MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS INNOVATION RESEARCH PROGRAM (SBIR)
SBIR 05.3 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 1-800-WIN-BMDO. 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.acq.osd.mil/bmdo.

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 2005 through 13 Sept 2005), contact the Topic Authors listed under each topic on the http://www.dodsbir.net website before **COB** 13 Sept 2005.

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.14 October 2005 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. If the Phase I option is exercised the option amount will count against the Phase II base program. 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.

An MDA SBIR Working Group then reviews the entire Phase II Invitation list and forwards their recommendations to the MDA Source Selection Authority for final approval.

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 be sent to the MDA SBIR Program Manager at the address listed below, to the designated Contracting Officer's Technical Monitor (the Technical Point of Contact (TPOC)) for the contract, and the appropriate Execution Activity SBIR Program Manager (Electronic submission will not be accepted).

Missile Defense Agency
MDA/SB Attn SBIR Program Manager
7100 Defense Pentagon
Washington, DC 20301-7100

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. While not guaranteed, MDA may consider a limited number of Phase II enhancements on a case-by-case basis. 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. 14 October 2005.

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

MDA SBIR 05.3 Topic Index

MDA05-050	Multi-sensor tracking techniques
MDA05-051	Software Formalisms
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MDA05-055	~~Automated Software Analysis and Visualization~~ *Duplicate: Please submit proposals to MDA05-052*
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MDA SBIR 05.3 Topic Descriptions

MDA05-001 TITLE: Developing Insensitive Munitions Technology for Missile Defense

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: BMDS/QS

OBJECTIVE: Develop and demonstrate innovative insensitive munitions (IM) technologies to moderate the response of large diameter (12 inches or greater) solid rocket motors (SRM) to unplanned stimuli such as heat, bullets or high-speed fragments.

DESCRIPTION: The Department of Defense (DoD) is required by statute to have programs that utilize Insensitive Munitions (IM) technologies. The current technology used to minimize the effects of unplanned stimuli on SRMs is insufficient and new IM technologies must be developed. Current large SRMS tend to react violently when exposed to fire, bullets and fragments. Over the years, the IM response of bombs, rockets and small missiles have been greatly improved, and now technology improvements for SRMs is the Department of Defense's number one IM priority. Exploitation of new IM concepts could provide sufficient enabling technologies to assist SRM programs in applying the technologies to improve IM compliance. The Missile Defense Agency (MDA) SRMs will be deployed and/or transported on ships, airplanes and land, thus technology that can benefits SRMs in all aspects of SRMs lifecycle are of a particular interest. MDA is also interested in technology geared towards 12-18 inch diameter and 20-24 inch diameter SRM groups. Areas of study include but are not limited to IM compliant propellants for large diameter SRMs and novel motor case/container venting techniques to mitigate the severity of reactions. Particular venting technologies of interest include, but are not limited to sensors that safely sense and initiate venting action when required, but not before; and permanent or removable venting hardware. The ideal reaction to unplanned stimuli would be no reaction or simple burning. Proof of concept and initial sub-scale IM testing of proposed solutions is part of this effort to demonstrate improved safety, the IM benefits, and effects on performance.

PHASE I: Define and identify concepts for IM technology improvements and new technologies for SRMs which include but are not limited to new energetic material formulations andmotor case/container venting technology. Identify the possible IM benefits and outline a proof of concept test plan, which can include but are not limited to testing of new energetic materials to obtain valuable characterization data, and analog or sub-sale motor test designs and venting tests. The use of MIL STD 2105C for designing, conducting and evaluating IM test programs is highly desirable.

PHASE II: Begin proof of concept testing. Demonstrate the new IM technologies and their applications. These activities could include analog and/or sub-scale tests to demonstrate compliance with individual IM performance parameters. Outline a plan that specifies what further work needs to be completed before the technology can be inserted into solid rocket motor development efforts.

PHASE III: Complete the work that will make the new technologies ready for insertion into SRM development programs. Validate the IM technologies including modeling and simulation techniques that can be utilized to reduce cost and speed of SRM development.

DUAL USE COMMERCIALIZATION: Development of IM technology in support of military and commercial research is a rapidly growing scientific endeavor. The proposed effort would be extremely useful in helping to ensure the safety of personnel exposed to explosives in commercial mining and commercial space flight applications (eg. solid rocket boosters). In addition, IM technologies provide the ability to reduce Department of Transportation Hazard Classifications to enable more economical and efficient commercial transportation of explosive materials.

REFERENCES:
1. "Insensitive Munitions Technology for Tactical Rocket Motors" by Andrew Victor 1993
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: Explosive, booster, propellant, rocket motor, missile, ballistic protection, thermal protection, energetic material.

MDA05-002 TITLE: Developing New Insensitive Munitions Packaging Solutions for Missile Defense

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: BMDS/QS

OBJECTIVE: Develop innovative insensitive munitions packaging concepts to protect solid rocket motors (SRM) greater then 12 inches in diameter or greater from unplanned stimuli such as heat, shock and bullet/fragment impact.

DESCRIPTION: Federal law requires that the Department of Defense (DoD) munition programs comply with insensitive munitions (IM) criteria. Unique packaging solutions need to be identified for large diameter SRMs. MDA is specfically interested in technology geared towards 12-18 inch diameter and 20-24 inch diameter SRM groups. Concept definition of unique packaging solutions for large diameter SRM programs is the focus of this effort. Efforts can include but are not limited to ballistic protection, novel shipping containers, case designs or new ways of placing the propellant in the motor itself and should outline how the concept improves the IM characteristics of the motor. The concept should address IM threats during a traditional munitions lifecycle, which can include deployment and/or transportation by sea, land and air. Include initial IM testing on sub-scale models to demonstrate the viability of proposed solutions is also part of this effort. Testing of the packaging solutions will need to be conducted proving increased safety without decreasing performance. Analysis and interpretation of this data is required. The use of MIL STD 2105C for the design, conduct and evaluation of IM test programs is highly recommended.

PHASE I: Define concepts for IM packaging improvements and how they will improve the IM performance of the motor. Develop models to predict the acceptability of the packaging concepts and sub-scale test plans to demonstrate the acceptability of packaging concepts to mitigate IM threats.

PHASE II: Build prototype test articles and demonstrate new IM packaging designs through IM testing. Analyze and interpret data from test results. Outline what further development or research is needed to begin incorporation into a large diameter solid rocket motor system. Provide data in support of modeling and simulations.

PHASE III: Finalize designs and validate by conducting and evaluating IM tests. Provide additional data in support of IM Modeling and Simulations. Outline how the designs can be incorporated into full-scale rocket motor systems.

DUAL USE COMMERCIALIZATION: Development of insensitive munitions technology in support of military and commercial research are rapidly growing scientific endeavors. The proposed effort would be extremely useful in helping to ensure the safety of personnel exposed to explosives in commercial mining and commercial space flight applications (eg. solid rocket boosters). In addition, IM technologies provide the ability to reduce Department of Transportation Hazard Classifications to enable more economical and efficient commercial transportation of explosive materials.

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: Explosive, booster, missile, ballistic protection, insensitive fill, thermal protection, venting, packaging, motor case

MDA05-003 TITLE: Developing Insensitive Munitions Modeling and Simulations for Missile Defense

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Weapons

ACQUISITION PROGRAM: BMDS/QS

OBJECTIVE: Develop innovative algorithms, build modeling and simulation tools, and populate a material database, which would support the development of insensitive munitions (IM) technologies for use in the development of large solid rocket motors (SRMs) (12 in. in diameter or greater).

DESCRIPTION: This program will develop/populate a physics- and chemistry-based modeling and simulations (M&S) toolkit to predict the systemic response of weapons to unplanned stimuli. The concept should address IM threats during a traditional munitions lifecycle, which can include deployment and/or transportation by sea, land and air. Population of the toolset with IM and Hazard Classification test results will support future acquisitions of large SRMs. A reduction in future IM destructive test costs and an improved IM response from missile systems selected in the future are expected outcomes. Propellant confinement techniques and dynamic responses of propellants with hydroxyl-terminated polybutadine (HTPB) binders need to be studied for better understanding of related design impact. The state of the art technology available to minimize effects of unplanned stimuli on missiles must be fully understood and new IM technologies must be developed. Population of the M&S toolkit and development of related modeling tools and algorithms are required to obtain compliance with Department of Defense (DoD) IM policy and certification of future Missile Defense Agency (MDA) systems.
This effort requires the creation and population of a database. Focus should be on cost effective IM response modeling and simulations.

PHASE I: Outline what data and testing would be needed to develop/create a database that can be used as a basis for developing an algorithm that can be used for IM predictions and correlation factors in SRMs. The data should cover a wide range of energetic materials (hazard class 1.1 thru 1.6) as well as leverage existing data to begin the initial population/creation of a database, which can include but is not limited to reaction violence, formulations and IM characteristics in relation to known IM stimuli. Emphasis should be placed on HTPB and other energetic materials used in SRMs. Outline initial ideas on how the data can be correlated and put into algorithms to help predict IM responses.

PHASE II: Collect needed data to begin developmental and prototyping of physics-based M&S capability to solve/determine how HTPB and other solid rocket formulations will react to IM stimuli. The models should try to focus on correlation with experimental data being scale up from small bench test to larger analog test predictions. Propellant reaction models should included dynamic responses and confinement responses. Outline a test plan to verify algorithms and models and what further data will be needed to make a more complete model.

PHASE III: Continue to collect data to add to database and refine models and algorithms. Begin steps to verify M&S prediction of solutions for protection against unplanned stimuli for large SRMs. Finalize the design of the M&S toolkit for at least one propellant type. The IM M&S models should be easily modified for incorporation into future MDA programs.

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 and commercial mining applications.

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 Insensitive Munitions Information Center (http://www.nato.int/related/nimic)
5. “US DOD IM Program” by Anthony J. Melita (http://ww.dtic.mil/ndia/2003gun/mel.pdf)
6. “Hazard Assessment Tests for Non-nuclear Ordnance”, Military Standard, Mil-Std-2105B, 1994
7. “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

MDA05-004 TITLE: Hyperspectral/Multispectral imaging for transient events

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: BMDS/AS

OBJECTIVE: Investigate new compact high-speed multi/hyperspectral sensing concepts for kill assessment, boost phase discrimination, and other target discrimination applications.

DESCRIPTION: Most current proven spectral data acquisition capability involves spectral information dispersed along one detector axis and spatial information to be acquired by mechanical or optical scanning. The delay in acquiring the 2D field of view and all spectral bins (datacube) results in spatial/spectral decorrelation due to fast objects moving through the FOV while the spectral data is being acquired. Novel approaches are required for “flash” imaging spectroscopy of high dynamic range very high speed transient events.

An example is accurate kill assessment. Determination of the likelihood of a successful intercept kill is required for interceptor tasking. Hyperspectral/Multispectral phenomenology in the UV-SWIR may provide information on intercept effectiveness as well as payload type. For instance, atomic emission of heavy metals within the fireball may be measured using a visible, high-speed spectrometer. Two band ratios can be used to measure fireball temperature as a function of time, where the fireball temporal temperature signature can be used to estimate kill effectiveness. The kill event fireball is very transient and measurements must be made by high speed sensors coupled to high-speed electronics allowing sampling rates of 100 kHz to 10MHz for several hundred to thousands of frames. For single impact events the sensor need not be a detailed imaging sensor but should be capable of a relatively large field of view.

