginning of life performance when exposed to 300 Krad (Si) total dose for both proton and ionizing radiation. We are looking for an improved, physics-based understanding of the potential laser diode failure mechanisms associated with these two unique environmental challenges as a means to develop innovative new manufacturing processes to create long-life, high reliability laser diodes for use in space applications. The primary diode wavelength of interest is 806 + 2 nm. The near term goal is 100 watts per bar, in a ten bar array. The long term goal is 150 watts per bar in a ten bar array. The lifetime goal is 10,000 hours.

PHASE I: Identify and procure/fabricate a proposed diode(s) for the program baseline. Develop rigorous test methodologies and physics-based phenomenology modeling approaches to assess life expectancy and reliability of proposed laser diodes for space laser communication applications. Develop detailed test plans and designs for associated test fixturing for both radiation and vacuum testing of laser diodes. Conduct preliminary vacuum testing of laser diodes, investigate any observed failure mechanisms, and develop a physics-based rationale for the failure mechanisms along with modeling and simulation validated by the vacuum test results. Develop preliminary diode design or process improvement to an existing diode design to develop long-life, high reliability laser diodes for space applications. 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: Complete vacuum testing of baseline diodes if required and update models. Perform radiation testing on the baseline diodes using test plans/methodologies developed in Phase I. Evaluate diode performance versus radiation exposure. Develop a physics-based rationale for the failure/degradation mechanisms along with modeling and simulation validated by the radiation test results. Complete final diode design or process improvement to an existing diode design. Fabricate prototype diode and perform vacuum and radiation testing. Document results. 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: Modify/improve the design if the Phase II proof of concept prototype did not meet stated goals. Work with a commercial company or independently to develop and space qualify the laser diodes developed in Phases I & II.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Laser diodes are used in a variety of commercial and military applications to support communications and other applications.

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KEYWORDS: Laser Diodes, Space, Laser Communications, Long-life, High Reliability, Vacuum, Radiation Hardness

MDA06-021 TITLE: Miniature Advanced Divert and Attitude Control (DACS) System Technologies

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: SS(DFS) / GM(DFG) / MP(DEP)

OBJECTIVE: Develop low weight, small volume, high performance miniature DACS system and or critical components, including propellants, thrusters, and control valves, that could be incorporated into a miniature kill vehicle, or precision propulsion components and systems to enable microsatellites to maintain precise station-keeping and/or execute precision orbital transfer and rendezvous missions, steer the spacecraft and sensors, and make incremental orbital adjustments.

DESCRIPTION: This topic covers a broad range of miniature DACS propulsion system hardware, components and control devices. Miniature interceptors, such as an integrated version of them launched from a single booster that could intercept multiple objects in the exoatmosphere, or space based interceptors along with micro satellites have the potential to solve many difficult BMDS issues. Miniature interceptors weighing between 1Kg to 6Kg are desired. Developing a DACS system that can meet weight (0.5 mass fraction)), volume (2,000cm3 - 4,000cm3), cost ($20K-$60K) and performance for such interceptors requires new innovative technologies. Divert velocity performance of >500 m/sec, with high mass fraction capability and time constant of a few milliseconds is desired. At the same time the DACS system should produce low vibration, shock and jitter that would effect the seeker operation in a minimal way. Since the kill vehicles under consideration are small and require hit-to-kill guidance accuracy, the proposed DACS system should pay special attention to effects on seeker stabilization and propose approaches and technologies to mitigate these effects. Representative requirements include controllable thrusters from 1mN to 300 N and response time of 1 to 10 msec. Cost, manufacturability, safety and storability are all important considerations. Technologies of interest have been divided into two areas for purposes of this topic description: 1.) Propellants and Thruster devices, which include but are not limited to: phase change solid to gas or liquid to gas electrothemal thrusters; monolithic thrusters using liquid or gel propellants, colloidal thrusters, innovative bipropellant or monopropellant concepts; pulsed detonation rocket engines; solid propellant multi-pulse or breech concepts, toroidal propellant tanks, new type of warm gas attitude control system; and 2.) Low cost, low power, lightweight liquid and/or gas flow control devices including but not limited to: micro/MEMS propellant valves, high performance valves and pumped pressurization techniques, miniaturized valves and pressure regulators that do not require pneumatic actuation pilot circuits or welded interfaces for attachment and suitable for conventional and advanced earth storable oxidizers and fuels, and miniaturized MKV DACS valve components exposed to the hot gas environment. Substantial latitude is left to interested firms in proposing novel miniature DACS concepts and technologies that could be applied to meet these needs.

PHASE I: Identify proposed technology. Conduct analytical and experimental efforts to demonstrate proof-of-principle and establish basic performance criteria and areas for further refinement in Phase II. Offerors are strongly encouraged to work with relevant BMDS system and payload contractors to help ensure applicability of their efforts and beginning work towards technology transition.

PHASE II: Demonstrate feasibility and engineering scaling of proposed technology. Fabricate a prototype that demonstrates capabilities defined during Phase I and demonstrate the technology in a laboratory environment and finally with field tests. 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, relevant BMDS system and payload contractors.

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

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technologies developed under this SBIR topic would have applicability to micro vehicles, unmanned vehicles, small munitions, automobile industry etc.

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1. George P. Sutton, “Rocket Propulsion Elements; Introduction to the Engineering of Rockets” Seventh Edition, John Willey and Sons, 2001.

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KEYWORDS: interceptor, DACS, propulsion, rocket propellants, MEMS, manufacturing, control valves

MDA06-022 TITLE: Space Component Miniaturization/Lightweighting

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: SS(DFS) / AS(DV) / MP(DEP)

OBJECTIVE: Development of innovative miniature/small satellite or KKV components which provide enhanced system functionality and increase payload margins for BMDS missions.

DESCRIPTION: The mission objectives of the Ballistic Missile Defense System (BMDS) call for global defense against all phases of flight and all types of missile threats. BMDS satellites and KKV subsystems are being designed to satisfy an ever increasing demand for additional system performance while substantially increasing payload margin, and reducing overall power consumption. This solicitation will pursue novel and revolutionary system component technologies that are innovatively designed and packaged for volumetric efficiently to meet this operational need. Concepts should facilitate integration, be environmentally robust, provide enhanced performance, and be relatively low cost.

The Missile Defense Agency (MDA) is interested in the following set of development concepts, although other novel technologies that meet the overall objective of this solicitation will also be considered. Concepts proposed shall be applicable to both satellites and kill vehicles; concepts shall not prevent space-basing of kill vehicles.

Sensing: The development of advanced methods and principles for miniaturization of space sensor electronic components is desired to reduce power, weight and size of essential on-board space sensor functions. This research effort seeks to identify the relevance and applicability of new physics-based discoveries in areas of high-speed storage, quantum computing, entangled quantum states for communication and encryption, nanotechnologies for electronic and optical device structures and interconnects.

Precision Navigation: The development of a miniature spacecraft attitude determination sensor is desired that is approximately 1.5 kg, consumes less then 2 W and is volumetrically efficient. Overall, the system should be able to sense motions less then 5 arc-seconds at frequencies from DC to 100 Hz. The system can meet the above stated goals using a combination of celestial body sensors (star, sun, Earth), GPS or Inertial Measurement Unit (IMU) technology or can use an advanced single multi-sensor component. Envisioned operating environments would be LEO to GEO orbits.

Control Moment Gyros (CMG): The development of miniaturized attitude control devices is desired that significantly increase the agility of small satellites with respect to state-of-the-art components. In particular, miniature CMG actuators are desired that are no more than 2x the mass of similarly sized Reaction Wheel Assemblies (RWA's) yet provide at least 20x the output torque, with a maximum mass of 3 kg per actuator, a footprint of less than 200 mm2 and requiring no more than 12 W of peak power (less than 6 W average power). A system of miniature CMG's should be able to meet pointing accuracies of 0.02 degrees for an appropriately sized (small) satellite. These actuators may be enhanced with variable wheel speed capability to allow for RWA mode operation to meet pointing accuracy requirements and allow for singularity avoidance alternatives.

PHASE I: Design and develop an Engineering Development Unit (EDU) for the proposed concept. The EDU will be tested to characterize performance and to assist in developing a Phase II design strategy. Proposed concepts should be functionally tested or modeled in a satellite or KKV relevant environment that includes, but is not limited to, vibration, thermal vacuum, radiation, stress, g-loads, etc. Contractors are strongly encouraged to work with BMDS system and subsystem contractors to correctly understand the operational and integration requirements, and thereby initiate the effort to transition the technology. The contractor shall identify key technical challenges and establish a plan to address and overcome those challenges. The contractor will also develop a Phase II program plan, including (but not limited to) a development and integration strategy, potential flight demonstration opportunities, program schedule, and estimated costs.

PHASE II: Utilizing the lessons learned from manufacturing and testing the EDU in phase I, design and fabricate a prototype concept to integrate on a satellite or KKV. The prototype will be tested in accordance with BMDS parameters. 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 BMDS system and payload contractors.

PHASE III: The technologies developed as a result of the Phase II contract is applicable to several DoD applications that are pursuing reduction in mass and volume, with enhanced performance capabilities. MDA could efficiently procure tailored concepts for their systems via the Phase III.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial application of high performance efficiently packaged space components is immense within the industrial space community. Smaller and lighter devices translate to decreased launch costs and optimal use of launch vehicle fairing volume.

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KEYWORDS: space sensor, star tracker, precision navigation, control moment gyro, reaction wheel assembly, micro-satellite component

MDA06-023 TITLE: Small Scale Cryogenic Refrigeration Technology

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

ACQUISITION PROGRAM: SS(DFS) / MP(DEP) / AS(DV)

OBJECTIVE: Develop next generation cryogenic cooling technology to support small scale applications cooling between 10-100K.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryocooling needs will require revolutionary improvements in cryocooling technology. Many different techniques have been reported that have potential for marked improvement in cryogenic cooling technology. Examples include use of micro electromechanical systems (MEMS) technology or downscaling of current thermodynamic cooling cycles have potential for use in miniaturized expanders and as advanced heat exchangers that have applications in many cooling concepts including high temperature superconducting electronics, small array infrared sensors, or payload thermal management. Long life (> 5 years, 100% duty cycle) AC or DC flow compressors in the 1-10 W output power range are needed to enable the use of small cooling systems that utilize that compressor to cool multiple loads throughout any particular spacecraft. These key technology developments will enable future cryogenic cooling technologies and offer significant leaps in efficiency, performance, low temperature capability, and integration potential.

Proposals do not have to attempt the creation of entire refrigeration systems, but rather should concentrate on the design and eventual demonstration of critical components to such systems. The objective of the effort should be therefore to show how downscaling of current applications to the 10-50 mW cooling load range might be feasible in the objective temperature range, using either a single or multiply staged refrigeration design.

PHASE I: Phase I SBIR efforts should concentrate on the development of the fundamental concepts. 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 cryocooler or as a cryocooler. This effort should include plans to further develop and exploit this technology in Phase II. 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: 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 working prototype device to meet emerging operational specifications. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. 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: Typical MDA military space applications relate to infrared sensing, electronics cooling, and superconductivity. Potential Phase III opportunities to transfer this technology to emerging MDA programs include the Advanced Space Based Infrared System and block upgrades to the Space Tracking and Surveillance System.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The applications of this technology could potentially be far reaching with large market potential due to the increased reliability and expected reduction in cost for cryogenic coolers. 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: Micro Electrical Mechanical System, MEMS, Cryocooler, Cryogenic

MDA06-024 TITLE: Innovative Micro Satellite Targets

TECHNOLOGY AREAS: Electronics, Space Platforms

ACQUISITION PROGRAM: AS(DV)

OBJECTIVE: The objective of this topic is to solicit innovative concepts to develop micro-satellites with the capability to emulate ballistic missile target complexes or serve as a well-characterized calibration source.

DESCRIPTION: This solicitation seeks novel, advanced micro-satellite technology concepts for developing polymorphic ballistic missile target complexes that can provide on-orbit, daily testing and calibration opportunities for assets under development and in deployment in the Ballistic Missile Defense System (BMDS). The development of on-orbit, polymorphic micro-satellites capable of changing optical, radar, and kinematics characteristics will provide the capability to develop and test advanced detection and discrimination technologies and concepts in near-real-time spirals. Innovative concepts for providing the micro-satellite target complexes with precision ephemeris, attitude determination and control, maneuverability and orbit maintenance, renewable power and command and telemetry communications concepts are also of interest under this solicitation. These concepts are constrained by a total micro-satellite size of approximately 1m3 and must weigh less than 100 kg. Concepts must be amenable to operation in LEO orbits from 500-900 km with on-orbit operation for a minimum of one year with a goal of three years. The use of exotic and novel materials and technologies to enable these desired capabilities in small, low-cost microsatellites is encouraged. The use of innovative spacecraft components to provide significant cost reduction at the system level is encouraged. Respondents may offer individual micro-satellite components and payloads or propose a system-based solution that includes an entire spacecraft concept. All proposals should be compatible with low-cost micro-satellite design concepts because the use of current space technologies and methodologies for satellite design and construction would result in orbital target complexes prohibitively massive, power hungry and expensive.

PHASE I: The Phase I work should culminate in a complete design including the fabrication of any engineering hardware needed to validate the design concept. Phase I should also result in a clear technology development plan, schedule, budget, requirements documentation, and CONOPs for the development to flight hardware.

PHASE II: The Phase II work will ideally result in a flight worthy hardware system or subsystem that can be integrated and launched on a government acquired vehicle to demonstrate the viability of the concept. Systems, subsystems, or components predicted to cost in excess of the Phase II ceiling will be considered. In this event, companies should strive to develop critical components to flight hardware status. Environmental testing of the flight hardware should not be considered in the cost proposal but will be negotiated with the government during Phase I.

PHASE III: The offeror is expected to work with other industry partners and DoD offices for Operational Systems to market and deliver specific target satellites tailored to individual applications.

COMMERCIAL POTENTIAL: A successful development and demonstration of this technology will result in continued use by MDA. There is also strong demand in both the commercial and military markets for those innovative concepts that make up the micro-satellite bus with maneuverability and orbit maintenance, renewable power, command and telemetry communications capability. Traditionally, vendors who sell novel concepts and components in these markets must show potential customers flight heritage through successful flight opportunity. While it is difficult to predict the possible commercial applications for the technologies involved for giving the micro-satellite polymorphic features, some of these will be applicable to other commercial and military micro-satellite missions, especially if successfully demonstrated in a space environment.

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KEYWORDS: radar targets, calibration, micro-satellite

MDA06-025 TITLE: Manufacturing Technology Innovations for Advanced Electro-Optical Components/Systems for Missile Defense Applications

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: MP(DEP) / TH(DFT) / SS(DFS)

OBJECTIVE: Develop innovative manufacturing, packaging, and processing technology for developing robust and reliable electro-optical devices and systems for missile defense applications.