For initial fireball flash analysis spatial resolution requirements are minimal. For longer time fireball and debris cloud growth and cooling evolution, spatial discrimination is needed to determine the extent, time history and composition of the impact area and debris cloud. Spectrally information is desired about the high energy spectral content at impact and the time dependent low energy spectral-thermal history of the debris cloud after impact.

To accommodate a wide set of phenomenology’s, only a few of which are mentioned here, the sensor response needs to be scalable from 200nm-12000nm. One instrument will probably not cover the entire spectral range due to optic component consideration but the concept should be applicable to any wavelength. The spectral resolution should be sufficient to capture the phenomenologies proposed, and need not be continuous or constant resolution over the full waveband.

Concepts are also desired that provide snapshot framed-spatially resolved imaging spectrometry of single extended plumes or groups/clusters of high temperature objects such as missile plumes at high frame rates to support booster analysis and discrimination algorithm development/validation. High frame rates (100’s Hz-kHz) are required to resolve transient events during boost such as chuffing and organ mode temporal resonances that aid in booster analysis and discrimination algorithm evaluation. The two-dimensional, spatially segmented image information coupled with the multispectral SWIR/MWIR/LWIR information can provide temperature spatial maps of the boost plume through band ratio techniques as well as spatially resolved combustion spectra of the plumes. Spatial temperature may be of use to aid determination of propellant type, engine size and likely booster heritage.

This technology concept would also supports dynamic analysis of IR transients and countermeasures. The system should be smaller and lighter than current technologies and robust enough to demonstrate a growth path toward a fly-away instrument, missile, airplane, or other high altitude platforms.

PHASE I: Develop a system design for a high frame rate hyperspectral/multispectral assessment sensor. Technical analysis should be provided that supports the proposed design and includes estimation of sensor noises. The design should provide sufficient technical justification as to the likelihood of effectiveness of the system. Demonstrate critical component technologies in laboratory breadboard experiments.

PHASE II: Construct and test prototype configurations to demonstrate the concept feasibility for the hyperspectral/multipsectral assessment sensor. During the Phase II, the contractor shall build a working breadboard-brassboard prototype of the sensor design put forward in Phase I. One possible experimental verification may be demonstrated during a scaled impact test (gas gun or sled track). Identify and reduce the risk of component technologies needed to perfect the design and demonstrate the approaches needed toward a flight capable instrument.

PHASE III: Transition to development of a flight instrument for high altitude or space experiment applications for MDA, DoD, and civilian science applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This system can be used as the basis for a scanning hyperspectral sensor for remote sensing for geologic delineation, forestry management, oil spill mapping and sediment transport studies. Also, laser processing of materials, welding process development, deep space and earth resource spectroscopy of upper atmospheric discharges.

REFERENCES:

1. E. K. Hege, D. O'Connell, Oceanit, Inc., W. Johnson, E. Dereniak, “Hyperspectral imaging for astronomy and space surveillance using CTIS”, Proceedings of SPIE Vol. #5159, Imaging Spectrometry IX , 6-7 August 2003, http://bach.as.arizona.edu/~hege/CTIS/SPIE_2003.pdf

2. Edelson, M. C., DeKalb, E. L., Winge, R. K., and Fassel, V. A., "Analytical Atomic Spectroscopy of Plutonium-I. High Resolution Spectra of Plutonium Emitted in an Inductively Coupled Plasma," Spectrochimica Acta, Vol. 41B, pg. 475, 1986. .

3. J. M. Mooney, V. E. Vickers, M. An, A. K. Brodzik, “A High Throughput Hyperspectral Infrared Camera”, Journal of Optical Society of America A, 14(11), 2951-2961, (November 1997).

4. C. E. Volin, J. P. Garcia, M. R. Descour, E. L. Dereniak, D. T. Sass, C. G. Simi, “Demonstration of a MWIR high-speed nonscanning imaging spectrometer”, Proceedings of SPIE Vol. 3718, Automatic Target Recognition IX, Published 1999.

KEYWORDS: kill assessment, hyperspectral, missile defense, atomic emission spectroscopy, plume, imaging spectrometer, flash spectrometer, impact flash, infrared

MDA05-005 TITLE: Exo-Atmospheric Seeker Performance Enhancement

TECHNOLOGY AREAS: Materials/Processes, Sensors, Space Platforms

ACQUISITION PROGRAM: BMDS/GM/AB/AS

OBJECTIVE: Develop technologies that lower cost and enhance Infrared Seeker performance in Exo-Atmospheric Kill Vehicle and other BMD exo-atmospheric IR sensor platforms (KEI, MKV, SM-3, etc.). Ideally, the innovative technologies should increase seeker acquisition range, expand FOV, improve target resolution, optimize Kill Vehicle navigation, and refine aimpoint selection.

DESCRIPTION: MDA is seeking innovative technologies that should be scalable to fit into the current seeker envelope (mass and volume) and be available for insertion in the 2010-2012 timeframe. Major components being considered for enhancement are a) Large Format Multi-Color FPA, b) Light Weight Zoom Optics, and c) Integrated IMU/Sensor. A known and acceptable design and development risk is associated with these technologies. The contractor should be innovative and knowledgeable of the current state-of-the-art technologies related to these areas.
a) Large Format Multi-color Focal Plane Arrays (FPA) development: The existing EKV seeker technology relies on multiple Long Wavelength Infrared (LWIR) Focal Plane Arrays (FPAs), filters, beam splitters, Read-Out Integrated Circuits (ROICs) and cooling circuits to perform multi-color sensing to acquire, track, and discriminate objects. Problems with spatial co-registration of targets and sensor calibration complicate system design and reduce system reliability. A larger (512 x 512) simultaneous/same-pixel multi-color LWIR/LWIR FPA with high pixel uniformity, smaller pixel size (~ 25 micrometer), reduced readout noise, improved resolution, and operability would improve an EKV seeker's ability to acquire, track, and discriminate objects. A reduction in cost, volume, and mass is achieved by incorporating multiple-FPA features in a single, large full-resolution FPA. The Normalized Detectivity (D*) of large format two color FPA should approach BLIP limit for LWIR (8 – 12 micrometer).
b) Light Weight Zoom Optics: The incorporation of a compact, light weight, all-reflective, zoom optical system with a large format FPA (512 x 512) would improve on-board discrimination performance of the exo-atmospheric system. This enhancement would provide a larger field-of-view (FOV) that would shorten search time, enable resolution of objects at longer acquisition ranges, and improve resolution in end game. Better resolution of objects in end-game enhances aim-point selection.
c) Integrated IMU/Sensor Electronics: An exo-atmospheric Inertial Measurement Unit (IMU) must be moved from test suite to test suite with absolutely no relative motion to the sensor. An innovative approach utilizing advanced technology to integrate the IMU and Sensor Electronics in a way that reduces weight, volume, density, enhances shielding, and incorporates thermal management features is sought. Electronics must share a common housing that incorporates EMI and ionizing radiation hardening. Integration into a common modular structure would reduce the common cabling from each separate unit to the Electronic Unit (EU). This approach eliminates the common cables associated with the low noise analog amplifiers and the analog-to-digital sampling circuits. These noise sensitive circuits not only require the shielding described above but they also require a conditioned low noise power source. From a cost savings perspective this modular configuration and design approach could yield benefits down stream as the concept is expanded to include the entire interceptor kill vehicle structure.

PHASE I: Design and develop a new and innovative component technology that will improve the seeker performance. Demonstrate the feasibility of the proposed concept and technologies.

PHASE II: Demonstrate technology in a breadboard configuration that is scaleable to proposed component requirements that satisfies the validation of its operation in the MDA's exo atmospheric seeker system. The contractor should coordinate with the prime contractor for detail system requirements and specifications. Identify technology applicability to selected military and any commercial benefit.

PHASE III: During Phase III the effort calls for engineering and prototype development, test and evaluation, and hardware qualification demonstration in a system level test-bed which shows application to an insertion potential into one or more exo-atmospheric seeker system.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Technologies have potential for incorporation in instruments that can be used in a wide variety of commercial environmental/remote sensing monitoring systems, homeland security, industrial and medical sensors, and aerospace systems requiring lightweight zoom optical systems.

REFERENCES:
1. J.S.Acceta and D.L. Shumaker, "The infrared and electro-optical systems handbook", SPIE Optical Engineering Press, Bellingham, Washington, 1993.
2. Becker, L. S. R., "Multicolor LWIR focal plane array technology for space and ground based applications," Proc. SPIE, Vol. 5564, p. 1-14.
3. Sood, A. K., et. al., "Design and development of multicolor detector arrays," Proc. SPIE, Vol. 5564, p. 27-33.
4. Dhar, N. K. and Tidrow, M. Z., "Large format IRFPA development on Silicon," Proc. SPIE, Vol. 5564, p. 34-43.
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6. Dual-band infrared focal plane arrays; Rogalski, Antoni; Proc. SPIE Vol. 4340, p. 1-14.
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9. Mann, Allen, Infrared Optics And Zoom Lenses, SPIE, TT 42, 2000.
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12. Chatfield, A. B., Fundamentals of High Accuracy Inertial Navigation, AAIA, 1997.

KEYWORDS: LWIR, Large Format FPA, Dual Color FPA, Compact, Infrared, Zoom, Reflector, Anastigmatic, Telescope, IMU

MDA05-006 TITLE: Manufacturing and Assembly of Innovative Electro-Optical Components and Systems

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: BMDS/MP/SS/GM

OBJECTIVE: Develop innovative products, manufacturing and assembly technologies that improve quality, reliability, and producibility of integrated optical sensor systems, components, and subcomponents for Ballistic Missile Defense systems (BMDS). Innovations sought include design, manufacturing and integration/assembly methods that will maintain or improve the high performance of electro-optical sensor infrastructures for missile interceptors and satellites while easing the effort required to perform integration and testing.

DESCRIPTION: Many missile defense products are fabricated in an R&D or laboratory environment; integration and testing of these products is usually a custom job which is both expensive and time-consuming. Furthermore, as sensors are integrated, there is continuing need for calibration, verification testing and alignment checking, all of which can be technically challenging, costly, and time consuming. The general trend is for long processes that require higher skill levels to drive the cost, and so decreasing the fabrication time is expected to provide the greatest cost savings. In many cases, the optical integration processes lead to significant technical, schedule and cost problems for the entire program. As a result, MDA is seeking innovative approaches that will significantly reduce the cost and time required for manufacturing and integration of optical detectors and sensor components of the BMDS. MDA is also interested in process technology that facilitates the transition of a product (breadboard, brass board or prototype) from an R&D environment to any manufacturing environment (commercial, defense or both).

Technical areas of interest include, but are not limited to:
1. Manufacturing of optics (mirrors, filters, and beam splitters), telescopes, optical components for Ladar, and optical train components. All wavelength bands from UV to Very Long IR are of interest, and the goal is to enable high manufacturing yield and low cost while not sacrificing the high quality required in optical systems. An example of “high quality” is 1/60-wave or the 1-50 nanometer-level tolerance of the front face of an optical element. While the details of each operational system drive the specific timelines, a general timeline goal is to move the manufacture of optical systems from 1-3 years down to 1-3 months.
2. Telescope designs that are scalable and amendable to modular assembly.
3. Advanced assembly and mounting methods capable of achieving optical-level precision and tolerances in the final system while reducing the cost of labor and custom equipment required for performing sensor/optics assembly. For example, the use of new materials and processes that speed the fabrication process may either enable or require new methods of mounting; a specific example is the precision mounting of a boron carbide element, where the potential for significant mass advantages with a high-stiffness material is tempered by the difficulty in seemingly-mundane tasks such as grinding precision mount surfaces or designing the mechanical connection. A different example is the introduction of an automated alignment procedure during assembly in which the assembly tolerances are achieved through movement of actuated optical elements or even independently-actuated mounting locations.
4. Novel optical metrology technologies for rejection of stray light, filtering, imaging, calibration, alignments, and /or bore-sighting of optical systems for high resolution and near-distortion-free imaging of targets.
5. Innovative optical inspection techniques for ensuring or improving the quality of the optical components and systems. These must be capable of being easily and cost-effectively incorporated during the manufacturing of optical components such as mirrors, beam splitters, and telescopes. A traditional optical-metrology process involves

measurement of optical error in a completely different environment and fixture with a different piece of equipment, and the fabrication timeline is driven by the exchange of parts between companies or elements of companies; one example of an envisioned innovation would be a metrology system integrated with the fabrication hardware for immediate feedback of error to the optical finishing tools.

PHASE I: Develop conceptual framework for electro-optical component product design, manufacturing approach or integration method that will improve performance, lower cost, or increase reliability of BMD element systems, subsystems, or components. Identify a key technology in that framework and demonstrate its high impact to MDA through initial analysis and possibly experiment. Offerors are strongly encouraged to work with system and payload contractors to help ensure applicability of their efforts and to facilitate future technology transition.

PHASE II: Validate the feasibility of an electro-optical product technology by demonstrating its use in the 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 printing, semi-conductor manufacturing, astronomy, and medical fields.

REFERENCES:
1. http://www.acq.osd.mil/mda/mdalink/html/sensors.html
2. Infrared Detectors and Systems, E. L. Dereniak and G. D. Boreman, John Wiley & Sons, Inc., 1996.
3. Infrared & Electro-Optic Systems Handbook, eds. Wolfe and Zissis.
4. Telescope Optics: Evaluation and Design, William-Bell, Inc., 1988.

KEYWORDS: manufacturing, integration, assembly, optical trains, optical sensors, optical components, telescopes, metrology, inspection.

MDA05-007 TITLE: Advanced Sensor Materials for Space

TECHNOLOGY AREAS: Materials/Processes, Sensors, Space Platforms

ACQUISITION PROGRAM: BMDS/SS/AS

OBJECTIVE: Research and development of innovative growth techniques and designs for semiconductor super lattices with narrow band gaps

DESCRIPTION: The Missile Defense Agency requires new concepts for very long wavelength infrared (VLWIR) detectors with increased operating temperature and improved detectivity for space based applications. These detectors will be required to operate at wavelengths beyond 15 micrometers and operating temperatures of at least 40K. The principal alternatives to extrinsic silicon at present are compound semiconductor super lattices based on III-V elements, such as antimonides and arsenides, or II-IV elements, such as tellurides. This research seeks to develop improved and innovative epitaxial growth techniques for growing super lattices based on advanced semiconductor alloy combinations such as InGaSb/InAs, HgTe/CdTe or other promising materials. The key issues to be addressed are the interface abruptness and repeated control of the individual super lattice layers, materials composition, extrinsic doping and minimizing background carrier concentration and defect densities. The second issue seeks to develop improved and innovative growth, handling and polishing techniques of the appropriate substrate materials for III-V super lattice deposition. The Antimony-based substrates available for group III-V epitaxial growth suffer from significant shortfalls in optical, electrical and structural quality. Innovative crystal growth or processing to modify the bulk and surface material properties is desirable. The third issue is to develop surface passivation of the Sb-based detector material. In order to implement antimonide based super lattice photodiodes in low background infrared detector arrays designed for space applications, problems with surface leakage on small area pixels must be addressed. Passivation layers must adhere to the detector material and must also be thermally compatible with it. Passivation layers should not cause contamination of the under lying antimonide-based materials through processes such as diffusion. Passivation layers need to demonstrate several orders of magnitude reduction in surface leakage and thus improved device impedance for infrared photodiodes. These three issues can be addressed individually or collectively.

PHASE I: Phase I will address the key issues of super lattice growth and design, III-V substrate growth, handling, and surface preparation, and super lattice surface passivation. A deliverable of a representative super lattice test samples to the government is encouraged. Substrate development will explore the optimal techniques for growth and processing bulk GaSb, and/or polishing GaSb wafers to produce a smooth, planar, damage free surface. A deliverable of a representative wafer to the government is encouraged. The development of passivation materials and processes will address deposition and evaluation of surface chemistries on antimonide-based materials. Preliminary characterization to demonstrate reduced surface carrier leakage is required. A deliverable of a representative test sample to the government is encouraged. Characterization of relevant structural, electrical and optical characteristics is required. If multiple techniques are proposed, an analysis of the relative merits of each technique will be performed.

PHASE II: Phase II – Task 1 will optimize the growth processes and designs demonstrated in Phase I with more extensive characterization and modeling as appropriate. Growth and evaluation of super lattice structures suitable for VLWIR photodiodes will be used to demonstrate the success of the program. Delivery of test materials and devices to the government for evaluation is required.

PHASE III: Phase III will develop and demonstrate prototype focal plane arrays with extensive focal plane test and evaluation as appropriate. Teaming with industrial focal plane suppliers is encouraged.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Structures based on semiconductor super lattices have applications in a wide variety of electronic and opto-electronic areas. Key devices with commercial markets would be room temperature operating infrared detectors, infrared lasers and low power transistors. The technical product from this effort would be high quality, heterostructure epitaxial materials. The commercial products can either be wafers of these materials, or devices fabricated from these materials.

REFERENCES:
1. J. L. Johnson, L. A. Samoska, A. C. Gossard, J. L. Merz, M. D. M. Jack, G. R. Chapman, B. A. Baumgratza, et al, Journal of Applied Physics Vol. 80, pg. 1116 (1996).
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3."Chemical Cleaning of GaSb (1, 0, 0) Surfaces," L. J. Gomez-Zazo et al., J. Electrochem. Soc. Vol. 136, pg. 1480 (1989).
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KEYWORDS: Super lattice; semiconductor; narrow band gap; infrared detector, very long wavelength IR, passivation, surface leakage current, antimonides, substrate materials; surface polish

MDA05-008 TITLE: Lattice Matched Substrates for Mercury Cadmium Telluride growth by MBE

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: BMDS/SS/MP/AS

OBJECTIVE: Research and development of innovative growth, surface preparation and polishing of bulk substrate materials suitable for the molecular beam epitaxy (MBE) growth of mercury cadmium telluride (MCT) infrared materials

DESCRIPTION: The Missile Defense Agency requires high performance, high sensitivity and low noise infrared focal plane arrays for space based sensing applications. The infrared detector material of choice is mercury cadmium telluride (MCT). The emerging growth technology of choice is molecular beam epitaxy (MBE), due to its intrinsic capability to control composition and uniformity over large areas. The substrate material of choice is cadmium zinc (or selenium) telluride (CdZnTe). To best utilize MBE, the substrate template on which the detecting material is grown must have extremely good materials properties of its own. In bulk cadmium (x) telluride (CdxTe) where x can be Zn or Se), it must have a [211] crystal orientation, have a Zn (or Se) fracture that lattice matches the bulk material with the crystal lattice of long wavelength infrared (LWIR) MCT epitaxy, which is between 3% and 4% for Zn. It needs to be at least 24cm2 in size, though the goal for current MBE systems is ~50cm2. The bulk material must be extremely high purity with contaminants <PPM and electrically active contaminants <<PPM and precipitates, especially Te and Cd precipitates, of <1ìm in size. The substrates must be planer and have a highly polished surface, free of contaminants and scratches. Expected etch pit densities are approximately 1x104 per cm2 or less. The focus of this effort is for bulk, II-VI substrates and not for silicon or gallium arsenide based compound structures.

PHASE I: Phase I will explore the optimal techniques for purifying, growing, slicing, and polishing [211] CdxTe bulk materials to produce a substrate wafer with a smooth, planer, damage free surface. It is appropriate that emphasis be placed on only one of the technologies identified (purification, growth, slicing or polishing) as long as both the materials and processes that feed that part of the technology development and the next step in the process that receives the output are fully identified and are participating in the results of any proposed effort. As clarification only, a proposed effort to polish substrates must have both an identified source of qualified substrates and an identified MCT MBE grower to qualify the output. Clarification is not intended to either limit the scope of a proposal or identify a specific approach of interest. Appropriate characterization of the CdxTe substrates must be included in the proposal. If multiple techniques are proposed, an analysis of the relative merits of each technique will be performed. A deliverable of a representative wafer(s) to the government for additional characterization is encouraged.

PHASE II: Phase II will optimize the purification, growth, slicing, and/or wafer surface preparation with more extensive demonstration and characterization. It is encouraged that modeling of the bulk and surface chemistry be used as appropriate. Growth and evaluation of MBE grown MCT layers suitable for LWIR detectors will be used to demonstrate the success of the program. Delivery of epi-ready substrates and MBE grown LWIR MCT materials to the government for evaluation is required. A hybrid focal plane array is not desired; multi-element test structures are sufficient for the purpose of demonstrating the technology.

PHASE III: Phase III will use the substrate materials developed in Phase I & II to develop and demonstrate prototype focal plane arrays with extensive focal plane test and evaluation as appropriate. Teaming with industrial infrared focal plane suppliers is encouraged.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Structures based on II-VI semiconductors have applications in a wide variety of electronic and opto-electronic areas. Key devices with commercial markets include high energy radiation detectors. The technical product from this effort is expected to be high quality substrate materials suitable for epitaxial growth of MCT detectors. The commercial products can be wafers of these materials or custom polishing services to the infrared industries.

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2. "Assessment of the purity of Cadmium and Tellurium as components of the CdTe-based substrates," R. Triboulet, A. Aoudia, and A. Lusson, Journal of Electronic Materials, Vol 24 No 9, p 1061

3. “Thermomigration of Telluride precipitates in CdZnTe crystals grown by vertical Bridgman method,” T. S. Lee, J. W. Park, Y. T. Jeoung, H. K. Kim, C. H. Chun, J. M. Kim, I. H. Park, J. M. Chang, S. U. Kim, M. J. Park, Journal of Electronic Materials, Vol 24 No 9, p 1053

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KEYWORDS: infrared detectors; substrate materials; surface polish

MDA05-009 TITLE: <u>Innovative Concepts for Next Generation Infrared Detector Arrays for Missile Defense</u>

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: BMDS -AS

OBJECTIVE: Research and develop innovative ideas that will lead to the development of a new class of sensitive infrared Focal Plane Arrays (FPAs) suitable for missile defense sensors, and commercialization.