DESCRIPTION:
(1) Innovations are sought in materials processing that improve CdZnTe substrates and/or HgCdTe material quality and result in improved yield, reduced noise, and improved radiation tolerance and useful life in either or both nuclear and/or natural environments. Proposed technology should address the development of very long wave IR, integral 2-color LW/LW IR or visible/near IR FPAs.

(2) Innovations are sought in integrating optical components for laser communications. Emphasis should be on miniaturized components for interceptors. Of particular interest are laser transmitters and receivers for the 1.06 micron and 1.53 micron regimes.

(3) Innovations are sought in both materials processing and device engineering for mitigating or eliminating hydrocarbon contamination problems in diode laser bars operating in a vacuum. Problems of hydrocarbons or other out-gassing contaminants attacking the facets of diode laser bars can degrade the optical performance and shorten the life-time, especially in the vacuum environment. The MDA is seeking novel device design, fabrication and packaging techniques to solve this problem. Mitigating techniques of interest include, but are not limited to, the implementation of micro-shades around the diode laser facets to prevent hydrocarbons or other gas-phase contaminants from migrating to laser facets or from traversing the optical path of laser beam, and/or contaminant-free packaging materials/processing steps. Proposed technology should address high power (>30 watts continuous per bar) laser communication in a vacuum environment (<10-10 Torr), be stable with temperature shocks/variations, be thermally matched with the attached GaAs-based laser bar/array structure, and should not impede the diode laser performance.

(4) Innovations are sought in process improvement (specifically process setup and in situ control) for optical mirror coatings (both reflective and radiation tolerance) used in telescopes for missile interceptors and satellite systems. Optical coatings are essential to the performance of a high quality optical system, involving transmission, reflectivity, emissivity and/or radiation tolerance. Errors in optics coatings typically require significant re-work to the optic including removing the coating, re-polishing the optic, and correctly applying the optical coating, which leads to significant delays and costs.

(5) Innovations are sought in high performance and efficient stray light analysis and testing, specifically the synergy between testing hardware apparatus and data analysis, that can be used to test telescopes or optical benches for strap down or gimbaled systems for missile interceptor or satellite applications. The reduction of stray light and verification thereof is pivotal to lowering the design, manufacturing and assembly/integration costs of optical telescopes.

(6) Innovations are sought in non-destructive evaluation techniques that can be used to evaluate mirror coatings and substrate quality. The technique developed is to accurately and quantitatively detect, identify, and map the defects in surface and subsurface of SiC aspheric-mirror quality structures used for satellite and missile interceptor telescopes. Innovations sought include non-destructive (and noninvasive) test methods, hardware apparatus, data analysis

methods or software that can be easily implemented during the manufacturing of aspheric type SiC mirrors. In situ nitoring/evaluation techniques will be given higher priority since these techniques would minimize rework of the mirrors, thus reducing overall cost.

Proposals can be submitted to address either one or combinations of the above topic areas.

PHASE I: Develop conceptual technology for electro-optical component product design, manufacturing approach and test method that will improve performance, lower cost, or increase reliability of optical devices, components, and systems described above for BMDS applications. Offerors are encouraged to work with system (interceptor or satellite) and/or their respective payload contractors to help ensure applicability of proposed effort and to facilitate future technology transition.

PHASE II: Validate the feasibility of electro-optical product 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 sub-system. 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.

PRIVATE SECTOR COMMERCIAL POTENTIAL: 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.

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KEYWORDS: manufacturing, optical telescopes, process development/improvement, electro-optics, opto-electronics, HgCdTe, IR material, focal plan array, laser diode, laser transmitter/receiver, optical coating, stray light, optical metrology

MDA06-026 TITLE: Ballistic Missile Defense System Innovative Power Storage Devices

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

ACQUISITION PROGRAM: MP(DEP) / TH(DFT) / GM(DFG) / KI(DFK) / AS(DV)

OBJECTIVE: MDA is seeking to improve the quality, reliability and producibility of batteries and related power sources in ballistic missile defense systems through innovative ideas applied in creative ways to accommodate unique 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. 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: Many 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 improved processing techniques to lower power source production costs and improve performance (e.g. produce thin film electrodes), eliminated or modified processing steps that induce defects, and innovative CAM/CAD tools 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 enhance production yield, consistency, reliability, producibility and manufacturability are desirable necessities for overall mission success.

Primary Reserve Batteries for Missile Applications: Three 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. average specific power of greater than 3 kW/kg, specific energy greater than 200 Whr/kg at the battery level); and enhancing conformability to allow fitting batteries into unconventional shapes for efficient space utilization (e.g. shapes other than right cylindrical or rectangular solids). Other desired improvements include battery safety under normal and abnormal use conditions (e.g. fire exposure); reducing “touch labor;” improved subcomponents used in these batteries (e.g. high efficiency insulation materials for thermal batteries), reducing parts count and simplifying fabrication techniques to reduce cost; and complexity (e.g. easier to assemble battery subcomponents).

Aerospace-grade Secondary Lithium Batteries: Two main interest areas for rechargeable lithium batteries are improved manufacturing techniques and developing lower cost as well as optimal cell designs with resulting battery configurations that accommodate short duration space missions (less than one year). Other interest areas include beneficial variations to lithium rechargeable cells that enable them to achieve moderate to high charge and discharge rates with suitable voltage characteristics (e.g. 10C); increasing energy density (e.g. long-cycle life batteries formed from 25 amp hr and larger cells with a battery energy density of greater than 130 Whr/kg, and high energy battery configurations with a cell level energy density of >400 Whr/kg); enhanced charging efficiency (e.g. >90%); improved calendar life; increased cycle life at greater depths of discharge (e.g. over 20,000 cycles at >50% depth of discharge); improved charging and cell balancing methods; software models that allow cell and battery life-cycle (voltage decay, capacity fade, response to limited over charging, thermal exposure, etc.) simulation; and increasing cell safety (e.g. benign response to abusive conditions like over charging, over discharging).

Active Primary Batteries: Two main interest areas are innovations that reduce production costs of lithium carbon monofluoride cells and increase voltage levels under higher discharge rates, especially at low temperatures (e.g. <20°F).

Fuel Cells for Airships: The main interest area is closed-loop regenerative fuel cell systems. Innovations should be capable of variable power draw, require no maintenance for extended operations (e.g. >1 year), and be scalable to systems on the order of 1000 kWh energy storage. Goals include specific energy of over 700 Wh/kg, and round-trip energy efficiencies of >55%. Other interest areas include rechargeable hydrogen storage systems with a mass fraction (i.e., weight of stored hydrogen/weight of hydrogen plus tankage) of at least 25% in support of hydrogen-based Regenerative Fuel Cell (RFC) systems (system must be readily refillable multiple times while incorporated in an RFC system and incremental improvements to existing pressurized gas storage approaches will not be considered) and photoelectrolysis systems that directly convert water and sunlight into separated volumes of hydrogen and oxygen. These approaches must show a path to practical lightweight implementation in an airship. Proposals for significant improvements to existing technologies to meet the specific energy and/or round-trip efficiency requirements will also be considered.

Photovoltaic Cells & Other Sources for Airships: Interest area is innovation that enables long-endurance, powered stratospheric flight with advanced power technology that gathers energy from the environment (e.g. photovoltaic cells for flexible surfaces). Future high-altitude airships will require photovoltaic technology that has higher efficiencies and specific power levels (e.g. megawatt-scale arrays) than are presently available. For systems that use direct sunlight, such as photovoltaics, performance requirements are >16% efficiency in the Air Mass Zero (AM0, i.e. space) environment, and >1500 watts/kilogram specific power at the cell level. For specific power measurements, the mass of the cell includes the active components and substrate. Alternate approaches to extracting energy from the airship's environment are also of interest, including leveraging the blackbody radiation from the earth and/or leveraging temperature differences. For technologies that can continuously extract energy from the airship's environment, reducing or eliminating the need for nighttime energy storage (such as batteries), lower specific power may be acceptable (e.g. order of tens of watts per kilogram). Technologies which leverage available 4 -40 micron energy to enhance the performance of conventional visible-range photovoltaics are also of interest. Any technology proposed should be scalable to systems on the order of tens to hundreds of kilowatts and capable of operating independently without maintenance for at least one year at the airship's flight altitude of 65,000 feet. Fuel-based systems will not be considered. The technology should be capable of functioning even when the airship has zero net air speed, and should not impose significant drag or thermal loads on the airship.

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 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. The new power source technology should be implemented at a manufacturer and be ready for inclusion in MDA applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: 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 applications. Fuel cells represent the next generation of commercial and military power sources. Solar cells also have potential for wider commercial and military use. Finally, the manufacturing and producibility enhancements for MDA batteries could be applicable to commercial battery manufacturing lines.

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KEYWORDS: power density, energy density, conformability, battery, regenerative fuel cell, solar power, photovoltaic, photoelectrolysis, hydrogen storage

MDA06-027 TITLE: Manufacturing Processes for Propulsion Technology

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: MP(DEP) / AB(DFA) / AS(DV) / KI(DFK)

OBJECTIVE: The Manufacturing and Producibility (MP) Directorate of the Missile Defense Agency (MDA) is seeking manufacturing improvements for low-cost, high-performance materials and components. The requirements for reliable performance in both lower and upper boost phases, as well as end game, require innovative and mature manufacturing processes. Applications of interest include solid boost motors as well as solid divert and attitude control systems (DACS).

DESCRIPTION: MDA propulsion systems exhibit stringent performance requirements while simultaneously exposing materials to severe operating conditions. Existing nozzle materials, such as phenolic-based ablators, high temperature metals, and carbon-carbon composites exhibit unacceptable erosion. Most metals and ceramic matrix composites offer inadequate thermomechanical properties at temperatures above 3000°F. Existing insulation materials, such as ethylene propylene diene monomer (EPDM) rubber, exhibit excessive charring which produces particulates and gas species that contaminate the exhaust plume. Additionally, present high temperature actuator designs are complex and can be improved through the use of innovative technology and high specific stiffness housing configurations. There is also a need for improvements in actuator technology by using alternative actuation techniques.

High temperature ablation-resistant structural materials: Ablation-resistant materials such as ceramics, composites, and refractory metals for components such as liners, nozzles, and hot gas paths. DACS materials including SiC composites, rhenium alloys, and Zr- or Hf-based composites shall be subjected to pressures above 2000 psi and flame temperatures greater than 4500°F. Boost 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 minimumproperty is a tensile strength of over 50 ksi (345 MPa).

Structural insulative materials: DACS components are attached to missile structures and electronic components that cannot tolerate high temperatures. Structural insulators including Na-Zr-P type ceramics, low conductivity/high strength foams, and ZrO2-based composites are desired. Optimal structural insulaters will be dimensionally stable to high temperatures, will not pyrolyze, and will exhibit nominal 10 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 2000°F with a future temperature goal exceeding 4000°F.

Actuator technology: Low voltage (with a goal of achieving 28 volts), high power density, high performance actuators (0.125 inch stroke in <10 msec) for 5 to 2000 lbf applications. Actuation technologies that maintain response, stiffness, and precision performance characteristics at high temperatures (>500F functional capability). Consideration of compact, innovative, and reliable potentiometers, digital encoders, contact-less rotary position indicators, and position measurement devices is desired. Additionally, MDA desires actuation technologies with reduced part counts and designs that enhance reliability and simplicity of fabrication. Alternate actuation methods that reduce cost and weight while maintaining performance requirements and high specific stiffness high temperature materials for actuator housings.

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 increase performance, lower cost, or increase reliability of the selected component. The proposal should provide a quantifiable assessment of the feasibility and pay-off of the selected technology. Experimental data to support the Phase I feasibility is desired but not mandatory.

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. 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.

PRIVATE SECTOR COMMERCIAL POTENTIAL: 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.

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

MDA06-028 TITLE: Advanced Missile Materials and Process Technologies

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: MP(DEP) / TH(DFT) / GM(DFG) / AL(DFL) / KI(DFK)

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 of novel materials and processes. Provide materials solutions to reduce cost, lower life cycle cost, lower operational maintenance, reduce lead time, enhance reliability and improve manufacturability for low-rate, non-labor intensive production of (BMD) systems.

DESCRIPTION: MDA is seeking high-performance materials and process technologies for enhancement of current missile defense systems. These endo-atmospheric or exo-atmospheric intercept systems are highly complex systems that incorporate aerostructures, seekers, guidance and control, electronics, power, propulsion and communication. Novel materials and process technologies offer a significant potential for enhancing performance properties while improving producibility of these systems. 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.

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

Kill Vehicles: The development of components that optimize composite performance to achieve material properties approximating those of beryllium while maintaining or enhancing producibility, reliability, cost effectiveness, and volume/mass efficiency. In addition, such composites should provide improved heat dissipation (target > 1000 W/MK) and electromagnetic interference shielding for missile (Exo-atmospheric Kill Vehicle, Multiple Kill Vehicle, and Kinetic Energy Interceptor) electronics.

Aerostructures: Advanced missile defense interceptors require lightweight thermal protection systems (TPS) 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 preliminarily material suitability analysis. Weather resistance requirements include impact due to rain, ice, snow, and/or sand. Proposals are sought that develop lightweight integrated heat shield and airframe designs which enhance the current TPS designs and improve insulative performance of the TPS, lightning strike performance and rain erosion performance.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle and to improve producibility, increase performance, improve thermal protection, lower cost, or increase reliability. A well-defined Phase II development and demonstration plan must be generated. Concepts may involve research and development, modeling, material characterization, technology development, tooling, test and validation techniques, and process controls.

PHASE II: 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: The developed technology has direct insertion potential into the BMD system, subsystem or component. Demonstrate new open/modular, non-proprietary composite materials and/or structures technology. Demonstration should be in a real system or operation in a system level test-bed.

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

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

MDA06-029 TITLE: Cost Modeling Interoperability & Integration within the Model-Based Enterprise

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: MP(DEP)

OBJECTIVE: To develop methods and tools that support the integration and interoperability of cost models as part of a model-based enterprise, with applications and systems across all phases of the product life cycle, all enterprise functions, and all elements of the supply chain.

DESCRIPTION: Acquisition programs continue to face significant cost management challenges. Common denominators in cost escalation include the inability to estimate costs accurately up front, account for uncertainty and risk, and accurately predict the cost impacts of changes during system development. The inability to reuse cost models across life-cycle stages is a major barrier to managing costs in program execution. Accurate cost models that integrate and associate costs across the product life cycle and among different systems and applications, as well as functions that contribute to “total cost knowledge” about a product, are needed. However, this is a complex challenge. Management of a product through its life cycle involves many systems, including engineering design systems, enterprise resource planning/management (ERP/ERM), product data/life-cycle management (PDM/PLM), and manufacturing execution systems. It also includes diverse functions and organizations with varying business processes and tool sets.

Cost modeling and management systems vary between organizations, and current applications generally do not support transparent exchange of information with other vendors' systems. To enable an accurate and thorough cost analysis, cost models must be system/application-independent, integrate seamlessly across different enterprise functions and life-cycle phases, and support the collection of information in a variety of forms. Successful systems integration and interoperability enables an accurate projection of costs at any stage of the product life cycle, supports trade studies to assess the cost impacts of options and contemplated changes, and enables optimization to deliver the best total value to MDA as well as other DoD customers.