DESCRIPTION: Current MDA seekers use HgCdTe (MCT) and InSb for IR FPAs. They are adequate to detect current threats. However, these materials will no longer be suitable to detect, track, and discriminate future threats. Also, because of defect related tunneling in MCT, the FPAs produce undesired levels of electronic noise and non-uniformities. The non-uniformities are corrected with complicated algorithms that require powerful signal processors. Current processors are barely adequate to perform this task and still remain within the weight and power constraints of the seeker system. FPAs with greater pixel-to-pixel uniformity would allow one to use the freed processing capability to address the discrimination problem using more sophisticated algorithms. Additional incentives to develop a new class of IR detector arrays are the high cost of MCT and its low reliability. The need for a new class of IR detector arrays rests on the assumption that future ballistic missile defense systems must be able to detect, track, and discriminate complex targets at longer ranges. This translates to the following FPA capabilities: increased sensitivity, improved uniformity, longer cutoff wavelengths (out to 14 ƒÝm), large formats (in excess of 256 x256), and high operating temperatures (as high as possible). The ultimate goal is a thermoelectrically cooled detector array.

In summary: This SBIR topic seeks novel ideas for a new generation of infrared detector arrays for future ballistic missile defense needs. The research involved may include the development of novel ideas that relate to the improvement of currently used infrared materials, or to the discovery of new IR materials or structures. Examples of currently researched materials are type II superlattices, PbSnTe, high-efficiency quantum well infrared photodetectors, and quantum- and nanotechnology-structured devices (such as quantum dots and carbon tubes)

PHASE I: Identify, research, explore, develop and analyze a novel concept of an infrared detector array that meets the capabilities described above. Determination of the feasibility of the concept by demonstration of a single detector with performance characterization is strongly encouraged.

PHASE II: Design, fabricate, and characterize the IR detector array investigated in Phase I. The contractor is encouraged to perform a prototype FPA demonstration with an existing ROIC.

PHASE III: The contractor will improve the performance of the IR detector array, support the integration of the detector array into an MDA seeker, address interface issues, and support the field testing of an MDA seeker demonstration for use in Ballistic Missile Defense Systems capability upgrades.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The IR detector technologies being developed in this effort are expected to have potential for commercialization with reasonable cost and maintenance, in such applications as law enforcement, surveillance, medical diagnostics, industrial and environmental monitoring.

REFERENCES:

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2. “MDA Infrared Sensor Technology Program and Applications,” M. Z. Tidrow, SPIE Proceedings, Vol. 5074 (2003), p39.

KEYWORDS: LWIR, Large Format FPA, Dual Color FPA, Compact, Infrared, Zoom, Reflector, Anastigmatic, Telescope, IMU

MDA05-010 TITLE: Low Cost, Strapdown Integrated Seeker

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: BMDS/TH

OBJECTIVE: The objective of this research and development effort is to develop and demonstrate technologies that support a low-cost, high-performance IR strapdown seeker applicable to THAAD and other BMD interceptor systems.

DESCRIPTION: The cost, mass and performance of the homing seeker in systems such as THAAD are primarily driven by the requirement for precision target detection, tracking and aimpoint imaging in the presence of shock and vibration from aerodynamic buffeting and propulsion system operation. These functions demand a stable optical platform for precision image processing. Traditional image stabilization involves the use of large, complex, multi-axis gimbals which are inertially stabilized using expensive, precision rate gyros, encoders and torque motors. Advances in microprocessor technology make the alternative, electronic image stabilization approach very attractive, and promise a substantial mass, volume and cost savings relative to gimbal stabilization. This, in turn, enables a lighter weight, lower cost, high performance kill vehicle. Technologies of interest include, but are not limited to: a) very stiff, light weight, low cost optical bench components and mirror substrates and fabrication techniques – silicon carbide or similar CMC materials which are also ionizing radiation tolerant are of interest; b) field-of-regard (FOR) and field-of-view (FOV) scan mirror control and sensing techniques – specifically, a full-aperture, 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 (1-2 cm), servo-controlled, 2-axis LASER pointing mirror with a closed-loop bandwidth of 10 kHz, +/- 5 degrees range in both axes, and <1 micro-radian precision is desired – non-mechanical approaches will be considered; c) shock/vibration mitigation approaches – “smart” structures which incorporate both sensing and PZT-like reaction to cancel shock/vibration, and other active/passive techniques which retain the optical system rigidity and pointing knowledge are desired; d) low-cost, compact (3-4 cubic inch), high-power-density (>100 mJ per pulse), high-efficiency pulsed (10 kHz) LASERs and associated components and thermal management technologies; e) large format LADAR receiver arrays and/or APD arrays operating at 1064 nm, and associated ROICs with sub-nanosecond response time; f) low cost, high performance IR focal plane technologies, that focus on 1-color extended MWIR (3-8 microns), co-located 2-color MWIR/LWIR (3-5/8-11 microns), and associated readout integrated circuits (ROICs) with 40M carrier charge capacity unit cell; g) multispectral, multiple sensor image processing and/or data fusion algorithms and technologies.

PHASE I: Conduct experimental and analytical efforts to prove feasibility of the proposed strapdown seeker concept and technologies.

PHASE II: Demonstrate engineering scale-up of proposed technology, identify and address technological hurdles and provide a prototype demonstration Demonstrate applicability to both selected military and commercial applications.

PHASE III: During Phase III the effort calls for engineering and development, test and evaluation, and hardware qualification with direct insertion potential into the THAAD system

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would be anticipated to have a high level of interest in the areas of satellite manufacturing, UAVs, automobile industry, etc.

REFERENCES:

1. J.S.Acceta and D.L. Shumaker, "The infrared and electro-optical systems handbook", SPIE Optical Engineering Press, Bellingham, Washington, 1993.
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KEYWORDS: strapdown, seeker, LADAR, mirror control, ROIC, APD array, image processing, data fusion.

MDA05-011 TITLE: Improved Iodine Injection, Mixing and Pressure Recovery

TECHNOLOGY AREAS: Air Platform, Space Platforms

ACQUISITION PROGRAM: BMDS-AL

OBJECTIVE: More efficient chemical processes for Iodine injection and supersonic mixing. Improved pressure recovery

DESCRIPTION: The ABL Chemical Oxygen Iodine Laser (COIL) creates a lasing medium by the generation of Singlet Delta Oxygen (SDO) mixed with Helium which is then injected with a mixture of Iodine, Helium and Nitrogen. For a number of reasons, this mixture has typically been made at relatively low pressures. Although attempts have been made to keep its Mach number as high as possible, pressure recovery is quite low and requires some sort of vacuum pumping. Increasing the pressure recovery by both efficiently increasing the Mach number of the Iodine injection and increasing the pressure of the cavity (while maintaining proper cavity kinetics) would have wide ranging system impacts for simplifying the pressure recovery system. Specifically, increased momentum in the laser cavity could have large potential benefits for the COIL, from reduced pressure recovery requirements to higher cavity energy density. If these results are realized, it would provide significant synergistic benefits to the ABL weapon system to include reduced payload weight, resulting in longer time on station, and more laser fluence on target due to increased laser propellants capacity. Additionally, improved efficiency could simultaneously mean increased laser power output for the same size device.

Proposal presenters are encouraged to show increased fluid momentum with a goal of 250 Torr pressure recovery within the COIL cavity while maintaining flow uniformity both in species mixture and density.

PHASE I: Establish a list of innovative concepts for achieving the goals above. Select the most promising approaches and conduct fluid mechanical modeling of alternative concepts. Develop a Phase II Program Plan for further, more detailed modeling of a subset of the current concepts as well as for utilizing a subscale test device to validate selected concepts.

PHASE II: From the concepts modeled in Phase I, accomplish a further down select and conduct detailed fluid mechanical modeling of the remaining competing concepts. Based on the results of this modeling, prioritize the remaining concepts for testing. Conduct subscale integration, testing, and test reporting as specified in the proposed Program Plan. This report must discuss fully how key technical challenges were overcome and risks mitigated. Demonstrate how linkage could be made to a full-scale device. Develop a Phase III Program Plan that will include your integration and test strategy for a 1/10th device. Generate concept requirements and testing guidelines based on requirements for the 1/10th scale device. Identify remaining key technical challenges, risks, and risk mitigation strategies. This plan should include proposals for actual lasing tests on a 1/10th scale laser either in-house, at a contractor facility, or in a government laboratory. Propose specific, high payoff technology transfer applications and experiments.

PHASE III: Design and build a 1/10th scale prototype, demonstrating its high momentum flow capabilities, flow uniformity and pressure recovery in a laboratory environment. Perform lasing tests on the prototype and provide a detailed evaluation report. Develop a Program Plan for design, fabrication, integration, testing, and test reporting for a full scale system or operation on a system level test-bed. Show near term application to one or more MDA element systems, subsystems, or components and investigate technology transfer applications. Propose and conduct specific, high payoff technology transfer experiments.

PRIVATE SECTOR COMMERCIAL POTENTIAL: More efficient supersonic mixing chemical processes have potential commercial applications such as for the supersonic combustion ram jet (SCRAMJET), aircraft signature reduction and turbine cooling. These improved COIL processes also stand to 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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2. Manke II, Gerald C. and Hager, Gordon D., "Advanced COIL – physics, chemistry and uses," Journal of Modern Optics vol. 49 no. 3/4, p.465-474 (2002).
3. Vetrovec, John, "Prospects for an Industrial Chemical Oxygen-Iodine Laser," SPIE vol. 2092, p.723-726 (1996).
4. Carroll, D.L, Solomon, W.C, "Advanced Mixing Nozzle Concepts for COIL," Proceedings of the International conference on Lasers '99 p. 69-77

KEYWORDS: Airborne Laser, Singlet Oxygen Generator, Iodine Injection, Pressure Recovery

MDA05-012 TITLE: Improved Optical Turbulence Forecasts

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace

ACQUISITION PROGRAM: BMDS-AL

OBJECTIVE: Develop more accurate and reliable forecasts of optical turbulence that are based on operational mesoscale numerical weather prediction forecasts

DESCRIPTION: To support the testing and deployment of the Airborne Laser (ABL), an Atmospheric Decision Aid (ADA) has been developed to provide mission planners with three-dimensional depictions of optical turbulence and its effects on laser propagation. The ADA uses numerical weather prediction (NWP) model data from the Air Force¡¦s operation mesoscale model as input to an algorithm for computing the refractive index structure constant (Cn2). The current algorithm for prediction optical turbulence is the Dewan model (Dewan et al. 1993). Validation studies have revealed that the Dewan model correctly forecasts path-integrated values of optical turbulence to within „b 50% of the observed values approximately half of the time. While this satisfies coarse forecast guidance requirements, it is not sufficient for predicting laser performance, which is necessary to optimize the ABL¡¦s loiter orbit location. We seek innovative methods that will result in improved optical turbulence forecasts. In particular we seek new algorithms for the prediction of optical turbulence based on operational NWP mesoscale model output and also methods to improve mesoscale NWP model deficiencies at levels of ABL interest (> 40kft).

PHASE I: Investigate and develop new methods of predicting optical turbulence using wind, temperature, and other variables typically available or easily computed from NWP model data. Assess the feasibility of these approaches using data from radiosonde observations or direct numerical simulations. Define candidate strategies for improving mesoscale NWP models¡¦ ability for forecasting upper-level mean flows, thermal structure, and wave and turbulence characteristics.

PHASE II: Refine methods for predicting optical turbulence. Validate performance of the new methods. Determine which candidate strategies for improving NWP models¡¦ ability for forecasting upper-level winds, mean flows, thermal structure, and wave and turbulence characteristics should be pursued and can be implemented into the Air Force¡¦s operational mesoscale model. Implement the worthy strategies and document their improvement on model performance and optical turbulence forecast accuracy.