The benefits of developing robust model-based enterprise tools for the Missile Defense Agency (MDA) are tremendous. These tools, when implemented properly, can shorten the product development cycle so products can be fielded quickly and affordably. The model-based environment will allow for more trade studies to be conducted, thereby lowering risk and improving mission assurance. MDA will be able to continuously measure contract performance through a rollup of the prime contractor and supplier network. MDA will be able to map technology and manufacturing readiness levels (TRL & MRL) to the product lifecycle within the model-based enterprise.

PHASE I: Establish a generic framework for cost modeling of a complex weapon system across its life cycle. Develop interface definitions that enable capture and integration of the information needed to accurately model all elements of cost. Develop an approach to automatic integration of dependent model elements such as mechanical part models with related material models and associated manufacturing process models. Develop an automated approach to identifying and quantifying cost uncertainty factors, sensitivities, and risks. Analyze the use of the framework with existing and emerging product design and business systems.

PHASE II: Select a set of commonly used commercial cost management applications and develop a methodology to integrate cost information from these applications into the generic cost modeling framework. Develop and demonstrate prototype application software with the commercial cost management applications.

PHASE III: Define standards for cost model systems integration and interoperability and propose these standards to the appropriate Standards Developing Organization. Commercialize the generic cost modeling framework as a software package that can be either marketed as a discrete product or integrated into commercial enterprise-level financial management systems.

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e. [GAO-01-288] Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes.

KEYWORDS: acquisition, cost modeling, cost risk, financial management, interoperable models, life-cycle cost, model-based enterprise

MDA06-030 TITLE: Electronics Packaging and Thermal Management

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: MP(DEP) / SN(DFN) / TH(DFT) / KI(DFK) / AS(DV) / AB(DFA)

OBJECTIVE: Develop innovative concepts for electronics packaging that utilize advanced packaging techniques currently available in the commercial electronics marketplace for miniaturizing electronics (e.g. cell phones), and selectively in the defense electronics marketplace, but which address specific needs for the BMDS. These special needs may include: high radiation environments; high environmental stresses (high-g forces in launch, interceptor maneuvers); low volume and weight density requirements for miniaturized parts; higher heat loads due to use of new wideband gap amplifiers and large digital arrays and circuits; and in certain cases extreme temperatures of operation that may exceed what is required or available in the commercial marketplace. Since the commercial marketplace drives the electronics manufacturing and packaging industrial base, innovative concepts are needed to assure that MDA and its contractors have access to technologies that may be needed to meet special BMDS systems needs.

DESCRIPTION: As electronics become more miniaturized, the removal of heat often becomes the limiting factor and a barrier to further performance enhancements. The mean number of I/O interconnects per chip is projected to be greater than 5,000 by the end of the decade, and feature size will decrease to less than 0.1 micormeters.

This is the case, for example, in radar transmit-receive modules, which are adopting higher power amplifiers that utilize Wide Bandgap (WBG) materials like SiC, GaN, and high voltage GaAs. Junction Temperatures need to be maintained in the range of 150-175°C In these cases, these amplifiers perform at higher temperatures than conventional silicon electronics and, even though they are more efficient (40%PAE), they operate nonetheless at 3-5x the peak power of more conventional electronics and therefore require much higher levels of heat removal.

The thermal management problem is addressed at different levels of the thermal path. At the transistor or device level,, features like the Field Effect Transistors (FETs) in a high power amplifier, are generating 10s of watts of power in a few square millimeters of area, with heat traveling through the die itself to the base which may be attached by solder or epoxy to a PCB board, co-fired ceramic or some other medium, or even flexible multi-layer membranes. Often a heat spreader is required at this interface to facilitate heat removal, with the die attached to the base with epoxy or solder. This interface is one of the primary thermal resistance barriers. In order to minimize the thermal resistance, high thermal conductivity materials are required, but equally important is the ability to match the CTE(Coefficient of Thermal Expansion) of the base of the die to the heat spreader.

The CTE of electronic device materials of interest to MDA vary widely in terms of ppm/°C: SiC = 2.7; Silicon = 4.2; GaAs = 6.5. The traditional heat sink materials like copper and aluminum which have good thermal conductivity (398 W/mK and 238 W/mK) but are poorly match in terms of CTE (Cu=17.8 and Al =23.6). Various alloys are used to reduce the mismatch, for example, CuW with a CTE of 6.5 and CuMo with a CTE of 7.5. Even though CuW and CuMo are better matched, their thermal conductivity is low (170 180 W/mK.

There are a number of innovative materials containing various forms of graphite like TPG (thermal pyrolytic graphite) with very high conductivity (>1000 W/mK). These materials can be formed into metallic and polymeric composites to better match themal conductivity with CTE. Various forms of diamond in the form of thin films or diamond powders in other matrices are also being used to increase the thermal conductivity of the material. Finally, micro-heat pipes embedded in the base materials are being investigated to significantly increase thermal conductivity to well above 1000 W/mK.

To extract heat from the heat spreader, various passive and active concepts (one and two phase systems) are being studied to dramatically increase the ability to transport the waste heat in terms of thermal fluxes that are typically in the range of a few 10s of watts/cm2 to more advanced systems that are able to remove heat on the order of 500-1000 W/cm2.

High density interconnect technology experienced rapid growth in recent years with the development of very high-speed wire bonding machines; the use of layered interposer boards, ball grid arrays and micro ball grid arrays; and flip chip and other surface mount techniques. Each technique has specific thermal management issues that must be addressed on a case-by-case basis depending of the nature of the packaging concept. In extreme cases of miniaturization, chips are stacked on top of one another, which add complexity to the heat removal issue but may offer opportunities for radiation hardening, since the volume and weight of shielding required is significantly reduced. PCB board coatings now being developed to increase hermeticity could also be tailored to increase radiation resistance.

PHASE I: Contractors shall analyze, design and develop candidate electronic packaging architectures that combine state-of-the-art electronics packaging techniques, available in the commercial marketplace or specialized techniques being developed within the defense industry, to facilitate high-density packing and interconnection of digital and analog devices, including MMICs. The proposed schemes should optimize a mix of techniques to facilitate thermal management to assure the devices operate within acceptable limits, and allow employment of shielding techniques if required to increase radiation hardness.

PHASE II: The contractor shall identify and select a specific board or other electronics assembly, in cooperation with an MDA prime contractor or major subcontractor building hardware for the BMDS, to demonstrate the integration of packaging techniques that can significantly reduce the electronics assembly footprint while at the same time managing thermal and radiation tolerance issues. The assembly will be prototyped, produced, and tested in Phase II.

PHASE III: The Offeror shall work with MDA industrial partners to transfer the prototype assembly to full-scale production, with potential integration into one or more BMDS systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: There are niche areas in the commercial marketplace where high-density, high-reliability electronics packaging is required, some even requiring radiation protection that could benefit from this activity. Since the requirements for high-density packaging are pervasive for smart munitions, as well as MDA interceptors, the proposed activity could have an impact well beyond MDA.

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KEYWORDS: High Density Interconnects, Electronics Packaging, Multi-layer PCB, Co-Fired Ceramics Boards, Wire Bonding, Ball Grid Array, Surface Mount Technology, Advanced Thermal Management, Radiation Hardening

MDA06-031 TITLE: Advanced Signal Processing Technologies for BMDS Radars

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Sensors, Electronics

ACQUISITION PROGRAM: AS(DV) / TE(DT) / AB(DFA) / GM(DFG) / MP(DFP)

OBJECTIVE: The MDA is seeking novel, innovative, and manufacturable high performance signal processing components, algorithms, software, and sub-systems supporting advanced radar systems.

DESCRIPTION: The requirements of ballistic missile defense drive radar system design in terms of sensitivity, bandwidth, polarization and time occupancy. Future systems are expected to achieve significantly greater flexibility and capabilities in part through increasing levels of digitization. Future systems are expected to support high time-bandwidth product pulse compression waveforms. In combination, these techniques exceed the capabilities of existing processors. Technologies and concepts are desired which support the high-throughput, lowpower signal processing in a cost-effective implementation. The concepts must have well defined open interfaces that readily support scaling and upgrades. Digital hardware, software, and photonic-based technologies are of equal interest. The threats envisioned for the near- and farterm are a challenging mixture of countermeasures that will require novel approaches to the discrimination problem. This topic is focused on technologies to defeat evolving threats (to include advanced Electronic Counter Measures (ECM), while operating in a nuclear environment, by developing technologies that support improved performance capability, supportability, reliability, availability, and system survivability. Methods for mitigating in-band Electro-Magnetic Inference including detection and pulse repair that reduce the impact on range and Doppler sidelobe levels are desired. The focus on the advanced signal processing topic is postbeamformer up to, but not including, discrimination.

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

Advanced Signal Processor hardware technologies. The hardware needs to support wide instantaneous bandwidth waveforms with any pulse coding, e.g., pseudorandom noise (PRN), polyphase, chaotic, non-linear FM, etc. for all-range processing. The functions of the processor will include pulse compression, EMI detection and mitigation, numerous range walks that include accelerating hypotheses, countering advanced ECM, Doppler processing, CFAR detection and feature extraction. The goal of this focus is a 50% improvement in radar processing throughput and a 50% reduction in life-cycle costs for the Radar backend electronics. Candidates for this hardware include, but are not limited to quantum processing, optical processing, FPGAs, and consumer-off-the-shelf boards.

Advanced Signal Processing algorithms. Algorithms are desired that improve the performance of the signal processor and are robust in severe EMI and ECM environments. The goals of these algorithms should be very low sidelobe levels while maintaining high resolution, detection of boosting/accelerating missiles, minimal losses through optimal processing, and minimal performance degradation in a severe in-band EMI and ECM environments. Advanced algorithms may include time-frequency and STAP algorithms as applied to above signal processing functions and feature extraction.

UHF Ionosphere Scintillation Mitigation Algorithms. Based on the collected radar data corrupted by the ionosphere scintillations, develop practical techniques and algorithms to mitigate the scintillation-induced adverse effects. Use advanced signal processing techniques to retrieve the uncorrupted backscattered radar signal or remove the scintillation/multi-path undesirable components either in the time or frequency domain. In addition, develop algorithms to generate simulated realistic scintillation data for performance testing of deployed EWR/UEWR detection, tracking and object classification algorithms. Demonstrate the effectiveness of the developed techniques and algorithms by processing and/or simulating the scintillated radar data under various ionosphere scintillation levels.

PHASE I: Develop and demonstrate the feasibility of the proposed technology or sub-system that address the specific needs identified in this topic. Demonstrations can be through hardware or models and simulations.

PHASE II: Refine architecture or technology developed in Phase I. Evaluate/demonstrate the Phase I technologies in a laboratory environment to show the enhanced capabilities resulting from the utilization of these unique technologies.

PHASE III: Demonstrate the new radar product(s) via operation as part of a complete system or operation in a system-level test bed. This demonstration should show near-term application to one or more MDA element systems, subsystems, or components. Partnership with traditional DoD prime contractors will be pursued since the Government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial application of high throughput signal processing components and systems will support medical imaging, oil exploration, and communications systems.

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KEYWORDS: STAP, Time-Frequency, spatio-temporal coding, phased array, open systems, signal processing, adaptive processing, FPGA, optical processing, EMI, countermeasures, radar, algorithms, scintillation

MDA06-032 TITLE: <u>Development of Digital Receiver/Exciters for Missile Defense Radars</u>

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: AS(DV) / AB(DFA)

OBJECTIVE: Identify, develop, and demonstrate advances in digital receiver/exciter technologies enabling advanced countermeasure mitigation capabilities.

DESCRIPTION: Anticipated threats to missile defense radars are a challenging mixture of countermeasures and simulation. Future systems are expected to incorporate multichannel adaptive digital beamforming to counter the active threats and therefore require affordable, high performance digital receivers and digital exciters. This phased array radar technology research effort is focused on developing low-cost, low-power, compact digital receiver/exciter technologies. Key areas of research include highly integrated monolithic microwave integrated circuits (MMICs), compact filters, low cost substrates, signal generation, and combined analog/digital design. These technologies should move the digital interface closer to aperture, thereby eliminating costly, bulky and sensitive analog electronics. They should use open architecture technologies to enable plug-and-play of building blocks to realize different receiver configurations and support for diverse RF applications. Finally, they should be capable of multiple waveform generation and processing capabilities beyond traditional LFM/stretch waveforms.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of digital receiver/exciter technologies that are scalable to desired missile defense radar system requirements.

PHASE II: Develop and demonstrate prototype digital receiver/exciter technologies that support missile defense requirements. Conduct hardware and/or software tests to evaluate the performance of the technology in a realistic environment.

PHASE III: Integrate digital receiver technologies into missile defense systems and demonstrate enhanced performance in realistic environments.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Telephony, networking, etc.

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KEYWORDS: GaAs, SiGe, MMIC, ADC, channel match, cancellation, digital beamforming, adaptive

MDA06-033 TITLE: Adaptive Digital Beamforming for Missile Defense Radars

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: AS(DV) / AB(DFA)

OBJECTIVE: The Missile Defense Agency (MDA) is seeking novel, innovative, cost effective concepts in adaptive digital beam-forming for application to ballistic missile defense radars.

DESCRIPTION: Develop software and/or hardware adaptive digital beamforming capabilities that fit within current missile defense radars or for advanced radar systems. Develop adaptive digital beamforming techniques to support wide bandwidth, arbitrary waveform capabilities, high time-bandwidth product pulse compression waveforms and space-time adaptive processing (STAP). Use simulation and analysis to assess performance of waveforms and beamforming techniques. Address beamforming technique effects on digital receiver and exciter technologies with respect to bandwidth, dynamic range, power consumption, and cost. Concepts must have well defined open interfaces that readily support scaling and upgrades.

PHASE I: Develop and determine feasibility of the proposed technology concepts that address the specific needs identified in this topic. Demonstrations can be through hardware or models and simulations.

PHASE II: Refine concept(s) developed in Phase I. Evaluate/demonstrate the Phase I concepts in a laboratory environment to show the enhanced capabilities resulting from the utilization of these concepts. Build and test prototypes (hardware and/or software) in a realistic test environment.

PHASE III: Integrate technology into a BMDS system or system-level test bed and demonstrate the total capability of the improved performance. This demonstration should show near-term application to one or more MDA element systems, subsystems or components. Partnership with traditional DOD prime-contractors will be pursued since the Government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Adaptive digital beamforming techniques can reduce sidelobes, improve discrimination, and increase functionality. The novel adaptive digital beam-forming concepts developed under this effort will potentially be useful in other military radar systems such as instrumentation radars as well as non-military applications such as air traffic control and weather radars.

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1. Chung-Yao Chang; Shiunn-Jang Chern, "Adaptively linearly constrained inverse QRD-RLS beamformer for multiple jammers suppression", Wireless Communications, 2001 (SPAWC '01). 2001 IEEE Third Workshop on Signal Processing Advances, 2001, pp.294-297.

2. R.G. Seed, A.S. Fletcher, and F.C. Robey, "STRAAP: space-time-radiating array adaptive processing," Phased Array Systems and Technology, 2003. IEEE International Symposium, 14-17 Oct 2003, pp. 136-141.

3. M. Skolnik, "Radar Handbook". McGraw-Hill, 1990.

4. Tsui, "Digital Techniques for Wideband Receivers", Artech House, 1002.

5. P. Pace, "Advanced Techniques for Digital Techniques", Artech House, 2000.

KEYWORDS: adaptive digital beam-forming, STAP, adaptive processing, beam-forming, multi-path, mainlobe cancellation, waveforms, signal processing

MDA06-034 TITLE: Innovative Technologies for Anti-Jam and Electromagnetic Attack Rejection in Ballistic Missile

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: GM(DFG) / TE(DT) / AB(DFA)

OBJECTIVE: Identify, develop, and demonstrate novel or innovative advances in anti-jamming and electromagnetic attack protection technologies that will support existing BMDS X-band, S-band, and other radar systems. The focus of this research is to provide increased protection and/or mitigation of the radar from jamming, high power microwave (HPM), ultra wide band (UWB), and electromagnetic pulse (EMP) attacks.

DESCRIPTION: The BMDS radar threats envisioned for the near- and far-term are a challenging mixture of electromagnetic threats that include jamming, high power microwave attack, ultra wide band and electromagnetic pulse attack among other countermeasures. These threats will require novel and innovative approaches to increase current abilities to counter these measures in the radar and developing more effective radar protection devices. This technology research effort is focused on developing and demonstrating technologies to defeat evolving advanced Electronic Counter Measures (ECM) and high-power, fast-rise-time HPM, UWB, or EMP attack through the radar front end by developing new technologies that provide improved protection for existing BMDS radars (SBX, FBX-T, THAAD, and AEGIS). Key areas of research include novel or innovative techniques in advanced signal processing, adaptive beam control, pulse limiters, advanced noise filtering devices, as well as other devices for increasing signal-to-jamming or signal-to-clutter ratios. Of particular interest are passive devices capable of increasing the signal-to-noise ration and/or providing the required ECM/HPM/EMP protection.

PHASE I: Develop and demonstrate the feasibility of the proposed technologies for anti-jam and/or HMP/EMP protection. Demonstrations can be through hardware or models and simulations.

PHASE II: Refine/update concept(s) based on Phase I results. Evaluate/demonstrate the technology in a realistic laboratory environment to show the enhanced protection capability provided by the technology.

PHASE III: Demonstrate the new technologies via operation as part of a complete system or operation in a system-level test bed. This demonstration should show near-term application to one or more BMDS radar systems. Partnership with traditional DoD prime contractors will be pursued since the Government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology is applicable to commercial air traffic control radar and commercial communications systems for anti-jam and EMI protection as well as protection of commercial equipment from EMP/HPM by terrorists groups. There also are numerous military applications outside of missile defense.

REFERENCES:
1. “Information Warfare Technology,” http://www.jya.com/mcsec09.pdf

2. Eileen M. Walling, “High Power Microwaves: Strategic and Operational Implications for Warfare,” Occasional Paper No. 11, February 2000, Center for Strategy and Technology, Air War, College, Air University, Maxwell Air Force Base, Alabama, http://www.globalsecurity.org/military/library/report/2000/occppr11.htm

3. John S. Foster, Jr., et al., “Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack,” Volume I: Executive Report, 2004, http//www.globalsecurity.org/wmd/library/congress/2004_r/04-07-22emp.pdf

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5. Chung-Yao Chang; Shiunn-Jang Chern, “Adaptive linearly constrained inverse QRD-RLS beamformer for multiple jammers suppression”, Wireless Communications, 2001. (SPAWC '01). 2001 IEEE Third Workshop on Signal Processing Advances, 2001, pp. 294 –297

6. A. Kikel, L. Altgilbers, I. Merritt, M. Brown, L. Ray, and T. Zhang, “Plasma Limiters,” AIAA Paper, AIAA-98-2564, 1998

7. Todd B. Hale, “Airborne Radar Interference Suppression Using Adaptive Three-Dimensional Techniques,” Storming Media, Report A755204, 2002

8. Gaoming Huang and Luxi Yang, “A Radar Anti-Jamming Technology Based On Blind Source Separtation,” 2004 Proceeding ICSP’04 Signal Processing, 2004

KEYWORDS: Anti-Jam, Electromagnetic Interference, Electromagnetic Pulse, High Power Microwave, Radar, X-Band, Electronic Countermeasures, Ballistic Missile Defense

MDA06-035 TITLE: Solid State Amplifiers and Transmit/Receive Modules for Ground-Based Missile Defense System Radars

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: GM(DFG) / MP(DFP)

OBJECTIVE: Develop innovative state of the art solid-state amplifiers and transmit/receive modules for form-fit functional replacement of high power traveling wave tubes and current modules to achieve higher power, better reliability, higher efficiency, and greater countermeasure resistance. Develop modules for:
• UHF radar transmit/receive function
• L-Band radar power amplifiers
• X-Band radar power amplifier and transmit/receive applications

DESCRIPTION: Develop form-fit function replacement modules that fit within or reduce current cooling load for existing ground-based missile defense radars. Develop capability to digitize radar returns at the module level for future all-digital radar.
• Develop solid state transmit/receive modules to replace current modules as they fail.
Develop simulation/analysis to assess performance of mixed-module (old and new) array.

Develop module with both analog and digital output (A/D conversion within the module so that when array is substantially filled with digital modules, the array can be re-wired for digit al operation.
• Develop amplifiers for form-fit-function replacement of High Power Traveling Wave Tubes in L-band radars like Cobra Dane. Achieve higher power, better reliability, higher efficiency, and achieve cost savings related to refurbishing current TWTS when they fail.
• Develop wide bandgap (e.g., GaN) semiconductor devices for efficient, reliable, high power electrical generation, control, conversion, and distribution systems for ballistic missile defense X-band radar applications. This includes: 1) developing high purity, semi-insulating silicon carbide (SiC), 4H and 6H polytype, and GaN bulk substrates (Focus is on 4 inch diameter wafer size with minimal defects and impurities, high resistivity, wafer flatness, minimum total thickness variation across the wafer, maximum usable surface area, and maximum boule length per run); 2) developing wafer slicing and surface preparation/polishing techniques that are quick, efficient, low cost, and minimize subsurface damage; 3) developing quick, superior quality epitaxy techniques for GaN on homo- and heterogeneous substrates; and 4) developing discrete and MMIC-like devices on these wafers for X-band applications.

PHASE I: Refine proposed technology approach, determine feasibility, develop preliminary design. Simulate operational characteristics.

PHASE II: Build and test prototype modules in a realist test environment.

PHASE III: Integrate technology into a BMDS system and demonstrate the total capability of the improved performance. Partnership with traditional DOD prime-contractors will be pursued since the Government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The novel solid-state transmit/receive and amplifier modules developed under this effort will potentially be useful in other military radar systems as well as non-military applications such as air traffic control and weather radars. The concept may be applicable to higher frequency radars.

REFERENCES:
1. Kazemi, Hooman, Jonathon B. Hacker, H. Xin, Mike Grace, Bill Norvell, Kevin Higgins, and Michael Gilbert, "An Ultra-Low Power Integrated T/R Module for Space-Based Radar Technology," IEEE National Radar Conference - Proceedings, Apr 26-29, 2004, Philadelphia, PA, p. 6-8.

2. Mancuso, Y., "Technological Trends for T/R Modules," European Microwave Week, including GAAS98, 28th European Microwave Conference and MTT-S European Wireless 98, Oct 5-6, 1998, Amsterdam, Netherlands, p. 73-78.

3. Trew, R.J., “Wide bandgap transistor amplifiers for improved performance microwave power and radar applications,” 15th International Conference on Microwaves, Radar and Wireless Communications, 17-19 May 2004, Volume 1, pp. 18-23.

4. Trew, R.J., “SiC and GaN transistors – is there one winner for microwave power applications?” Proceedings of the IEEE, June 2002, Volume 90, Issue 6, pp. 1032-1047.

KEYWORDS: circuit design, transmit/receive modules, power amplifiers, Cobra Dane, L-Band radar, UEWR, UHF radar

MDA06-036 TITLE: <u>Thermal Initiated Venting Systems (TIVS)</u>

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: TH(DFT) / QS

OBJECTIVE: The objective of this research and development effort is to reduce the danger of a large diameter (12 inches or greater) solid rocket motor (SRM) from exploding or even fully igniting during a fire by developing an improved thermal venting systems and sensors.

DESCRIPTION: Solid rocket motors are used in many military weapon systems, to include THAAD, PAC-3, SM and many others. A key operational phenomena of solid rocket motors is that their propellant is highly sensitive to chamber pressure to initiate or maintain combustion. Most of these solid rocket motors can be effectively "extinguished" if the chamber pressure is allowed to fall to atmospheric pressure through a "venting" of the motor casing. In fact, many solid rocket motors have incorporated an explosively generated vent as a means of thrust termination. This technology should be examined so as to provide a means of preventing a solid rocket motor grain from igniting in the first place when subjected to a fire or other source of inadvertent extreme temperature. This would involve a temperature sensing device of high reliability and an active mechanical means to vent the motor casing without excessive violence or heat. The sensor should be easy to integrate into the SRM systems. Much work can be done in the area of how the sensor would be powered and how the venting mechanism can be made to as to minimize the incorporation of additional energetics or unstable chemicals. The venting mechanism should also contain away to de activate it during for launch.

PHASE I: Conduct experimental efforts to demonstrate proof-of-principle of the proposed technology to prevent grain ignition. (This can be simulated with pressure vessels.) Demonstrate the initial feasibility of a TIVS system.

PHASE II: Demonstrate feasibility preferably on an analog or sub-scale motor and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: The cost avoidance realized by the Ballistic Missile Defense System and the services by employing this technology would be significant. Hence, the anticipated Phase III program customers would include a wide range of current interceptor programs. During Phase III the effort calls for engineering and development, test and evaluation, and hardware qualification.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would be anticipated to have a high level of interest with commercial launch rocket propellants, etc.

REFERENCES:

1. "Insensitive Munitions Technology for Tactical Rocket Motors" by Andrew Victor 1994

2. "Department of Defense Acquisition Manager's Handbook for Insensitive Munitions" Rev 01, January 2004

3. NATO Insensitive Munitions Information Center (http://www.nato.int/related/nimic)

4. "US DOD IM Program" by Anthony J. Melita (http://ww.dtic.mil/ndia/2003gun/mel.pdf)

5. "Hazard Assessment Tests for Non-nuclear Ordnance", Military Standard, Mil-Std-2105B, 1994

6. "US Navy Insensitive Munitions Requirements," Navel Sea Systems Command, NAVSEAINST 8010.5B, 5 Dec 1989

KEYWORDS: Thrust termination, Venting, Insensitive munitions, Sensors

MDA06-037 TITLE: <u>MIL-STD-1901A Compliant In-Line Electrical Initiation Systems for Propulsion Applications</u>

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: AB(DFA) / QS / MP(DEP)

OBJECTIVE: The objective of this research and development effort is to develop in-line electrical initiation systems for propulsion applications that are fully compliant to all provisions of MIL-STD-1901A and MIL-DTL-23659.

DESCRIPTION: MIL-STD-1901A currently requires that propulsion Ignition Systems utilize energy train and pyrotechnic train interruption devices whose reliability is demonstrated through approved statistical and experimental approaches, unless the following provisions are met:
• The initiator device can only be initiated with an electrical stimulus of greater than 500 V
• The energetic material contained in the device is equal or less sensitive than Boron Potassium Nitrate (BKNO3).

In a number of MDA controllable propulsion applications, it is not feasible to utilize traditional energy and pyrotechnic train interruption devices (usually known as “out-of-line devices”). These applications include Divert and Attitude Control System (DACS), axial stage Attitude Control System (ACS) and multiple pulse solid rocket propulsion systems. Usually in these applications, multiple ignition events are required on-demand, and it is difficult to package traditional compliant “out-of-line” Arm-Fire Devices (AFD’s) capable of supporting multiple ignition events. There is significant pressure from DoD safety boards to field fully compliant initiation systems for emerging and future MDA propulsion systems. Focused investment on enabling technology is critically needed to accelerate development and insertion of viable 1901A compliant initiation systems into spirally evolving and new-start MDA propulsion systems.

To address this issue, the Missile Defense Agency has invested resources in high voltage initiation system approaches that use DoD-approved pyrotechnics. These systems show great promise and have achieved successes in ground testing. However, these systems still have some problems that thwart their transition to actual applications, including the following:
• Tend to have high and statistically variable breakdown voltages.
• Generally, are not compliant to MIL-DTL-23659 Electrical Cook-off requirements, particularly when installed in igniters.
• Tend to have high inductances, particularly when integrated into systems where high voltage fireset components used to trigger the device are removed from initiator components.
• Have potential to induce Electromagnetic Interference (EMI) into adjacent electronics, when the high voltage fireset is discharged.
• Require excellent design and process control to avoid electrical arcing and Coronal Discharge effects, when fired under vacuum conditions where many MDA propulsion systems operate.

This topic requests proposals that pertain to the development of fully 1901A compliant in-line initiation systems, which address the above issues. Desired characteristics include:
• Approach must be fully MIL-STD-1901A compliant without the use of safety augmentation devices, including full compliance to testing and requirements outlined in MIL-DTL-23659. This includes compliance to the Electrical Cook-off Test specified in A.4.10 of MIL-DTL-23659D, with the exception that the selected device must not undergo deformation, rupture or venting that could initiate the next in-line energetic component.
• Approach must be applicable to initiators of multiple sizes and interfaces. A notional minimum size is an initiator of 0.20” diameter x 0.20” long.
• Device must be capable of reliably initiating output charges of different sizes. Example current needs include an output of 100 psi in a 5 cc chamber (small initiator) to 500 psi in a 20 cc chamber (larger initiator).
• For most applications, initiators are inserted through a propulsion system bulkhead and must be able to sustain over 3000 psi operating pressure on the output side for over 2 minutes without leaking. Rocket motor chamber temperature varies between 3500 deg F and >6000 deg F, depending upon application.
• Approach should include or be compatible with an electrical fireset capable of converting standard missile 28 V power to high voltage and discharging it with output characteristics required to reliably function the selected initiator. The ability to closely couple the fireset and initiator is desired. The ability to integrate environmental “Safing” and “Arming” features into the fireset is desired.
• Selected electrical fireset and initiation system approaches should be capable of reliably operating in a vacuum environment of 1.4 Torr or less, without generating arcs or discharges.
• Ignition systems that can demonstrate breakdown capability with high statistical reliability and without selective pre-screening of components are preferred. Initiation systems must provide a high degree of protection against function at >500 V. However, all-fire function at <1500 V is preferred.
• In-line Electrical Initiation Systems with a >50% cost reduction over traditional out-of-line AFD’s is preferred.