PHASE III: Successful algorithms that improve optical turbulence forecasting would be implemented into the ABL ADA. Improvements to the mesoscale NWP model forecasts would be incorporated into the Air Force Weather Agency operational mesoscale model. Other DoD groups that would be interested in purchasing the improved optical turbulence forecasting technology include those groups involved with laser weapon and communication development.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Civilian interests include astronomy observatories.

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KEYWORDS: optical turbulence, laser propagation, numerical weather prediction, mesoscale models, stably stratified turbulence, Direct Numerical Simulation

MDA05-013 TITLE: <u>Eyesafe Short Wave Infrared (SWIR) Laser for Laser Ranging</u>

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS/AL

OBJECTIVE: The objective of this research and development effort is to develop and demonstrate technologies that support a low-cost, high-performance eyesafe SWIR laser that can be used for an airborne application. Potentially, this technology is directly applicable to an enhanced Next Generation Active Ranging System (NGARS) for the ABL.

DESCRIPTION: The ABL program is considering alternatives to the current Active Ranging System (ARS) to enhance performance. The current system uses a CO2 laser and 2 HgCdTe detectors in the receiver. In an effort to improve performance MIT Lincoln Laboratories (MIT/LL) is developing a new 1.55-ƒÝm InGaAs APD (Avalanche Photo-Diode) device as the receiver. This device will require a new laser to provide the active stimulus. While the APD device is active down to about 0.9 ƒÝm, the ABL program desires an eye-safe laser (defined according to the ANSI Standard, Z136.1) to minimize the risk to other aircraft personnel in the event of inadvertent lasing. We are focusing on lasers in the 1.5 to 1.6 ƒÝm band.

The current ARS is a pod-mounted design on the top of the ABL aircraft. It uses a turreted system to provide pointing and tracking of the laser ranging sub-system on moving missile targets. Given this is an airborne application; minimization of the usage of key system resources (component weight, power usage, and cooling requirements) is critical.

The goal of this technology development activity is to enhance the state of the art in capability of compact lasers operating in the 1.5 to 1.6 ƒÝm wavelength range. As part of the proposal, a successful offerer will include an estimate of the laser power and range performance of the proposed laser.

As goals, the laser should have a pulse duration in the range of 2 to 100 nanoseconds (ns). It is desired that the PRF (Pulse Repetition Frequency be less than 1000 Hz (for lasers with 100 ns pulses) and 10 kHz (for lasers with 2 ns pulses). The laser should have a diffraction-limited beam operable as a laser radar source. If the laser could be operated as a coherent laser radar, that would be a plus. It is also desired that the system have a wall plug efficiency of at least 5%. Finally, the laser should be operable as either an oscillator or amplifier.

The goals for the system level implementation are a weight for the laser head of less than 70 lbs. Additionally, any separate power supply and/or control units should have a combined weight of less than 130 lbs. A goal would also be the capability to remote the laser head from the other units by at least 5 meters using a rugged umbilical cord.

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

PHASE II: Demonstrate engineering scale-up of proposed technology, identify and address technological hurdles and provide a prototype demonstration. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Engineering and development, test and evaluation, and hardware qualification of the proposed technology with direct insertion potential into the ABL system.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would be anticipated to have a high level of interest in the areas of communications, aircraft safety, and other areas where a range measure would be beneficial (without risking damage to personnel).

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KEYWORDS: Laser, laser ranging, LADAR, eyesafe, SWIR, surveillance, missile defense, airborne.

MDA05-014 TITLE: Highly Reliable, High Power Cryogenic Red Diode Lasers

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

ACQUISITION PROGRAM: BMDS-AS

OBJECTIVE: Develop a highly reliable, high power cryogenic red diode laser array capable of pumping an innovative, high power (100 kW or greater) cryogenic laser. This technology would enable compact, long-life high power laser device for missile defense applications.

DESCRIPTION: The cryogenic red diode laser array should be capable of emitting around 630 nm, produce excellent beam quality and be highly reliable. The design should be flexible enough to be useful for optically pumping a cryogenic laser in a variety of gain generator/resonator configurations.

PHASE I: Develop concept for a cryogenic red diode laser, capable of emitting at a power level greater than 0.5 W per diode. Design and plan for fabrication into bars. Perform modeling to establish design trades and to predict performance. Provide a test plan with methodology. Obtain experimental data to anchor the model. Plan how the performance will be measured. Plan how the diodes will be combined into bars and arrays.

PHASE II: Prove the concept in diodes and bars. Achieve lasing and measure power and beam quality. Evaluate reliability. Develop into an array. Measure temperature scaling.

PHASE III: Build and demonstrate a high power array. Measure array power, beam quality and reliability.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The medical world can use red diode lasers to generate singlet oxygen that can in turn be used for sterilization/decontamination and the deactivation of chem/bio agents. Red diode lasers also have applications in the entertainment industry.

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KEYWORDS: red diode laser, cryogenic optical pump, high power diode laser, highly reliable diode lasers

MDA05-015 TITLE: Optics Technologies for Cryogenic Sensors

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: BMDS-SS

OBJECTIVE: Develop structures, optics, electronics, and coatings technology to enable performance of 0.5m-class gimbaled optical systems in a cryogenic space environment. The primary application for this effort is the Space Tracking and Surveillance System. The technology may also be applied to next generation kill vehicles.

DESCRIPTION: Advanced mirror systems are needed to handle the stressing environmental loads associated with room-temperature handling, repeated cryogenic-temperature testing, and cryogenic operation in the on-orbit space environment. The move to advanced materials such as silicon carbide requires development of optical, thermal, and structural technologies to fully realize the stiffness, mass, and manufacturing benefits of the advanced materials at the system level. While considerable investment has been made in procuring mirror blanks, other aspects of producing a useable optical system have lagged behind. This effort is intended to produce innovations in these other areas; in no order of priority, these important technology areas include:

(i) The mounting structure -- Mirrors made with advanced materials such as silicon carbide require compatible mounting structures. The mount must be space-qualifiable, enable dimensional stability of the optical system from room to cryogenic temperatures, perform at a cryogenic temperature range of 70-130 K, and provide the capability to direct heat away from the base of the mount, i.e. no heat output allowed in other directions. Additionally, the mount must have approximately the same CTE characteristics of the optic itself so as to minimize mirror distortions as the temperature changes. Furthermore, repairability of the mounting structure is highly desirable.

(ii) A gimbal structure-- The optical system of interest includes a gimbal for 2-axis pointing of the optical instrument. Challenges for the gimbal subsystem include long life on orbit (10 years desired), cryogenic operating temperatures, temperature cycling to cryogenic temperatures during check-out before launch, and thermal isolation from the attachment structure. It is highly desirable that the gimbal have approximately the same CTE characteristics as the mount and optic itself so as to minimize mirror distortions as the temperature changes. Furthermore, repairability of the gimbal is highly desirable.

(iii) Mirror finishing-- Mirrors made from advanced materials for application at cryogenic temperatures allow, and may even demand, new processing methods that decrease the overall cost and schedule of production to become cost-competitive with beryllium-based telescopes. Of particular concern are novel processing technologies for roughing the mirrors to achieve figure but eliminate sub-surface microcracking that limits performance in a radiation environment. Technology is sought to minimize the cost and schedule of finishing 0.5m-class mirrors, especially aspheric shapes typical of imaging systems.

(iv) Electronics – Currently the cost the gimbal electronics together with mirror polishing and telescope alignment are the predominant cost drivers for both space and missile telescopes. Novel approaches to the design of radiation hardened electronics are needed to address cost-perfomance trades particularly for large (>0.25m) telescopes.

(v) Coatings-- Optical structures technology is advancing rapidly, but a complete optical element also requires the application of a coating. The technology to coat these materials for performance in the space environment is, however, lagging the substrate technology and needs development. Coatings enhance or enable the optical or thermal properties of a component according to the system requirement. For the flat and aspheric components in the optical path, a set of high reflectivity coatings in the 8-12 micron range are desired. Optical coatings must withstand thermal cycling at temperatures down to 70K and possibly 35K. For other components in the system, where thermal transmission and stray light are concerns, example coatings include: black diffuse coatings for scatter suppression, high reflectivity gold coatings for specular baffle vanes, and thermal control coatings for heat rejection on cryogenic structural surfaces.

A systems vision concept that addresses mounts, gimbals, finishing, and coatings approaches for a cryogenic space optical system is desired required such to ensure that the component technology pursueud can be better appreciatedtransitioned into real system application. Identifying an approach for each area is useful because the development of technology in one area cannot be at the expense of performance in another area, e.g. thermal coatings development on a structure that cannot support mirrors in a cryogenic environment is not useful. In addition, the system concept is expected to help influence early design requirements and bring focus early to important integration issues.

Each Proposal submitted will focus on one and only one of the technology areas of this topic. However, an offeror may submit multiple proposals, either in one area or in multiple areas.

PHASE I: The contractor shall conceive and develop a concept that meets the program objective in one of the technical areas. The contractor shall identify and discuss a realistic broad sensor system concept to illustrate how the proposed technology will fit. Proof of concept/technology will be demonstrated through analysis (at a minimum) with sub-scale or reduced-fidelity hardware testing, in addition, being highly desirable. Offerors are strongly encouraged to work with system and payload contractors to help ensure applicability of their efforts and beginning work towards technology transition. The contractor shall propose an experiment for Phase II that demonstrates performance of the chosen technology.

PHASE II: The contractor will take the innovation of Phase I and design/develop/construct a breadboard device to demonstrate the innovation. This device may not be optimized to flight levels, but should demonstrate the potential of the prototype device to meet actual operational specifications and clearly identify the path to be followed to take the device to a flight-ready status. The demonstration should validate applicability of the concept/technology so as to transition the technology to an operational system by subscale demonstration, performance in a relevant environment, or similar incremental approach. 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: Develop and implement specific optical structures and coatings technology for use in imaging and directed-energy systems such as the Space Tracking and Surveillance System, Airborne Laser, Exoatmospheric Kill Vehicle, earth observation, and others.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The increased understanding of the use of advanced materials in optical systems could lead to commercialization of the results in a wide variety of applications, including other spaceborne and airborne optical systems (both military and commercial), semiconductor fabrication, and other industrial applications.

REFERENCES:

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[3] Developments in Optical Component Coatings, Proceedings of SPIE, Volume 2776, edited by Ian Reid, Aug 1996.
[4] Spacecraft Thermal Control Handbook, Ed. By David Gilmore, 2nd Edition, 2002, The Aerospace Press.
[5] Optical Materials and Structures Technologies II, Proceedings of the SPIE, edited by William A. Goodman, from the SPIE Annual Meeting in Aug 2005 in San Diego, CA.

KEYWORDS: Cryogenic structures, mirrors, gimbals, cryogenic coatings, optical coatings, mirror mounts.

MDA05-016 TITLE: Enhanced Cryocooler Component and Integration Technologies

TECHNOLOGY AREAS: Materials, Sensors, Space Platform, Weapons

ACQUISITION PROGRAM: BMDS-SS, GM, MDA/MP

OBJECTIVE: Reduce mass or power input to the cryocooler component for space payloads or interceptor sensors by improving performance in space refrigerators OR developing cryogenic and ambient thermal integration technology to enable efficient system integration of space cryocooler. MDA has interest in satellite and interceptor systems with components operating at several different cryogenic temperatures: 85K, 40K, and 10K, or combinations thereof.