PHASE I: Conduct studies and component demonstrations necessary to demonstrate that selected concept can meet full requirements of MIL-STD-1901A and the guidelines outlined above.

PHASE II: Demonstrate the feasibility and engineering scale-up of a fully compliant Ignition System. Demonstrations shall include firing components and prototype ignition systems under representative operating conditions (e.g., vacuum) and with a program representative igniter. Additionally, key critical safety tests outlined in MIL-STD-1901A and MIL-DTL-23659 shall be performed.

PHASE III DUAL USE APPLICATIONS: Transition the fully compliant in-line electrical initiation system to a MDA program element application via rigorous engineering development and qualification activities. Private sector applications include Launch Vehicles (Propulsion and Separation Ordnance), Safe Demolition Initiators, and Air Bag Initiators.

REFERENCES:
1. MIL-STD-1901A, "Munition Rocket and Missile Motor Ignition System Design, Safety Criteria For", dated 6 June 2002

2. MIL-DTL-23659D, "Initiators, Electric, General Design Specification For", dated 3 March 2003

KEYWORDS: Arm Fire Device, MIL-STD-1901A, MIL-DTL-23659, In-Line Electrical Initiator

MDA06-038 TITLE: Developing Solid Rocket Motor Insensitive Munitions Solutions for Impact and Rocket Propelled

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: QS

OBJECTIVE: Develop innovative insensitive munitions (IM) concepts that can protect large solid rocket motors from impact stimuli caused by fragment, bullets, rocket propelled grenades (RPG) and shape charge threats.

DESCRIPTION: Federal law requires DoD munitions programs to utilize insensitive munition (IM) technology. Unique practicable and affordable solutions need to be identified for large solid rocket motors to achieved IM compliance. Current IM propellants, such as polyether systems, even when coupled with composite rocket motor case technology exhibit poor IM characteristics when configured in diameters of 12 inches or more. IM propellants and ingredients under development cannot provide an immediate solution to the IM problem. However, new innovative technologies coupled with new solid rocket motor designs can offer more immediate solutions to IM shortfalls. This topic solicits solutions that focus on impact and rocket propelled grenade (RPG) threats which have become more prevalent in today's theater environments. These threats are characterized in Mil-Std-2105C and the NATO STANAGS, impact threats are covered by bullet and fragment impact tests and RPG threats are covered by the shape charge jet test.

PHASE I: Define technology concepts and which threat the technology will protect against. Develop design concepts on how the technology could be integrated into the system. Do small scale proof of concept tests and develop a full test plan based on initial concept test results.

PHASE II: Finalize the test plan. Develop analyses and do validation testing. Analyze results and provide data and modeling to support the results. Outline how the technology can be integrated into the solid rocket motor system.

PHASE III: Improve design concept. Prove concept further and begin integration into SRM system. DUAL USE COMMERCIALIZATION: Development of insensitive munitions technology in support of military and commercial research is rapidly-growing scientific endeavors. The proposed effort would be extremely useful in providing data to ensure the safety of personnel exposed to explosives in commercial space flight applications.

REFERENCES:
1. “Department of Defense Acquisition Manager’s Handbook for Insensitive Munitions” Rev 01, January 2004

KEYWORDS: insensitive propellants, solid rocket motor design, booster, missile, ballistic protection

MDA06-039 TITLE: Hypergolic Chemical Leak Detector

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: TH(DFT) / QS

OBJECTIVE: The objective of this research and development effort is to develop a detector/sensor that would be able to detect rapid changes in concentration which signal leaks of hypergolic rocket fuels and oxidizers and it is flush mounted on the outside of the missile canister.

DESCRIPTION: A number of currently used missile systems use hypergolic rocket fuels and oxidizers as a means of propulsion. A significant shortfall in this area is our inability to accurately verify any leaks present of the hypergolic fuels. The key to the utility of this detector is NOT a low threshold for detection, but a programmable detection of a pre-set "rate of change" of the target contaminant. A true "leak" of significance should result in a fairly rapid change in the concentration of the target chemical inside the missile canister. Once a threshold for a selected rate of change has been reached, the alarm should sound. As a back-up the sensor should also sound an alert when a certain, relatively high, concentration of the contaminant has been reached, regardless of how long it took to get there. The chemicals the unit should be sensitive to include any of the common Hypergolic rocket fuels and oxidizers, to include Monomethyl Hydrazine, RFNA, MON-25, and others.

This leak detector should be self powered with a battery that could last at least 10 years and the battery should be changeable from outside of the canister. The detector should have a data output port that could be tapped by a centralized data management system, for historical data. The detector should be flush mounted on the outside of the missile canister, be lightweight and occupy a minimum space. The detector should have a visible and audible alarm and have both an electronically discernable "test" mode as well as a manual push button type test mode to make sure the unit is working. Typically, the detector should be checked just before missile canisters are loaded onto some means of transportation and again following offload.

PHASE I: Conduct experimental efforts to demonstrate proof-of-principle of the proposed technology to detect and characterize leaks in the above mentioned fuel systems. Demonstrate the initial feasibility of the detector system.

PHASE II: 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: The cost avoidance realized by the Ballistic Missile Defense System and the services by employing this technology would be significant. Hence, the anticipated Phase III program customers would include a wide range of current interceptor programs. During Phase III the effort calls for engineering and development, test and evaluation, and hardware qualification.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would be anticipated to have a high level of interest as a diagnostic tool in the area of explosives, commercial launch rocket propellants, etc.

REFERENCES:
1. P. Marteau, F. Adar, and N. Zanier-Szydolski, “Application of Remote Raman Measurements to the monitoring and Control of Chemical Processes,” American Laboratory, pp21H-21Q, Oct. 1996

KEYWORDS: Hypergolic, Propellant, Detector

MDA06-040 TITLE: Safe and Arm and Arm and Fire Devices

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: TH(DFT) / QS / AB(DFA)

OBJECTIVE: The objective of this research and development effort is to develop a millimeter size propulsion safe and arm and arm fire device compliant with MIL-STD 1316E and 1901A.

DESCRIPTION: An Arm Fire (AF) device is a safety device that provides electrical and mechanical interruption of an ignition train in order to prevent the unintended functioning of a missile's rocket motor. These devices are used to prevent accidental or inadvertent ignition of rocket motors during flight or in any usage which could cause an extreme hazard to personnel or facilities. AF devices incorporate a fail-safe mechanism that enables the device to remain armed only while power is applied. When power is removed from the device, they return to the safe position.

A Safe and Arm (S&A) device is a safety device which can be fail-safe or which can incorporate a latching mechanism which enables the device to remain armed after power is removed and can be typically be returned to safe position by applying power. Latching S&A devices are commonly used to initiate system destruct in the event of a test failure. Fail-safe S&A devices are typically used for launch vehicle initiation and for rocket motor stage separation during flight. S&A devices commonly use an Explosive Train (ET) to transfer energy to another device from the S&A.

S&A and AF devices are essential elements of today's complex launch vehicles, missiles and weapons systems. These devices must be compact, highly reliable and satisfy stringent performance requirements. Using traditional manufacturing methods, current S&A devices are precision electromechanical systems that are typically 4 inches by 4 inches by 3 inches and weigh 3.7 pounds. Today's advanced S&A designs are 2.25 inches by 2.25 inches by 2 inches and weigh 1.25 pounds. An innovative design for S&A and AF devices that is based on MEMS (micro-electromechanical systems) propulsion technology could reduce the size by a factor of ten and reduce the weight to grams.

The application of microtechnology such as MEMS technology to S&A and AF devices holds great promise in attaining substantial reductions in the size, weight, volume, parts count and cost. These improvements potentially offer orders of magnitude improvements over existing S&A/AF designs. MEMS technology has matured to the state where compact and reliable S&A/AF device designs can be created using well established and demonstrated MEMS manufacturing processes. Furthermore, these MEMS systems can be designed, built, tested and flight qualified using existing MEMS design and manufacturing methods and fabrication infrastructures.

PHASE I: Conduct a study which establishes and quantifies the performance and advantages of micro S&A and AF devices, performs trade analysis studies among design alternatives, delivers preliminary conceptual designs of both S&A and AF devices as well as manufacturing plans for both to assure manufacturability.

PHASE II: 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: Build actual flight devices that will be subjected to a rigorous test and qualification.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Launch vehicles, Air Bags initiators, Microthrusters, and MEMS Switches.

KEYWORDS: Safe and Arm, Arm and Fire, MEMS

MDA06-041 TITLE: Developing Insensitive Munitions (IM) Modeling and Simulation Capability for Large Rocket Motors

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: QS / AB(DFA)

OBJECTIVE: Demonstrate an IM modeling and simulation tool that is tailored to be used in the design and development of large (12 inches or greater in diameter) solid rocket motors (SRMs).

DESCRIPTION: There is a great need to identify or develop models that simulate the reaction of SRMs to unplanned heat and shock stimuli as described in MIL-STD-2105C. Such models would have great potential to reduce the need for expensive IM destructive testing and, possibly, speed the motor development process. Presently, insufficient models and codes are available to the solid rocket motor industry which can accurately predict how a motor will react under IM stimuli. This program will focus on tailoring and demonstrating a computerized mathematical model that will predict the physical reaction of SRMs exposed to IM stimuli.

PHASE I: Develop or tailor a model and associated database that will predict the reaction of a large diameter SRM to the heat stimuli of MIL-STD-2105C and demonstrate the model's reliability using subscale or analog motor tests. The tests should be designed to identify critical physical properties and compliment MIL-STD-2105C. The test articles will be properly instrumented to measure those properties to populate the database. Outline the test plan for phase II.

PHASE II: Expand the model to simulate SRMs reaction to additional the IM stimuli of MIL-STD-2105C and/or show scalability of the model and conduct validation and verification tests to populate the database with all applicable physical properties. The testing will continue with test articles loaded with Hazard Classification 1.3 propellant that is typical of MDA SRMs. Provide a report that provides an analysis of the model's accuracy and recommendations for continued improvement in that accuracy.

PHASE III: Continue to improve the model and assess its applicability in predicting hazard classification of SRMs for transportation purposes. Utilize large diameter analog motors for validation and verification of the model. Propose how the model could be utilized to reduce IM/hazard classification testing required by MIL-STD-2105C and TB 700-2, "DOD Ammunition and Explosives Hazard Classification Procedures."

DUAL USE COMMERCIALIZATION: Development of IM M&S technology in support of military and commercial research is a rapidly growing scientific endeavor. The proposed effort would be extremely useful to help ensure the safety of personnel exposed to explosives in commercial space flight applications, commercial mining, and in the production, storage and transportation of SRMs.

REFERENCES:

1. "Insensitive Munitions Technology for Tactical Rocket Motors" by Andrew Victor 1994

2. "Department of Defense Acquisition Manager's Handbook for Insensitive Munitions" Rev 01, January 2004

3. "Experimental Support of a Slow Cook Off Model Validation Effort" by Alice Atwood, November 2004

4. NATO's Munitions Safety and Information Analysis Center (MSIAC, formerly NIMIC)

5. "US DOD IM Program" by Anthony J. Melita (http://ww.dtic.mil/ndia/2003gun/mel.pdf)

6. "US Navy Insensitive Munitions Requirements," Navel Sea Systems Command, NAVSEAINST 8010.5B, 5 Dec 1989

KEYWORDS: Explosive, booster, missile, ballistic protection, insensitive fill, modeling tools, confinement techniques, algorithms, material database

MDA06-042 TITLE: Radiation Hard Electronic Components

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: SS(DFS) / MP(DEP) / GM(DFG) / AB(DFA) / TH(DFT) / AS(DV)

OBJECTIVE: To achieve the practically-oriented development of digital and analog electronics components capable of reliable operation in BMDS space and interceptor environment.

DESCRIPTION: Current analog-to-digital (A/D) and D/A converters; memory; general-purpose (GP) and digital signal processors (DSPs); avionics components do not always reliably operate in the natural radiation environment for the projected design-life of the BMDS system. Surveys of the BMDS contractors have identified these components as the highest priority for radiation hardening to meet BMDS space system and interceptor design requirements. This topic seeks the development of one or more of these components capable of enduring and reliably operating in BMDS mission environment for the design-life of the BMDS. Specifically, the goal is to achieve near-current-commercial product performance while being capable of surviving radiation effects for space systems and transient radiation survivability for interceptors in a hostile man made environment. We seek innovative concepts that use radiation-hardening by process, by design, by architecture or a combination of these approaches that will result in cost effective solutions.

PHASE I: In Phase I, we seek innovative concepts that address one of the components and a reference architecture based on that component capable of reliable operation in the BMDS system for its projected mission life. We recognize that the component alone is only part of the problem, and expect the reference architecture to address any auxiliary issues impacting reliable operation, such as the need to error detect and correct (EDAC) memory devices, which themselves may not be reliable components. Note that each proposal may address only one component, but that offerors may submit multiple proposals. Offerors are strongly encouraged to work with space system and interceptor contractors to help ensure applicability of their efforts and beginning work towards technology transition.

PHASE II: The contractor will design, develop, and fabricate a breadboard device or a system-level prototype, traceable to an implementation in an objective (i.e., actual flight) system. The approach must be flexible for use in a wide range of mission designs. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end the offerror is encouraged to develop a partnership with system primes or subtier vendors for space systems or interceptor contractors, as appropriate. The offerors should strongly pursue funded (if possible) co-support from system primes (and their subcontractors), as these are strong indicators of relevance of the proposed work.

PHASE III: In this phase, the contractor will produce components to fully comply with the established requirements for use in the Space Tracking and Surveillance System, MDA interceptor and DoD systems, or commercial applications. The offerors are highly encouraged to demonstrate partnerships with system primes or sub-tier 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.

PRIVATE SECTOR COMMERCIAL POTENTIAL: All of this work applies to the larger class of satellite and missile systems, which include commercial satellites and launch vehicles. As we find that ground systems are experiencing single-event upsets, it will soon be true that even they will require the solutions called for in this topic, particularly high-reliability systems, whose failure has life-and-death consequences.

REFERENCES:
1. D.G. Mavis and D.R. Alexander, “Employing Radiation Hardness by Design Techniques With Commercial Integrated Circuit Processes”, Digital Avionics Systems Conference, 1997. 16th DASC, AIAA/IEEE, Volume: 1, 1997, page(s): 2.1 -15-22 vol.1.

2. D. Alexander et al., "Scaleable HBD Cell Library for Radiation Tolerant ASICs for Space Applications", Conference Proceedings, GOMAC 2001.

3. G.C. Messenger and M.S. Ash. The Effects of Radiation on Electronic Systems. Van Nostrand Reinhold, New York, 1986.

KEYWORDS: radiation effects on electronics, single event effects, single event transients

MDA06-043 TITLE: Radiation Hardening Designs and Techniques for Missile Defense

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: GM(DFG) / TH(DFT) / AS(DV)

OBJECTIVE: The overall objective of this effort is to investigate designs, techniques, materials, and/or novel approaches in combining these factors for BMDS interceptors that will provide an increased level of resistance to damage induced by nuclear environment radiation without a negative impact on weight, or performance.