DESCRIPTION: Proposals can be submitted to support either the cryocooler thrust of this topic OR the thermal integration thrust of this topic. Multiple proposals can be submitted in either thrust area. An offeror may choose to address any one target temperature or several in the same proposal.

Cryocooler components. Next generation satellite and interceptor infrared sensing technologies and on-board cryocooling needs will require revolutionary improvements in component level technology. Innovative concepts should either address significant performance enhancements or order of magnitude size decreases in space qualifiable refrigeration technology. Examples might include distinctly or in combination:

1. The internal heat exchangers in cryogenic refrigerators are the primary location of available energy (exergy) destruction or entropy generation (losses) in these systems. As such, they present the largest targets for increasing system efficiency and indirectly for decreasing refrigerator mass per unit of cooling load. This topic seeks proposals which would offer innovative materials, geometries, or fabrication methods which would improve refrigeration systems used in space cooling applications. Examples of such technology enhancements for regenerator development might include:

• Rare earth and related alloy improvements to screen geometries considering various manufacturing techniques to tailor porosity while maintaining or enhancing heat transfer and needed specific heat capability and penetration depth.
• Consideration of alternate configurations such as channel geometry to replace screens for enhanced heat transfer.
• Improvements in the use of rare earth particle geometries to tailor porosity and retention characteristics under oscillating flow.
• Improvements in the exit (cold-end) and entrance (warm-end) of heat exchangers to minimize flow losses considering both linear, u-tube, and coaxial geometries.

2. MEMS technology and advanced manufacturing techniques have potential for use in miniaturized coolers and as advanced heat exchangers that have applications in many cooling concepts including advanced reverse Brayton coolers, Joule-Thomson coolers, and hybrid expansion cycle coolers. Long life (> 10 years, 100% duty cycle), high pressure ratio (4-6:1), DC flow (unidirectional flow) compressors are needed to enable the use of hybrid cooling systems that utilize a higher temperature cryocooler for pre-cooling and cool to low temperatures via a Joule-Thomson, reverse Brayton, or other expansion cooling cycle.

3. Space qualifiable refrigeration system cold ends capable of sustaining significant (>50mW) cooling loads at or below on of the target temperatures. The threshold specific power goal would be 400 W (input)/W (cooling) while the objective goal would be 200 W/W.

Proposals should clearly indicate their objective cooling load temperature and load magnitude.

OR

Thermal Integration. Next generation space infrared sensing technologies and spacecraft cryogenic and ambient temperature cooling needs will require revolutionary improvements in thermal storage, thermal switching, high cryogenic and ambient heat flux applications, and thermal transport. Specific examples of thermal transport issues include:

• Uniform temperature control (less than 0.1K variance) of large (2056x2056 pixel) focal plane arrays at a selected temperature within the range of 10-40 Kelvin.
• Very long cryogenic transport distances of 1-3 meters.
• Removing ambient temperature waste heat from coolers or electronics located on gimbal, across the 2 axis gimbal, and transporting the heat to radiators located on the main body of the spacecraft.
• High heat flux applications include cooling 10-30 W at 35 Kelvin and up to 150 Watts at 100 Kelvin with cooler interfaces of < 9 cm^2 and high flux ambient cooling applications over 15 W/cm^2.
• Passive thermal storage phase change devices servicing temperature regimes hitherto impractical, for example the region below 30K.

Potential technology candidates include loop heat pipes, capillary pumped loops, heat pipes, active pumped loops, heat pumps, dispersed reverse Brayton cooler expanders on both micro and mesoscales, and hybrid Joule-Thomson cooling systems. Flexible cryogenic and ambient cooling is essential to meet emerging requirements for advanced systems and is enabling technology for increasingly compact / higher density Air Force and Department of Defense infrared sensing payloads

PHASE I: Phase I SBIR efforts should concentrate on the development of the fundamental concepts for increased efficiency or reduced mass of space cryogenic coolers or their attendant integration peripherals. 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 space payload simulated in ground testing conditions. This phase should address in particular the improvements to heat exchange efficiency or payload integration offered by their effort. This phase should make plans to further develop and exploit this technology in Phase II.

PHASE II: Phase II SBIR efforts should take the innovation of Phase I and design/develop/construct a breadboard device to demonstrate the innovation. This device may not be optimized to flight levels, but should demonstrate the potential of the prototype device to meet actual operational specifications. Demonstration of the potential improvements in efficiency or mass reduction of space cryogenic coolers or space payloads should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort.

PHASE III: Typical MDA military space applications for cryogenic coolers relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Potential Phase III opportunities to transfer this technology to emerging MDA programs include the Space Tracking and Surveillance System (STSS) and BMDS engagement systems, such as Ground Based Midcourse Interceptor, THAAD, Carrier Vehicle for Multiple Kill Vehicle or Kinetic Energy Interceptor Systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The applications of this technology could potentially be far reaching with large market potential due to the increased efficiency and to a lesser extent the expected reduction in mass 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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8. Michael Rich, Marko Stoyanof, Dave Glaister, "Trade Studies on IR Gimbaled Optics Cooling Technologies," IEEE Aerospace Applications Conference Proceedings, v 5, p 255-267, Snowmass at Aspen, CO, 21-28 Mar 1998.
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11. Shams, Q. A., Moniuszko, M., and Ingham, J. C., “Applying MEMS technology to field, flight & space deployable systems”, ICIASF Record, International Congress on Instrumentation in Aerospace Simulation Facilities; ISSN: 0730-2010, Aug 2001; p.246-255.
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KEYWORDS: manufacturability, producibility, reliability, cryocooler, cryogenic, Heat Pipe, Space, Flexible Lines, Infrared Sensors, Loop Heat Pipe, Thermal Management, Low Temperature, Capillary Pumped Loop

MDA05-017 TITLE: Manufacturing of Low Cost and High Performance Electronics for Cryogenic Cooling System

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: BMDS-MP/SS

OBJECTIVE: To develop innovative, low-cost cryogenic cooler control electronics for Ballistic Missile Defense System’s (BMDS) satellites. Electronics for cryocoolers must meet the high performance, radiation hardness, long life-cycle, and low power consumption requirements for BMDS applications.

DESCRIPTION: The major cost-driver in the manufacture of cryocooler systems is the cost of radiation hardened control electronics (over 300 krad total dose) which is about 2/3 of the entire cooler system. 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 and manufacturable while maintaining the reliability required for the specific missions. MDA is seeking manufacturing, packaging and integration technologies for cryocooler electronics that can enable more cost-effective assembly or that enable use of modified commercial off-the-shelf or military off-the-shelf components to reduce unit production cost for satellite 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 applicable for integration with various BMDS sensors and potentially scalable to adapt cryocooler size and design. Any one proposal must select one targeted thermodynamic refrigeration cycle from the following set of cycles: Stirling, Pulse tube variant of the Stirling, or Reverse Brayton. This integration requirement implies that the proposal must address:

a. The feedback control system by which cryogenic thermometry transducers operating in the range of 30-350K provide input to the power controls of the cryocooler. This thermometry system would be an integral portion of the proposed electronics system.
b. Vibration control of the proposed mechanical system if the characteristic fundamental frequency is less than 400 hertz, to include vibration transducer excitation and measurement.
c. Realistic power output levels in the range of 100 to 200 W.
d. Provision of conductive thermal heat sinks for high power dissipation components.

PHASE I: Develop concepts, design, and methodology for manufacturing, packaging and assembling electronics for cryogenic coolers that will lower the cost and improve performance and reliability of overall cooler units. Offerors are strongly encouraged to work with system, payload, and cryocooler contractors to help ensure applicability of their efforts and to ensure a practical technology transition.

PHASE II: Validate the feasibility of designing, manufacturing, packaging and assembling of electronics for the cryogenic cooling units by designing/developing/constructing a breadboard device to demonstrate the innovation. This 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 cryocooler would be desirable. This breadboard demonstration would not necessarily use radiation hardened components. If off the shelf parts are used, then the final report shall indicate the one-for-one substitutions for radiation hardened components which were made. 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: Successfully demonstrate new open/modular, non-proprietary, cryogenic cooler control electronics. 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 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. 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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MDA05-018 TITLE: Microsatellite-based Space Targets for Calibration and Test of Advanced Radar and STSS Technologies

TECHNOLOGY AREAS: Information Systems, Sensors, Space Platforms

ACQUISITION PROGRAM: BMDS-MDA/AS, MDA/STSS

OBJECTIVE: The objective of this topic is to solicit innovative concepts to develop micro-satellites with the capability to emulate ballistic missile target complexes and 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). Currently, the conduct of calibrated BMDS testing is limited to expensive integrated flight tests. These testing opportunities are too infrequent to allow test and development in the loop. 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 micro-satellites 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: STSS, radar targets, calibration, micro-satellite

MDA05-019 TITLE: Innovative Manufacturing Process Improvements

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

ACQUISITION PROGRAM: BMDS - MDA/MP

OBJECTIVE: Develop and apply innovative manufacturing processes that improve capabilities, product quality and reliability, reduce unit costs, reduce cycle time, reduce process variability, and enhance manufacturing yields and sub-systems and component performance. These innovations will be targeted at the entire enterprise and in turn provide solutions to manufacturing problems associated with design, fabrication, sustainment (COTS, obsolescence, supply chain management, technology refresh, repair, etc.) which are common among the elements comprising the Ballistic Missile Defense System (BMDS). The investments made should allow for rapid transition of the results into systems and subsystems being developed for the BMDS.

DESCRIPTION: MDA is seeking innovative approaches and tools from small businesses that will allow economically feasible acquisition of new manufacturing process technologies for ballistic missile defense systems. These processes can range from improvements in fabrication of advanced materials (possibly an innovative alternative single process improvement), design engineering tools, tools to monitor manufacturing process development, etc through innovative application of methods and tools to improve manufacturing processes and procedures on current systems and subsystems. MDA is also interested in process technology that facilitates the transition of a product (breadboard, brass board or prototype) from an R&D environment to any manufacturing environment (commercial, defense or both). Investment decisions will take into account the maturity of the technology and the ability to transition the technology to a customer. The use of Technology Readiness Levels and Engineering/Manufacturing Readiness Levels to describe current technology maturity will be helpful in evaluating the planned effort. It is expected that a TRL of at least three will already have been demonstrated to be considered for this topic.

The technology of interest falls into the following three phases of acquisition: (1) In the weapon system design and development phase, the technology investment is to enable virtual evaluation of multiple design options, foster rapid design for low life-cycle cost and low variability manufacture as well as to mature needed process capabilities to acceptable and quantified risk levels (process maturation). (2) In the production phase, the emphasis is on rapid, low-cost, high-quality manufacturing; efficient factory operations and supplier interactions; and the decoupling of unit cost from production volume. (3) In the support and sustainment phase, the concentration is on efficient repair processes; rapid, low-cost spares and replacement parts acquisition; and efficient maintenance, repair and overhaul (MRO) operations.