DESCRIPTION: BMDS missile systems must function reliably when exposed to background radiation from space and radiation resulting from nuclear events (including x-ray, prompt and persistent gamma, single event effects, total ionizing dose, space radiation, etc.). Systems must also survive and function after prolonged periods in battlefield/storage environments (Shock, vibrations, thermal, etc). Optimal utilization of mass in a missile system (especially lightweight kill vehicles) 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 interceptors to endure and reliably operate in BMDS mission environments without increasing weight or decreasing performance. Systems of interest include all BMDS kill vehicles and space-based platforms.

Technical areas of interest include: advanced materials, composite materials with shielding layers, coatings, and processes. 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 can be inserted into missile defense interceptors.

PHASE I: 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 interceptors in perturbed environments consistent with High Altitude Nuclear Bursts as described in reference 2 or prolonged natural space radiation. Determine feasibility of radiation hardening missile components and/or subsystems using proposed concepts without sacrificing performance characteristics while achieving a reduction or net zero impact in mass. 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, 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: 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.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercial potential exist in the medical community, homeland security sector, and power and automotive industries.

REFERENCES:
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KEYWORDS: radiation effects, radiation hardening, materials, space radiation

MDA06-044 TITLE: Manufacturing Technology Innovations for Radiation Hardened Electronics for Interceptor and Satellite Control Systems.

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: MP(DEP) / SS(DFS) / KI(DFK)

OBJECTIVE: Develop innovative, radiation and nuclear hardened control electronics for: divert and attitude control systems (DACS) for missile interceptors and space systems; cryocooler control electronics for missile interceptors; and control systems for satellite electrical energy storage systems. The control electronics for should also offer high performance, miniaturization, reliability, low-cost, and low power consumption. The control systems should be scalable to handle a range of loads and special consideration should be given to designs that have utility to both satellites and interceptors where applicable.

DESCRIPTION: The Missile Defense Agency (MDA) is seeking reliable and high performance radiation hardened electronics for controlling DACS and related propulsion mechanics; mechanical cryocoolers and electrical energy storage systems. The radiation environments for interceptors and space systems differ due to the mission requirements and the offeror should be aware of these differences. For missile interceptors, the components on the control board, electrical interface, and in electromechanical motors must function reliably when exposed to radiation resulting from high altitude nuclear events. The radiation effects to be considered are dose rate effects, total ionizing dose (TID), prompt and persistent gamma, x-ray, electromagnetic pulse (EMP) and high energy ion radiations to withstand single event effects (SEE, SEL, Neutron Induced Upset). Other considerations of interest include, but are not limited to, mitigation of gate rupture, thermal pulse, or blast overpressure under the radiation from nuclear events. For space systems, the driving radiation requirement is reliability for >10 years operation for an accumulated dose of 300KRad with single event rates associated with natural low energy orbits.

1. DACS and Related Propulsion Mechanics
The control electronics are used for amplification, power conditioning and switching and contain high power electronics required for controlling electromechanical type gas actuator valves and feedback control functions. The proposed technology can be also used for space electronics, or forward deployed high power electronics systems. Innovations are sought include novel device design, fabrication, miniaturized packaging, and assembly techniques that are low cost, radiation hardened, and adaptable for the plug and play with DACS hardware, avionic signal motor control processors, and Field Programmable Gate Arrays for avionic control units. Targeted properties for the high power electronics include:

- Voltage: 50V to 150V
- Current: 2A to 40A
- Operating frequency: 20kHz to 60kHz
- Miniaturization to reduce the surface area
- Radiation hardened designs for field effect transistors (FETs), FET driver chips, acceleration sensors, hall sensors, motor control processors, optical isolators, amplifiers, and serial communication Inertial Control System.

2. Mechanical Cryocoolers for Interceptor Applications
For interceptors, MDA is considering the use of mechanical coolers that continually run in the silo to provide a higher level of mission assurance. These coolers can be located either in the kill vehicle or in the silo housing and the control electronics should address the requirements of either situation. MDA is seeking innovative and low cost electronic products and designs to be used to control cryogenic coolers.

The devices and designs need to be low cost, compact and manufacturable while maintaining reliability. MDA is seeking a design for cryocooler control electronics that can enable more cost-effective assembly or that enable use of modified commercial off-the-shelf (COTS) or military off-the-shelf (MOTS) components to reduce unit production cost for MDA applications. The electronics must still meet the life requirements of such coolers (>10 years) while providing low power consumption and low weight, and being easily integrated with coolers manufactured by current industry. The cooler electronics must be scalable to adapt cryocooler size and design. Any one proposal must target the thermodynamic refrigeration cycle of either: Stirling, or Pulse tube variant of the Stirling. This integration requirement implies that the proposal must address:

a. The feedback control system by which cryogenic thermometry transducers operating in the range of 65-350K provide input to the power controls of the cryocooler. This thermometry system would be an integral portion of the proposed electronics system.
b. For cryocoolers where the cooler is integral to the deployed sensor, vibration control of the proposed mechanical system if the characteristic fundamental frequency is less than 400 hertz, to include vibration transducer excitation and measurement. This excludes the case where the cooler resides within the silo housing and separates from the kill vehicle at launch, or if the offeror can definitely prove that the vibration from the cryocooler will not impact the performance of the focal plane array.
c. For cryocoolers where the cooler is integral to the kill vehicle, the control electronics should not place undue noise on the kill vehicle power bus, through use of a filter. A modular approach, i.e., one in which the filter is a module added to an existing or modified COTS or MOTS controller design is encouraged.
d. The cooler heat load is not expected to exceed 250 mWatts at 65K.
e. Cryocooler control electronic designs need to have the option of being radiation hardened to a nuclear detonation for the option of placing the cryocooler on the interceptor.

3. Satellite Energy Storage System
MDA is seeking satellite control electronics for the transfer of electrical energy generated from solar cells to battery storage. The control electronics design needs to be modular, or scalable, to handle varying energy generation and storage loads. The design must be sufficiently flexible for interfacing solar cells from multiple solar cell and space battery manufacturers (lithium ion and metal hydride). The design should be capable of monitoring individual battery health and controlling charge/discharge to maximize individual battery lifetime. The design should be capable of monitoring and adjusting for peak and minimum power generation cycles. This control system is aimed at a satellite in a low energy orbit and the resultant radiation environment, for which the control system is expected to tolerate, is 300 Krad over a 10 year life.

PHASE I: Develop concepts, design, and methodology for manufacturing, packaging, and assembling control electronics that will meet the radiation hardness requirement and improve system performance and reliability. It is permissible to evaluate commercial off the shelf (COTS) components.

PHASE II: Validate the feasibility of designing, manufacturing, packaging, and assembling of the control electronics by designing, developing, and constructing a breadboard device to demonstrate the innovation. The electronics may not be optimized for flight qualification, but should demonstrate the potential of the prototype device to meet actual operational specifications and clearly identify the path to be followed to take the electronics to flight readiness. The electronics should be demonstrated by integration of prototype items for MDA element systems, subsystems, or components. Integration with a working DACS, cryocooler or electrical energy generation/storage would be desirable. This breadboard demonstration would not necessarily use radiation hardened components. If COTS parts are used, the final report shall indicate the one-for-one substitutions for necessary radiation hardened components.

Validation would include, but not be limited, to system simulations, operation in test-beds, or operation in a demonstration sub-system. A partnership with the current or potential supplier of MDA element systems, subsystems, or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: The contractor will apply the innovation demonstrated in the first two phases to one or more MDA interceptor or space elements, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Innovations developed under this topic will benefit both DoD and commercial space and terrestrial programs.

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KEYWORDS: manufacturing, control electronics, power electronics, Radiation Hard, DACS, propulsion

MDA06-045 TITLE: Advanced Strategic Sensors

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: SS(DFS) / AS(DV)

OBJECTIVE: The overall objective of this effort is to develop innovative solutions to improve strategic space sensors.

DESCRIPTION: The Missile Defense Agency (MDA) is interested in technology developments in support of advanced strategic sensors MDA requires high performance, high sensitivity and low noise sensors for space based sensing applications. Space based sensors operate in low background environments where radiation hardness is key to mission operation. Sensor bands from the visible through very long wavelength infrared (IR) wavelengths are of interest. Specific technologies of interest include sensor materials, detectors, focal plane arrays (FPAs), Read Out Integrated Circuits, and optical filters which will: 1. Be capable of operation in a space/nuclear radiation environment; 2. Provide performance sufficient for strategic systems for meeting the requirements of the BMDS; and 3. Offer system performance advantages over current sensor approaches.

Innovative Materials Solutions:
The Air Force and the Missile Defense Agency require new concepts for very long wavelength infrared (VLWIR) detectors with increased operating temperature (>60K), and improved detectivity for space based applications. These detectors will be required to operate at wavelengths beyond 20 micrometers. The presently available detectors are based on extrinsic silicon with an operating temperature below 20K. Detectors with increased operating temperatures with equivalent or better detectivity will significantly reduce satellite system costs. Key issues to be addressed are innovative detector materials design and device architectures, the interface abruptness between epitaxial layers and repeated control of the individual layers, materials composition, and doping. Material issues are minimizing background carrier concentration and defect densities. Molecular beam epitaxy and metal organic chemical vapor deposition will be considered, as well as other similar epitaxial growth techniques. Concepts must addess meeting surviving a 300 kRad(Si) total dose (proton and ionizing radiation) over the expected mission life.

Radiation Hard Visible FPA:
MDA is interested in the investigation of methodologies to design or process visible detector arrays and readout circuitry to improve radiation tolerance of visible FPAs.. The projected radiation environment for any developed devices is 300 kRad(Si) total dose (proton and ionizing radiation) over the expected mission life. The device design goal is to minimize total degradation to < 30% in device performance from beginning of life values (i.e. End of Life > 0.70 * Beginning of Life performance). In addition to be capable of operating at moderately reduced temperatures, it is desireable that the visible detector arrays and readout circuitry are capable of being optimized to operate near the low temperatures of other photon sensors (e.g. LWIR devices), in order to minimize sensor integration costs.

Bandpass Filters:

For infrared applications in military systems it is often necessary to use optical filters which only transmit a given wavelength band while blocking all other wavelengths. Selected substrate and coating materials must transmit (i.e. low loss) multiple wavelengths; wavelengths greater than 5µm are of particular interest. Filters must maintain a transmission greater than 90% and be radiation hard up to 300 kRads. Improvements on current technology may result from design methodology, deposition monitor and control, or other innovative approaches. Successful filters shall simultaneously maximize the throughput in the bandpass, minimize the transition from bandpass to blocking, and maximize the blocking in magnitude and spectral extent.

Read-Out Integrated Circuit (ROIC):
Innovative rad-hard by design ROIC concepts that can be fabricated by known CMOS foundries are of interest to MDA. Radiation hard by design ROICS decrease the overall cost of FPAs by exploiting existing commercial foundries rather than relying on increasingly scarce and costly "proven" foundries. ROIC designs must be radiation hard to 300kRads(Si) and include features for mitigation of single-event upsets and latch-up.

Medium and Long Wave Infrared FPA:
MDA is interested designs and/or processes to improve their radiation tolerance and performance of medium and long wave infrared (M/LWIR) detector arrays. . The projected radiation environment for any developed devices is 300 kRad(Si) total dose (proton and ionizing radiation) over the expected mission life. The device design goal is to minimize total degradation to < 30% in device performance from beginning of life values (i.e. End of Life > 0.70 * Beginning of Life performance) and increase operating temperatures to above 60K, which will decrease overall FPA costs.

This solicitation is broad based, from architecture changes to components to entire sensors. Specifically sought are new and innovative schemes and technologies that involve modified production processes, improved or new materials, altered chip packaging, unique/modified sensor types or designs or other innovative options that will increase the intrinsic resistance of sensors to ionizing radiation damage. Radiation hardness and the ability for the technology to be qualified for space applications are crucial for successful proposals.

Any proposal submitted must focus on one specific area: the detector, the focal plane, ROIC, or bandpass filters. An offeror may submit multiple proposals with unique approaches in one area, or in multiple areas.

PHASE I: Identify and investigate materials, unique device designs, novel sensor architectures, and/or production process changes or additions suitable for FPA component fabrication that will result in significant improvement in the performance, operational lifetimes or cost reduction. A deliverable or proof-of-concept design available to the government for additional characterization is highly desirable. Offerors are strongly encouraged to work with system, payload and component contractors to help ensure applicability of their efforts and beginning work towards technology transition.

PHASE II: Using the resulting materials, designs, architectures, concepts and/or process changes or additions in Phase I, implement, test and verify these changes in prototype fashion to demonstrate the feasibility and efficacy of the focal plane array components. In Phase II, the contractor is required to have radiation testing performed to verify that hardening to protons and ionizing radiation to a total dose of 300 kRads(Si) is established and damage is minimized. A full scale processing methodology shall be developed and demonstrated. 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 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 product. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to BMDS systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Innovations developed under this topic will benefit both DoD and commercial space and terrestrial programs. Possible uses for these products include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. Enhancements to imaging quality show significant potential.

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KEYWORDS: infrared detectors, infrared focal plane arrays, radiation hardening, bandpass filters

MDA06-046 TITLE: Low Cost, Radiation Hardened, Inertial Measurement Unit

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: SS(DFS)

OBJECTIVE: Development of a miniaturized, lightweight, radiation hardened, integrated subsystem to provide high accuracy inertial knowledge in both absolute location/velocity and angular orientation.

DESCRIPTION: The classic approach to satellite attitude determination requires independent sensor subsystems such as star trackers, inertial reference units based on rate sensors, and, more recently, the use of the Global Positioning System (GPS) to provide data to specialized algorithms/computer systems to determine satellite orientation and position. Proposed MDA systems, such as the Space Tracking and Surveillance System (STSS), are required to track objects at great distances and relay information as to the three-dimensional position and velocity of the satellite and absolute inertial pointing of their optical payload when viewing an object of interest.

Current approaches to solve these types of problems are somewhat ad-hoc and mission specific based on performance requirements and limitations of sensors due size, weight, etc.. Future systems will require a dedicated miniaturized, on-gimbal, inertial measurement capability imbedded within the surveillance tracking system. As gimbaled optical systems are of interest in the future, this device will have to be very compact, lightweight, low heat dissipation, and be separable from its support electronics. In addition, the systems must be capable of supporting long duration missions of seven or more years. For the missile interceptors the intent is to better maintain track precision in an extreme shock, vibration and radiation environment. The intent of this SBIR is to develop innovative approaches to addressing either or both of the above space and/or missile interceptor requirements.

Missile interceptor IMU performance and interface requirements are captured in the MDA IMU core standard (incorporated by reference) and the satellite tracking performance goals are as follows:

Maximum Linear Position Error < 15 m
Maximum Linear Velocity Error < 0.20 m/s
Maximum Rotational Error, 1ó, any axis < 10 µrad
Angular Rate capability > + 0.5 rad/s (w/o change in measurement mode/accuracy)
Angular Acceleration Capability > + 0.5 rad/s2 (w/o change in measurement mode/accuracy)
Quaternion output data rate > 100 Hz
Angular sensor output data rate > 250 Hz
Min Sensor/Electronic cable separation 10 m

Integrated sensor mass < 10 kg
Electronics mass < 10 kg
Power consumption, integrated sensor < 20 W
Total system power < 40 W
Operating temperature range -54 to 32°C
Survivable temperature range -60 to 71°C
Radiation Hardness (total dose) > 300 Krad (Si) proton and ionizing radiation

PHASE I: Develop a preliminary design for a small, compact, low-power, lightweight, system that provides a measurement of its location and angular orientation in the earth centered inertial coordinate frame to the accuracy necessary to provide high accuracy inertial line-of-sight (LOS) knowledge that meets or exceeds the government's performance goals. The system design must be capable of operations in the specified space environment over a minimum seven year expected life. The proposed design must be space qualifiable and demonstrate it is consistent with available radiation hardened parts. The design will also include a COTS design variant as the laboratory prototype to be built in Phase II. This design variant will utilize COTS parts/components. Where necessary, the COTS prototype design must account for performance differences between COTS and Space Qualified parts/components. The offeror will demonstrate any performance differences between COTS and the Space Qualified parts/components and will have an approach to de-rated those COTS parts/components to mimic actual rad hard part performance during prototype development and test. Modeling, Simulation, and Analysis (MS&A) of the design must be presented to demonstrate understanding of the sensors physical principles, performance potential, scaling laws, etc. MS&A results must clearly demonstrate how performance goals will be met. Proof of concept hardware development and test is highly desirable. Proof of concept demonstration may be subscale or specific high risk components. Results should be used in conjunction with MS&A results to verify scaling laws and feasibility.

PHASE II: Complete the critical design of the space qualifiable design and the COTS-based equivalent prototype design including all supporting MS&A. Fabricate the COTS-based equivalent prototype device and perform characterization testing within the financial and schedule constraints of the program to show level of performance achieved compared to stated government goals. The COTS version will not require environmental qualification testing and is to be a proof-of-concept demonstration of the technical approach. 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.

PHASE III: Modify/improve the design if the Phase II proof of concept prototype did not meet near-term goals. Work with a commercial company or independently to develop and space qualify the miniaturized payload inertial measurement unit developed in Phases I & II.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Current approaches to this problem require the integration of multiple subsystems to determine the inertial location and attitude. This device will incorporate all of these features into a single integrated unit at a lower cost. Non-DoD applications include commercial aircraft inertial navigation systems (INS) and guidance systems for launch vehicles and reusable spacecraft.

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KEYWORDS: Inertial Measurement Unit (IMU), Inertial Navigation System (INS), Guidance Navigation and Control (GN&C)

MDA06-047 TITLE: Development of High-Fidelity Techniques to Model Impact Flash and Post-Impact Thermal Signature Prediction and Support Kill Assessment

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: MS(DES) / AS(DV) / AB(DFA) / BC(DFB) / DT(DE) / GM(DFG) / KI(DFK) / TH(DFT)

OBJECTIVE: The objective of this research is to develop innovative modeling techniques for efficient physics-based impact flash phenomenology modeling and late time debris thermal and spectral signatures to support kill assessment.

DESCRIPTION: The Missile Defense Agency (MDA) is interested in advancing the state-ofthe-art of impact flash phenomenology modeling and composite scene generation to support kill assessment. Accurate kill assessment is critical for actionable missile defense. Determination of the likelihood of a successful intercept kill is required for interceptor tasking. There are two key elements that must be accurately modeled: prompt impact flash and long term thermal signature. Hyperspectral phenomenology in the UVSWIR can provide information on intercept effectiveness as well as payload type. For instance, atomic emission of heavy metals within the fireball can be measured using a visible, high speed spectrometer. Infra-red (IR) sensors provide key thermal signature data that is used to assess target damage and breakup. Given the complexity of target debris late-time kinematics and propagation, analysis of these thermal signatures for kill assessment is challenging. To improve the understanding of thermal kill assessment signatures, high-fidelity physics-based tools are needed to simulate the IR radiation emission post-intercept of propagating target and payload debris. These simulation tools should accurately capture target payload and debris temporal thermal signatures from impact for several tens of seconds in the post-intercept regime. The simulations should be scalable, massively parallel, and provide rapid turn around. Impact flash model data generated from Computational Fluid Dynamics (CFD) codes are needed to generate 3-D spatial and temporal flow-field databases as a function of weapon type, impact materials, altitude, orientation, and velocity. Hyper/multispectral scene generation of the impact flash event will use the 3-D flow field databases to perform model verification and validation, sensor design, signal processing, feature extraction, and kill assessment.

PHASE I: Perform research to support development of innovative correlated multi-spectral impact flash/flow-field databases and late time thermal signatures modeling capabilities. Demonstrate composite hyper/multispectral scene generation with 3-D impact flash flowfields. The models should provide accuracy not reliant on semi-empirical or analytical methods, but be driven by first principle numerical modeling techniques. Perform verification and validation of the synthetically generated impact flow field with measurement data. Calculated post-intercept thermal signatures should reflect debris temperature, mass, and surface characteristics. The required tools should calculate the heat generated in target and payload debris due to warhead impact and any subsequent reactions of high explosives that make up the payload. The radiation models used should not only capture IR emission, but also debris heating due to IR absorption. Based on the research, define the software architecture and interfaces for an integrated process for the generation of impact flash/flow-field databases and hyper/multispectral composite imagery. Assess state-of-the-art tools and techniques for simulation of IR emission and temperature profiles of post-impact target debris. Propose new approaches that would address identified deficiencies in existing codes. A critical component of this phase is determining the best general approach to simulation of heat generated from warhead impact and payload reactions, and the IR radiation emissions that result. Perform a critical demonstration of a limited impact scenario. Develop a Phase II work plan for implementing proposed approaches for simulation of impact flash and late-time thermal signatures of post-impact target and warhead debris.

PHASE II: Design, develop, and test the capability for parallel kill assessment models integrated into an MDA physics signature code such as FLITES or CHAMP. Create numerical tools based on approaches identified in Phase I. This would include the algorithm and code development necessary to simulate, flash signatures, temperature profiles and IR signatures for propagating and evolving post-impact debris. Demonstrate new algorithms using hypothetical intercept scenarios to show more clearly resolved lethal volumes. Validation will be done using existing test data. The numerical tools produced in this stage must meet the requirements of being scalable, massively parallel, and offer quick turn around and analyses of flight test missions. Apply the capabilities to demonstrate the synthetic generation of a MDA impact flash event and perform validation. Develop bounding sets of impact flash and thermal signature databases as a function of time, space, weapon type, materials, altitude, orientation, and velocity. Address various target specific scenarios. These potentially include AEGIS BMD, THAAD or MDA/GM against payloads such as unitary high explosives, bomblets, bulk chemical, and others. This broad range scenarios dictates that the simulation approach must be general in nature and broadly applicable to an array of problems.

PHASE III: Fully develop the integrated environment for synthetic hyper/multispectral impact flash modeling. Perform verification and validation against real-world impact flash events. Transition synthetic impact flash imagery generation environment to support MDA and DoD agency applications. These simulation tools will be used to provide direct guidance to flight test mission execution. This includes understanding pretest safety issues, post-test interpretation of kill assessment tools, and be incorporated into BMD lethality analysis as a primary parametric study toolset. Because the simulation method is not to be BMD element specific in nature, it can be readily applied to other problems of interest to MDA.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This project will have broad commercial impact all areas of sensing and surveillance supporting weather predictions, virtual training, and flight simulations. It will provide a fundamental improvement to an array of physics-based simulation techniques, including heat generation due to high velocity impact, and coupled multi-body IR emission. This would include simulation of multi-body impact and impact testing, explosives testing and debris scattering for mining and excavating methods that use explosives. Modeling of industrial processes such as welding, spray, sputtering deposition would also benefit from this topic"s simulation development effort.

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KEYWORDS: Kill Assessment, Physics-Based Signature Code, FLITES, Impact Flash, Infrared Signature, Sensors, Phenomenology, Multi-Spectral, CHAMP

MDA06-048 TITLE: High Fidelity Scene Generation for Distributed Hardware in the Loop of BMDS Components

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

ACQUISITION PROGRAM: MS(DES) / AB(DFA) / BC(DFB) / DT(DE) / GM(DFG) / KI(DFK) / TH(DFT)

OBJECTIVE: Investigate implementation of real-time multi-waveband synchronized distributed high fidelity physics based scene generation for BMDS hardware in the loop validation and test.

DESCRIPTION: The development and integration of components of each of the BMDS system elements and the various integrated elements is being accomplished at both Government and contractor engineering test facilities and ranges at many different geographic locations. In some cases this could be as simple as processors for interceptor guidance and control in one laboratory and the sensor/seeker in a hardware in the loop test chamber across the campus. In many cases the BMDS has matured to where command control, sensors, signal processing and discrimination algorithms are being developed in concurrent spirals and the need has emerged to efficiently integrate these elements in both system Hardware in the Loop (HWIL) simulation and system of systems HWIL simulations for test, assessment, and training. In the last year the fidelity of realtime scene generation models have been improved to support real-time stimulation of the sensors and signal processor simultaneously in multiple wavebands. Recent MDA development efforts have shown that the PC based real-time capabilities for real time scene generation using such MDA codes as RTCHAMP and FLITES have improved to support operation at full closing rates. Only recently, due to advances in graphic hardware and software, has real-time externally synchronized scene generation based HWIL been shown to be viable for MDA applications.

The need is to now investigate how to take one common battlespace geometry and multiple target environment/state data sets and distribute that across geographically diverse advanced PC scene generators. The goal is to provide synchronized deterministic physics-based stimulation of the “system’s signal processors, seekers, acquisition sensors, tracking sensors, and kill assessment sensors. The goal is to distribute a minimal set of geometry descriptions and the data for each remote processor to provide the identical high fidelity rendered radiometric output at each node or location without having to distribute the full rendered data set. Supervisory process monitoring and synchronization control must be developed to track the status of each remote HWIL process to insure that the simulation stays within timing parameters and doesn’t become time skewed, opening the loop on the simulation.

PHASE I: Investigate distributed scene generation approaches for both local and geographically separated processors. Determine the viability of network support for graphics and state environment variable distribution for visible, IR and RF wavebands. Analyze current infrastructure for MDA distributed simulations and ground test facilities and determine the viability of HLA, DIS, TENA or other architectures for real time sensor/signal processor, and B2MC distribute HWIL testing. Using existing MDA realtime simulation codes and advanced PC graphics hardware with external sensor synchronization, demonstrate a conceptual architecture in a laboratory setting with simulation of communication overheads, routing issues, and network delays. Design and analyze a distributed HWIL process monitor and feedback architecture for implementation of a many node distributed ground test HWIL simulation or test.

PHASE II: Based on the investigation and analysis of Phase I, develop and integrate a prototype demonstration system based on current MDA physics-based real time codes and state of the art graphics scene generation hardware. Configure nodes for battle management, radar, IR, and kill vehicle sensors and signal processors.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Field Emission Displays, Bio-Assay Spectrometers, Chemical and Biological Detection, Infrared Spectrometers, Microchemical Processing.

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KEYWORDS: distributed scene generation, real time hardware in the loop, infrared scene generation, HLA, DIS, TENA, hardware in the loop, interoperability, modeling and simulation, grid computing, web services, enterprise computing

MDA06-049 TITLE: Simulation Tool to Intercept Multiple Missiles Employing Quick and Random Evasive Flight Path

TECHNOLOGY AREAS: Information Systems, Space Platforms

ACQUISITION PROGRAM: MS(DES) / AS(DV) / BC(DFB) / DT(DE) / GM(DFG) / KI(DFK) SS(DFS)

OBJECTIVE: Develop a simulation tool and supporting algorithms for effective team dispatching of multiple interceptors to destroy multiple missiles that are capable of randomly changing their flight paths on approach to target.

DESCRIPTION: Develop a simulation tool that accurately represents a variety of defensive missile scenarios and military operations and uses an efficient computational algorithm to quickly and effectively analyze and integrate flight path data for missiles that are specifically designed to elude interceptors via quick and random flight path changes while approaching their intended targets. The challenge is to develop the capability for an in-flight integrated intercepting strategy for multiple interceptors tasked with destroying multiple adversarial missile threats as quickly as possible while minimizing the expenditure of fuel, since the missiles will purposely elude interception for as long as possible to maximize the resources consumed by the interceptors. Key elements of this tool should include search-surveillance-engage modes, formation control and reconfiguration, information exchange, resource management, and flight path data fusion. The development of the proposed technology should also account for realistic constraints on the movement of the interceptors such as minimum turning radius and maximum velocity so that issues of coordination and cooperation among the interceptors should be addressed. In addition, sets of assumptions and technology enablers used in the development of the simulation tool should be clearly specified.

PHASE I: Develop a general framework for this simulation tool that can be used to represent a large class of missile defense scenarios by conferring with MDA personnel, especially in the sponsoring offices. Develop alternate approaches to obtain different degrees of optimal strategies of destroying random path-changing missiles.

PHASE II: Develop a proof-of-concept simulation tool to compute, analyze, and test intercepting-eluding strategies. Assess the feasibility of the proposed strategies and algorithm performance.

PHASE III DUAL USE APPLICATIONS: If the exit criteria of Phase II are met, the result of Phase II can be directly applicable to a variety of commercial and military missions that include track/geo-locate, network routing, missile defense and space persistent patrol.

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KEYWORDS: Multi-Agent Systems, Cooperative Control, Distributed Sensing, and Swarming

MDA06-050 TITLE: <u>Enhanced security features for Commodity Integrated Circuits</u>

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: MP(DEP) / GM(DFG) / AB(DFA) / TH(DFT) / AS(DV)

OBJECTIVE: To render impossible the misuse and reverse engineering of modern defense-related integrated circuits for purposes of replication or countermeasure development.

DESCRIPTION: It is often necessary to reach out to foreign-made integrated circuit technologies for missile defense systems. This topic focuses on ways to access the best technologies without comprising the ability to secure strategic advantages. MDA also seeks radiation hardened anti-tamper technologies to protect parts that are being introduced into the field in the event they fall into adversary hands. Examples include, but are not limited to: structured application specific integrated circuits, field programmable gate arrays, processors and other silicon based complex components.

PHASE I: The contractor shall develop a solid methodology for building radiation hardened anti-tamper components in foreign fabrication facilities with safeguards that preclude an adversary securing any critical technology information. The contractor shall perform an analysis and limited bench level testing to demonstrate the feasibility of manufacturing radiation hardened solutions in overseas locations. This phase should have demonstration manufacturability without necessary actual building prototypes.