Technical areas of interest: This topic’s focus is on innovations that can be developed/demonstrated or even inserted into systems fabricated for missile defense systems:

Transition from Design to Manufacturing: This area is focused on the tools and techniques that will allow for seamless transitions from design to manufacturing. It has been proven that early design decisions can have tremendous impact on the affordability of your final product. The decisions made during the design period determine up to 80% of the product's costs while decisions made during production only account for 20% of the product's costs. Further, decisions made in the first 5% of product design could determine the vast majority of the product's cost, quality and manufacturability characteristics. Tools that can assist both industry and Government program managers make better decisions on designs and their impacts on transition to production of affordable high quality products are needed. These tools need to work in today’s capability based acquisition environment and be flexible so as to conform to changing customer needs. Theses tools and techniques also need to address the enterprise’s entire production system which includes its suppliers, inventory management, material handling systems, manufacturing processes, labor force capabilities and distribution systems. A few examples of areas of interest are as follows:

Techniques for effectively introducing, analyzing, and managing manufacturing constraints and variability as independent design variables, Algorithms and automated software for identifying intrinsic design risk based on a component's requirements, intended use, design and planned manufacturing processes, Algorithms and automated software for providing unambiguous engineering data that effectively direct manufacturing process development funding towards design variables with the highest potential payback, and away from areas with low payback potential, Algorithms and automated software for reducing weight of metal and composite structures while preserving or enhancing design margins.

Electronics Processing and Fabrication: Develops and deploys manufacturing technology for electronic materials, devices, integrated circuits, subassemblies, and subsystems. Scope includes digital electronics, analog microwave and millimeter wave electronics, and photonic and electro-optic technologies. A few examples of areas of interest are as follows:

Wide band gap material growth and processing, E/O materials and processing, Electronic packaging and interconnect technology, Thermal management, Portable automated equipment and techniques for in-situ maintenance and repair of fiber optic/photonic data links and interconnects.

Advanced Materials and Structures: The development of affordable, robust manufacturing and assembly processes and capabilities for advanced materials and structures has high potential to increase weapon system effectiveness and survivability. Key technical barriers include the stabilization of complex materials processes to improve yield and reduce process cycle time during phase change processes (ingot melting, casting, welding, laser additive machining (LAM)) and thermomechanical processing (rollforming, forging, friction stir welding (FSW)), and material coatings technologies. A second challenge is to accelerate the technical qualification of affordability-driven materials processes for service in progressively more complex applications affecting flight and system safety. A few examples of areas of interest are as follows: Processes for applying radiation hardened coatings to mirrors optimized for LWIR/VLWIR that operate reliably when exposed to background radiation from space and radiation resulting from nuclear events (including prompt and persistent gamma, single event effects, x-rays, total ionizing dose, space radiation, etc.), Lean processing methods (casting, forging, etc), Special Materials (e.g. high temperature, corrosion resistant, damage resistant), Joining technology, Test and inspection, Low cost tooling, Innovative, cost effective, and precise machining processes for difficult to machine materials such as high temperature alloys, ceramics, carbon reinforced composites, and combinations thereof, Cost effective forming/fabrication technologies and processes for near net shape creation of complex shaped components from high temperature and advanced ceramic materials.

Advanced Manufacturing Enterprise and Sustainment Technology: The opportunity to achieve dramatic cost and cycle time reductions, involving defense development, production, and repair activities, through the accelerated implementation of advanced industrial practices represents an assured force multiplier investment. The development of more effective industrial and manufacturing engineering processes for planning, scheduling and controlling factory operations are needed. These processes are directly responsible for more than one-third of weapon system costs, and strongly influence the efficiency of another third of incurred costs. Additionally, the introduction of "Lean" practices and associated business process reengineering efforts offer the potential to significantly reduce repair cycle time (25 percent to 40 percent) and product development costs for modifications and upgrades (20 percent to 30 percent). A few examples of areas of interest are as follows: Supply Chain Management, Technology Refresh, Parts Obsolescence Management, Enterprise Modeling and Simulation, Commercial/military manufacturing integration, Lean manufacturing.

PHASE I: Demonstrate a new and innovative manufacturing process technology that can meet MDA needs including, where appropriate, a process technology roadmap for implementing promising approaches for near term insertion into BMD element systems, subsystems, or components. Opportunities are many and exist at discrete component up to system (element) level. A dialogue with the TPOCs listed is encouraged.

PHASE II: Validate the feasibility of the innovative manufacturing process by demonstrating its use in the production, 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. 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. Innovative processes should be developed with the intent to readily transition from design to production in the MDA as well as other DoD systems' supply chains.

PHASE III: Successfully demonstrate innovative manufacturing process. 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 one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Many of the technologies under this topic would be directly applicable to other DoD agencies, NASA, and any commercial manufacturing venue. Improved manufacturing and processing techniques would directly improve production in the commercial sector resulting in reduced cost and improved productivity. Possible areas of applicability are computer manufacturing, automotive industry and aerospace industry

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5. Spacecraft Thermal Control Handbook, Ed. By Gilmore, David, 2nd Edition, 2002, The Aerospace Press
6. “Lightweight Mirror Systems for Spacecraft -An Overview of Materials & Manufacturing Needs,” By Carlin, Patrick S. /Air Force Research Laboratory

KEYWORDS: process reliability, reduced costs, improved productivity, manufacturing, mirror coatings, anti-reflection coatings, athermalization

MDA05-020 TITLE: Ballistic Missile Defense Innovative Anti-Tamper Techniques

TECHNOLOGY AREAS: Materials, Weapons, Nuclear Technology

ACQUISITION PROGRAM: BMDS – MDA/MP

OBJECTIVE: Develop and implement new innovative anti-tamper (AT) techniques that demonstrate the capability to delay, or make economically infeasible, the reverse engineering or compromise of critical U.S. BMDS weapon system technologies.

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. Both, software and hardware based protection techniques will be considered. Areas of interest include but are not limited to:

ADA Software Protection:
The military has a significant number of software applications developed using legacy programming languages such as ADA. ADA was developed by the military but was abandoned in favor of commercially available languages and their associated development tools. New systems and existing system upgrades often use legacy software such as ADA in standard sub-applications to avoid rewriting code in a current commercial programming language. There are many tools available and being developed for protecting software from tampering, but these tools only work with the standard commercially available programming languages, not legacy software like ADA. An innovative software protection architecture is needed that can protect applications developed using legacy languages like ADA from exploitation.

Non-Performance Degrading Software Protection for Real-time Processes:
The military has a significant number of real-time executables that may be considered critical program information and need AT protection. Commercial AT applications exist, but these applications degrade performance and that is not acceptable for critical real-time processes. An innovative anti-tamper protection architecture is needed to protect real-time processes from exploitation without degrading the performance specifications.

RFID Tamper Evident Labels and Seals:
There is a need to provide a layer of AT protection using embedded tracking technologies to protect critical program information from reverse engineering or exploitation. Develop a tamper evident label with an embedded, covert, nano or RFID tag technology that triggers a signal when there is an attempt to enter an enclosure. This will benefit MDA programs that need covert tracking technologies to notify of potential reverse engineering efforts of critical program information.

X-ray Detector Devices:
Reverse engineers commonly use X-rays as a tool to investigate a device they plan to attack. X-raying provides insight to the reverse engineer on the internal layout of the device without causing permanent damage to the device. The reverse engineer would be able to investigate printed wiring boards and potential anti-tamper sensors or indicators deployed in the device. There is a need for an on-chip, passive, x-ray detector to detect reverse engineering x-ray attempts. The detector will need to provide a disabling or indication capability.

Memory Device Eraser:
Critical program information that resides on memory devices used in military electronic applications could fall into unfriendly hands and be exploited. There is a need for an innovative anti-tamper protection scheme to protect critical program information on memory devices. The purpose is to add longevity to critical technology by deterring efforts to reverse-engineer, exploit, or develop countermeasures against a system or component. The protection technique must guard or erase the memory device on demand or in the event of tampering so that critical program information is not compromised.

MEMS Tampering Sensors:
There is a need to develop innovative MEMS sensors for anti-tamper applications to protect critical program information from reverse engineering or exploitation. Develop a covert MEMS sensor that detects tampering attempts and triggers a penalty that results in protecting critical program information. The sensor may be passive or active and provides obvious or hidden penalties. This will benefit MDA programs that need covert sensors to notify of potential reverse engineering efforts of critical program information.

PHASE I: The contractor shall develop the conceptual framework for new and innovative AT techniques/technologies to protect the total system or critical portions thereof from compromise via reverse engineering. The contractor will also perform an analysis to estimate the degree of protection afforded by the AT techniques and provide an analytical rationale for the estimate.

PHASE II: Demonstrate and validate the use of AT techniques into one or more prototype modules and estimate the effectiveness of the techniques employed and their applicability to real-time applications. 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 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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1. Huber, Lt Col Arthur (USAF) and Scott, Jennifer, “The Role and Nature of Anti-Tamper Techniques in U.S. Defense Acquisition,” Acquisition Review Quarterly, Fall, 1999.

KEYWORDS: Anti-Tamper (AT), Real-time Software, Embedded Software, Reverse Engineering, Hacking, Exploit

MDA05-021 TITLE: Advanced Missile Aerostructures and Thermal Protection System (TPS) Technologies

TECHNOLOGY AREAS: Materials, Weapons

ACQUISITION PROGRAM: BMDS - MDA/TH, MP, GM

OBJECTIVE: Develop innovative missile body structures and thermal protection system technologies for advanced interceptors.

DESCRIPTION: Advanced missile defense interceptors are designed to achieve supersonic to hypersonic velocities during flight to provide the capability of reaching offensive missile targets sufficiently early to minimize threat capability. As a result, these interceptors experience significant aerothermal heating to the external airframe and require lightweight thermal protection systems (TPS). The TPS and external aerostructures (which may include nosecones, radomes, windows, shrouds, mid-body structures and motor case exteriors) are designed to minimize internal temperature rise and ensure missile airframe structural integrity during flight including operation in adverse weather. These aerostructures and TPS must also be capable of surviving impact by rain droplets at high velocity. Additionally, these systems must meet a variety of requirements such as weight, erosion/ablation performance, cost, and component survivability to name a few. New advanced interceptors are expected to achieve much higher velocities and longer flight times resulting in more severe aerothermal heating and loads than currently designed systems. Potential missile defense applications include THAAD, Ground-based Mid-course Interceptor, Kinetic Energy Interceptor and others.

This topic calls for new innovative technologies applicable to light-weight heatshield and airframe design. Innovative methodologies to optimize and enhance the current TPS designs are of interest as well as designs and methodologies to provide integrated TPS and structures. Key issues include insulative performance of the TPS, lightning strike performance of the integrated design, rain erosion performance, minimization of ablation in hypersonic environments, non-ionizing chemistry of the TPS, and structural performance for flight load requirements. In addition to hardware-oriented development, there is a need for improved tools and techniques for modeling and analysis of thermostructural behavior and rain droplet – aerostructure interactions. Typical aerothermal environments of interest include higher than Mach 8 flight regimes with cold wall heat rates and aerodynamic shear rates greater than 400 Btu/ft2-sec and 60 lbf/ft2, respectively. Environments for weather encounter are typically in the range of Mach 3 to 6.