PHASE II: The contractor shall demonstrate and validate functional prototypes of radiation hardened anti-tamper solutions that can be scaled to cost-effective production quantities. The contractor shall also provide compelling evidence that the properties sought in this solicitation are met through red-teaming, reward incentives, mathematical rigour, or a combination of these and other techniques. A partnership with a current of potential supplier of MDA systems, subsystems or components is highly desirable. Identify an commercial benefit or application opportunities of the innovation.

PHASE III: The contractor will seek to transition components for use in the Space Tracking and Surveillance System, MDA interceptor and DoD systems, or commercial applications. The contractor will demonstrate partnerships with system prime contractors or sub-tier suppliers for insertion into one or more MDA Element systems or subsystems. When complete, an analysis will be conducted to evaluate the ability of the technologies to protect against tampering in a real-world manufacturing situation.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This work can be of great benefit in digital rights management architectures, and high-value asset protection.

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KEYWORDS: radiation effects on electronics, single event effects, single event transients

MDA06-051 TITLE: <u>Ballistic Missile Defense Anti-Tamper Coating Manufacturing</u>

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: MP(DEP)

OBJECTIVE: Develop and implement new innovative anti-tamper (AT) coating manufacturing and application techniques that allow for the effective protection of critical electronics.

DESCRIPTION: The MDA Director has issued a directive necessitating the protection of critical program information from unintentional transfer and the policy for the implementation of anti-tamper technology on MDA acquisition and associated technology programs. AT technology consists of engineering activities that prevent and/or delay 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 effort will focus on developing innovative AT techniques and technologies that provide protection from reverse engineering and compromise of both hardware and software. Attention will be placed on integration into weapons platforms and their “real-time” processing requirements. As a result, the MDA will maintain a technological edge in support of the war fighters. Additional information on Anti-Tamper within the Department of Defense may be obtained at the DoD Anti-Tamper Executive Agent website, http://www.at.hpc.mil/index.htm.

The intended research area is the development of innovative manufacturing, producibility, and application processes for anti-tamper coatings. Specifically, investigations into 1) coating application processes that are compatible with the environment suitable for electronics; 2) cost effective manufacturing processes for a coating that functions as required; and 3) techniques for monitoring the health of electronics during and after the application of anti-tamper coatings. The critical issue for protective coatings is ensuring the additional manufacturing step of applying, curing, and long-term exposure of the coating does not affect the functionality of the underlying electronic component. The anti-tamper coating manufacturing and application processes investigated and developed may include the development of technical procedures and equipment.

There have been previous DoD funded research efforts into the development of anti-tamper coatings, but this focus area is for improving the ability to produce an anti-tamper coating that performs as required while not damaging or limiting the life of the electronics.

PHASE I: The contractor shall develop the conceptual framework for new and innovative AT coating manufacturing, producibility, and application processes. The contractor will also perform an analysis and limited bench level testing for an understanding of issues in manufacturing and applying anti-tamper coatings in a safe manner to critical electronics.

PHASE II: Demonstrate and validate the use of AT coating manufacturing, producibility, and application techniques into one or more prototype efforts and estimate the effectiveness of the techniques. A partnership with a current or potential supplier of MDA systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

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

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in manufacturing processes take place at the supplier/subcontractor 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 producibility or performance of products that utilize innovative process technology.

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KEYWORDS: Anti-Tamper (AT), Electronics, Coating materials, Reverse Engineering, Hacking, Exploit

MDA06-052 TITLE: Ballistic Missile Defense Anti-Tamper Volume Protection

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Space Platforms

ACQUISITION PROGRAM: MP(DEP)

OBJECTIVE: Develop and implement new innovative anti-tamper (AT) volume protection technology for the protection of critical technology against exploitation.

DESCRIPTION: The MDA Director has issued a directive necessitating the protection of critical program information from unintentional transfer and the policy for the implementation of anti-tamper technology on MDA acquisition and associated technology programs. AT technology consists of engineering activities that prevent and/or delay 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 effort will focus on developing innovative AT techniques and technologies that provide protection from reverse engineering and compromise of both hardware and software. Attention will be placed on integration into weapons platforms and their associated hardware and software. As a result, the MDA will maintain a technological edge in support of the war fighters. Additional information on Anti-Tamper within the Department of Defense may be obtained at the DoD Anti-Tamper Executive Agent website, http://www.at.hpc.mil/index.htm.

The intended research area is the development of innovative volume protection technologies and techniques that can be integrated and are compatible with commercial-off-the-shelf (COTS) and military hardware. Such measures could be integrated with hardware to add an additional layer of protection, without significantly changing the appearance, functionality, or performance of the system. These measures must show potential to monitor and/or react to tamper events that may lead to unauthorized access to critical program information (CPI). Though the particular solution may be tailored to an individual design, the concept and methodology of the solution should be applicable to various COTS and military hardware.

The focus is to develop volume protection that is 1) difficult to detect or identify (visible, x-ray, microscope, etc.) and 2) seamlessly integrated with the volume being protected. This new and innovative volume protection technology should have the ability to be configured to simply detect a tamper event or to detect and react to a tamper event.

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

PHASE II: Demonstrate and validate the use of AT volume protection technologies into one or more prototype efforts and estimate the effectiveness of the techniques. A partnership with a current or potential supplier of MDA systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

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

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in manufacturing processes take place at the supplier/subcontractor 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 producibility or performance of products that utilize innovative process technology.

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KEYWORDS: Anti-Tamper (AT), Electronics, Volume protection, Reverse Engineering, Exploit

MDA06-053 TITLE: Reduced Print Thru in HEL Deformable Mirrors

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

ACQUISITION PROGRAM: AL(DFL)

OBJECTIVE: Improved HEL system performance for longer HEL run times and larger target salvos.

DESCRIPTION: Performance of HEL systems is driven in part by their ability to compensate for the distortions that are present in the optical path of the HEL. A wavefront control system is used to compensate for these distortions increasing the intensity of the laser beam at the target. This control system makes a measurement of the distortions with a wavefront sensor and sends correction signals to a deformable mirror that is in the path of the HEL. The number and spacing of the actuators in the deformable mirror is set by the smallest anticipated spatial frequency of the distortions. The wavefront sensor devotes a subaperture to command each of the actuators in the deformable mirror. The number of control system channels corresponds to the number of sensor subapertures and actuators. The control system spatial frequency response will be limited to be less than the actuator spacing by the Nyquist criterion. When present day deformable mirror designs are run for extended periods of HEL illumination, the deformable mirrors generate their own thermal distortions that essentially map the pattern of the actuators under its faceplate. This distortion is predominantly at the actuator spacing and thus cannot be compensated by the wavefront control system. The next generation of deformable mirror designs must incorporate materials for the substrates and actuators that reduce the thermal distortion of the mirror, and especially the distortions that map the location of the actuators.

PHASE I: In the proposal, review the requirements for the deformable mirrors that are needed for future HEL applications that need to address multiple salvos, longer range applications or commercial applications that require long run times. In the proposal, assess the design of the present day deformable mirrors and examine the fundamental parameters that limit their use at longer run times. Develop innovative and creative concepts to reduce the thermal distortion of deformable mirror under long time HEL radiation. Conduct detailed finite element thermal analyses of the proposed concept that shows truly innovative breakthroughs in long term thermal performance. Phase II Program Plan that designs, fabricates and tests under high power loading, the design selected during Phase I.

PHASE II: Construct a subscale model of the proposed deformable mirror design formulated during Phase I using the required materials and processes proposed in Phase I. Conduct high power laser experiments with the subscale model and compare the results to predictions using the same analysis codes used in Phase I. The subscale model must be of a size that allows resolvable measurements to be made, giving reasonable confidence that the design will meet requirements at full scale. Propose a Program Plan for the construction of a full size deformable mirror that could be a form, fit and function replacement for the ACDM or BCDM in future spirals of the ABL program.

PHASE III: Construct a full size deformable mirror that could be a reasonable form, fit and function replacement for the ACDM or BCDM in the ABL system in future spiral upgrades. Conduct testing of the deformable mirror at high power with equivalent thermal loading, i.e., increased absorption with laser power levels obtainable at present day COIL laser facilities. Compare the thermal distortion at long run times to model predictions of the thermal distortion, especially those that are not correctable by the closed loop wavefront control system.

PRIVATE SECTOR COMMERCIAL POTENTIAL: HELs have been proposed for many industrial applications such as welding, cutting and material processing. Use of HEL for commercial applications will require the use of deformable mirrors, especially in the resonator cavity, to achieve optimum performance. Understanding the design and performance of the SOA in materials and processes will lead to deformable mirror designs for these systems that meet requirements and will be more cost effective.

KEYWORDS: Airborne Laser, COIL Laser, Wavefront Control, Deformable Mirror, Thermal Distortion

MDA06-054 TITLE: ABL (Airborne Laser) Detection Sensor Improvements

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: AL(DFL)

OBJECTIVE: The objective of this effort is to enhance the ability of today’s airborne surveillancesystems to detect, classify, and track ballistic missiles for missile defense. While the primary focus of this effort is enhancement of detector capability, advancements in the other components of an infrared surveillance system that result in improved capability are also desired.

DESCRIPTION: The current ABL sensor system utilizes a scanning array based on outdated technology. Recent and emerging technologies could make significant gains for ABL’s surveillance capabilities. By sensor we mean lasers, entire transmitter systems, detectors, and/or entire receiver systems. ABL desires improvement in sensor capability in the following key areas (although all areas of improvement will be considered):

1) Increased FOV for each single measurement.
2) Increased maximum detection range.
3) Increased capability to correctly discriminate between ballistic missile targets and other types of tracks.
4) Increased angular resolution for a 2-D passive only angle-angle track. Desired capability is for a 3-D position track with enhanced resolution. Finally, the optimal solution includes a 3-component velocity estimate with high accuracy.
5) Short pulses (of no more than a few to enable good range resolution).
6) Average power of greater than 12 Watts. For multiple pixel FOVs, even higher average powers may be required.
7) Minimize weight, volume, power and cooling requirements to support airborne applications.
8) The following environmental capabilities are desirable: operate at 50k feet, survive temperatures of -30 to +60 C, and survive 10g shocks.

While the current ABL sensor system uses LWIR detectors and an active laser ranging system, the focus of this effort is not limited to any particular detector band or technology. The sensors could be direct detection systems or coherent detection systems. The ABL program is interested in all technology solutions that could improve its sensor performance that can be packaged for an airborne application.

PHASE I: Analyze proposed sensor technologies and applications for performance improvement. Evaluate initial packing issues and technology capability. Laboratory demonstrations of candidate technologies would be considered a plus.

PHASE II: Develop and test a bread-board/brass-board level advanced sensor system. Include sufficient analyses to evaluate system performance across a spectrum of both operating conditions and inputs (including targets, clutter, and background effects). Evaluate and characterize packaging issues to support airborne installation and operation.

PHASE III: Develop flight-certified surveillance systems that can be installed on a variety of DoD aircraft (to include ABL and other airborne surveillance platforms). Private Sector Commercial Potential: These systems could be used to support Drug Enforcement and Homeland Defense (Border Control) activities. Additionally, the enhancements in the core detector technology could support a variety of manufacturing applications where process monitoring via proposed sensing technology occurs.

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KEYWORDS: Surveillance, Detector, Missile Defense, and Airborne

MDA06-055 TITLE: High Performance, Long Life, Lightweight, Corrosion Resistant Valves

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

ACQUISITION PROGRAM: AL(DFL)

OBJECTIVE: Improve the reliability and lifetime and reduce the overall system weight for the numerous, currently pneumatically actuated, flight qualified valves used by the Airborne Laser (ABL) Program.

DESCRIPTION: The ABL Chemical Oxygen Iodine Laser (COIL) creates a lasing medium by utilizing Chlorine to produce Singlet Delta Oxygen (SDO) which in-turn dissociates a separately supplied Iodine molecule and then excites the resulting Iodine atom for lasing. Both Chlorine and Iodine are extremely caustic substances and require great care when handling. Of particular importance is the lifetime of high performance valves used to meter these substances as well as all other ABL fluid products (Helium, Nitrogen, ammonia and Hydrogen Peroxide). The desired lifetime performance goals are three years continuous exposure to all ABL chemicals and a minimum of 4000 cycles before replacement/refurbishment. These valves must be able to turn on and shut off in the continuous range between 10 ms to 150 ms. Since the valves must operate on an aircraft, overall contribution to ABL system weight is an important consideration. Finally, it is required that the product be utilized in the operational environment of the ABL while being capable of being easily serviced. The desired end product would be a Line Replaceable Unit (LRU) for reliably and precisely handling all ABL fluid products. If these results are realized, it would provide significant synergistic benefits to the ABL weapon system to include reduced payload weight, more reliable operation, a safer operational environment and a reduced logistics footprint.

Proposal presenters are encouraged to show innovative methods for the development, production, test and delivery of reliable, high performance, long life, lightweight, corrosion resistant valves for operation of the ABL system suitable for its operational environment. Proposals for accelerated development are strongly encouraged.

PHASE I: Establish a list of innovative concepts for achieving the goals above. Select the most promising approaches and conduct verifiable modeling and/or subscale experiments of the most promising concepts that have a clear traceability to the ABL system. Resistance to the chemical environment must be clearly demonstrated in this phase by all candidate materials as well as a high confidence pathway to high cycle capability. Based on results, develop Preliminary Concepts for preferred candidate devices and Phase II Program Plan for the design, fabrication and test of devices to validate the selected concepts. The program plan shall include down-select criteria and alternative approaches should initial testing invalidate the initial candidates selected.

PHASE II: Execute the Program Plan developed in Phase I as directed by the government. Conduct a Concept Design Review for the candidates selected in Phase I and prioritize this list for further development. Conduct fabrication, integration, testing, and test reporting for the two to three leading candidate devices as specified in the proposed Program Plan. This test report must discuss fully how key technical challenges were overcome and risks mitigated. Select the leading candidate for meeting the established program goals; identify any improvements based on work to date and conduct a Preliminary & Critical Design for the improved device. Quantify weight, cost and maintenance/supply improvements to be expected if this device should be selected for production. Develop a Phase III Program Plan that will include your production and test strategy for an operational device. Identify remaining key technical challenges, risks, and risk mitigation strategies.

PHASE III: Design a methodology for full scale production. Validate weight, cost and maintenance/supply improvements to be expected for device in production. Initiate Limited Rate Initial Production. Perform full scale acceptance tests on the initial production units to validate baseline performance. Based on test results and Government direction, initiate full scale production and estimate requirements for long range production. Design a methodology for pre-planned product improvement (P3I).

PRIVATE SECTOR COMMERCIAL POTENTIAL: More efficient and maintainable handling of hazardous chemicals has numerous potential commercial applications for firms that recurrently handle these products. Improved COIL processes also benefit the industrial use of high power lasers for welding, cutting, and other material process applications which require lasers with high power output and excellent beam quality.

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KEYWORDS: Airborne Laser, Chemical Oxygen Iodine Laser (COIL), Iodine, Chlorine, Valves, Pneumatic, Solenoid, Flight qualified