PHASE I: Evaluate/develop conceptual designs, materials or techniques that provide significant thermal protection system improvements compared to current state-of-the-art techniques. As part of Phase I, the technical scope may include materials development and characterization, and/or modeling and thermostructural analysis. A well-defined Phase II development and demonstration plan must be generated.

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 BMDS elements including spiral block upgrades to current platforms as well as new interceptor systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: There are numerous and far-ranging possibilities of commercial applications for an ultra-lightweight, durable, and reliable TPS system in commercial launch vehicles and NASA in addition to military reusable space vehicles.

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Reynolds, R.A, Nourse, R.N, and Russell, G.W, Aerothermal Ablation Behavior of Selected Candidate External Insulation Materials, 28th AIAA Joint Propulsion Conference and Exhibit, July 1992.

3. A. L. Murray, G. W. Russell, "Coupled Aeroheating/Ablation Analysis for Missile Configurations," Journal of Spacecraft and Rockets, Vol. 39, No 4, April 2002.

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5. Russell, G.W., Kinetic Decomposition and Thermal Modeling of Chartek 59C, 29th AIAA Joint Propulsion Conference and Exhibit June 1993.

6. Russell, G.W., DoD High Speed Aerothermal Analysis and Design - Historical Review and New State of the Art Approaches, NASA Thermal and Fluids Analysis Workshop, August 2003, NASA Langley Research Center, Hampton, VA.

KEYWORDS: Missiles, Thermal Control; Thermal Insulation; Light-Weight, Shock Resistance, Vibration Resistance, Rain Erosion, Composite, Lightning Strike

MDA05-022 TITLE: Ballistic Missile Defense System Innovative Power Storage Devices

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

ACQUISITION PROGRAM: BMDS-MDA/MP

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.

DESCRIPTION: Many battery and power source products made for missile defense applications are manufactured in low volume and 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. Technical areas of interest include, but are not limited to the following:

Primary Reserve Batteries: 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 Watt hrs/kg at the battery level). Providing conformability will allow fitting batteries into unconventional shapes and results in more efficient space utilization (e.g. shapes other than right cylindrical or rectangular solids). Improvements in battery safety under normal and abnormal use conditions (e.g. fire exposure) are always important. Reducing “touch labor”, parts count and simplifying fabrication techniques reduce cost, and complexity (e.g. improved pyrotechnic igniter designs). Other desired improvements include increasing reliability, manufacturability, assembly and performance of electrodes/separators used by these batteries (e.g. elimination or modification of processing steps that induce defects).

Secondary Lithium Batteries: Develop improved designs, manufacturing processes or beneficial variations to lithium rechargeable batteries capable of moderate to high rates (e.g. 10C) for aerospace applications. Improvement areas include increasing energy density (e.g. batteries formed from 25 amp hr and larger cells with a battery energy density of greater than 130 Watt hrs/kg), improved calendar life, better cycle life at greater depths of discharge (e.g. over 20,000 cycles at greater than 50% depth of discharge), improved charging methods and increased cell safety (e.g. benign response to abusive conditions like over charging, over discharging).

Hybrids: Explore the use of battery/capacitor hybrids to provide power sources with optimum power and energy densities for missile defense applications (e.g. combinations of the above mentioned primary battery energy and power performance targets).

Improving Manufacturing & Production: Research and develop improved processing techniques to lower power source production costs.• Develop or exploit existing CAM/CAD tools to aid battery design, production, reduce non-recurring engineering costs, and shorten lead times. Enabling technologies that produce extremely lightweight, safe, relatively inexpensive, inherently powerful primary batteries with enhanced consistency, producibility and manufacturability are necessary for mission success. elimination or modification of processing steps that induce defects)

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 judging 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 many types of power storage devices. Thermal primary batteries are used in military and commercial launch vehicles to power various subsystems in-flight. Lithium oxyhalide 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 but are mainly used in commercial applications. Finally, the manufacturing and producibility enhancements for MDA batteries could be applicable to commercial battery manufacturing lines.

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

KEYWORDS: power density, energy density, conformability, hybrid, primary battery, secondary battery, lithium

MDA05-023 TITLE: <u>Computer Network Operations (CNO) Technologies</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS-MDA/GM, MDA/BC

OBJECTIVE: Develop and demonstrate innovative virtual software solutions to the problem of Cyber Security Technologies in the context of Ballistic Missile Defense System (BMDS) Program Protection Plans and associated architectures.

DESCRIPTION: Cyber Security refers to defensive and offensive 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. The insider threat is an insidious and difficult threat faced by cyber security specialists and network defenders. To facilitate early and accurate detection of the insider threat, a number of new methods and ideas should be explored, including techniques to understand the behavior of information system users and to be able to determine that a user's behavior is not normal. Solutions should mitigate increased system latency or network response times. 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 in a work-centered environment supporting the Computer Network Operations manager.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of methods for Cyber Security application software systems that provide Cyber Security services that contribute to Cyber Security initiatives for missile defense systems.

PHASE II: Develop and demonstrate prototype platform/software/hardware that demonstrates advancement of Cyber Security initiatives 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 Cyber Security 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.

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2. Spafford, Eugene and Crosbie, Mark, "An Architecture for Intrusion Detection using Autonomous Agents," Purdue University, 11 June 1998.
3. Spafford, Eugene and Crosbie, Mark, "Active Defense of A Computer System Using Autonomous Agents," Purdue University, Feb 15, 1997.
4. Charles Pfleeger, Security in Computing, Prentice Hall Technical References, Copyright 2003, Chapter Five, Trusted Operating System Design, pages 250-265.
5. IDMEF Data Model, http://www.izerv.net/idwg-public/archive/0248.html

KEYWORDS: cyber security; computer network attack; computer network defense; agent based systems; intrusion detection; insider threats.

MDA05-024 TITLE: Ballistic Missile System Advanced Materials and Structures

TECHNOLOGY AREAS: Materials/Processes, Weapons, Nuclear Technology

ACQUISITION PROGRAM: BMDS-MDA/MP, TH, AL, GM

OBJECTIVE: Develop innovative advanced material structures and processes for implementation in BMD Systems

DESCRIPTION: MDA is seeking to reduce cost, reduce lead time, enhance reliability of component and system performance, and enhance producibility for low-rate, non-labor intensive production of ballistic missile defense systems through novel application of advanced materials / composites technologies, structures, and processes. Innovations can include Design for Manufacturability and Assembly (DFMA), improvements in fabrication, or open architecture and modular designs. Concepts may involve research and development, modeling, material characterization, technology development, lean manufacturing processes and component assembly processes, tooling, test and validation techniques, and process controls.

Solutions should incorporate innovative designs, lean manufacturing, and the utilization of high-strength, light weight materials, resulting in low life cycle cost, reduced lead time, low operational maintenance, improved performance and reliability, improved manufacturability, and cost reduction.

Technical areas of interest include, but are not limited to:
Materials: Resins and fiber systems with low-out gassing and low coefficient of thermal expansion (CTE), High glass transition temperature resin systems. Low density, high stiffness nanostructured metallic and ceramic materials, Ultra-high temperature, high strength, high stiffness, lightweight ceramic or metallic composite materials, Polymer matrix and metal matrix graphite and ceramic composites, Low permeable materials and coatings, Active and passive sensing/health monitoring.

Structures: canisters and missile round pallets, large vacuum vessels, optics benches and large diameter vacuum beam tubes, chemical resistant steam ejector tubes, Kill Vehicle (KV) structure and component housings.

Airborne Laser and KV Divert and Attitude Control Fuel Tanks: Prevent laminate micro-cracking. Redesign the boss region to eliminate the CTE mismatches and differential strains that results in leaks. Reduce the weight of the tanks by 40%.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle and to improve producibility, increase performance, lower cost, or increase reliability.

PHASE II: Develop, fabricate, and validate the feasibility and engineering scale-up of proposed technology. Validation would include BMD system simulations, operation in test-beds, or operation in a demonstration sub-system.

PHASE III: The developed technology has direct near-term insertion potential into a 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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Brandon J. Arritt, Eugene R. Fosness, Peter M. Wegner, and Jim Guerrero, "Composite Tank Development Efforts at the Air Force Research Laboratory Space Vehicles Directorate," AIAA Space Conference & Exposition, Albuquerque, NM, August 2001.
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Defending America: The Case for Limited National Missile Defense, J. Lindsay, M. O'Hanlon, Brookings Institute Press, April, 2001.
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KEYWORDS: composites, lightweight, advanced materials, reliability, producibility, manufacturability

MDA05-025 TITLE: <u>Secure Computing Infrastructure Technologies</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS-MDA/GM, MDA/BC

OBJECTIVE: The computing infrastructure of communications networks is an important target for the enemy and therefore must be extremely secure and highly survivable. Understanding the nature of attacks against these systems and the effectiveness and efficiency of this infrastructure is of critical importance.

DESCRIPTION: Survivable information technology integrates techniques from both information security and fault tolerance. However, the combination of these two paradigms creates a difficult problem because it causes a conflict with their fundamental foundations. Specifically, information security strives to minimize what is to be protected, place it in as few locations as possible, and maximize the security at those places. Fault tolerance, on the other hand, strives to replicate what is to be protected creating redundancy, and disperse it in as many locations as possible. Therefore, the task of this research is to develop technology that can make the information communications of the global ballistic missile defense system more secure and fault tolerant while gaining insight into the attacks and effectiveness of countermeasures against these attacks. Ideally, the solution or solutions should be as general and system independent as possible. Cyber forensics techniques are required that allow analysts to piece together reliable evidence of misuse in a real-time manner to support large, geographically dispersed networks aiding post-attack analysis, countermeasures development, and legal prosecution.

PHASE I: Research technology for increasing the security and survivability of a communications system and develop tools that evaluate the effectiveness and efficiency of the communications system and attacks against it. Deliver a demonstrable prototype as a proof of concept.

PHASE II: Develop and demonstrate innovative generic hardware and software technologies for implementing a secure and fault tolerant communication system. Develop and demonstrate these tools to support the understanding and effectiveness of countermeasures against attacks on the communication system.

PHASE III: Commercialization and transition/transfer of developed products to the military and commercial markets.

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.

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3. Reiter, M., Birman, K., Renesse, R., “A Security Architecture for Fault-Tolerant Systems,” ACM Transactions on Computer Systems, 12(4):340-371, 1994.
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KEYWORDS: information security, information assurance, fault tolerance, survivability, communication protocol.

MDA05-026 TITLE: Nuclear Radiation Mitigation Technology for 2-Color Focal Plane Arrays

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: BMDS-MDA/AB/MP

OBJECTIVE: Develop and test a method for mitigation of transient radiation-induced noise in a 2-color FPA for use in the Aegis SM-3 KW sensor.

DESCRIPTION: Multicolor imaging in optical sensors provides significantly improved target location and discrimination compared to single band sensors. The Aegis SM-3 Kinetic Warhead (KW) seeker must operate for up to several minutes in a high radiation space environment, including that caused by a nuclear detonation. Because of severe weight and sensor payload packaging constraints on the current KW, a single 2-color focal plane array (FPA) is preferred over using two single-color FPAs. However, radiation noise mitigation techniques for 2-color FPAs are not mature compared to those available for single color FPAs. Innovations are needed to either extend existing single-color mitigation techniques or to develop new radiation noise mitigation technologies for 2-color FPAs.

PHASE I: Conduct simulation or experimental proof-of-principle demonstration of a proposed radiation noise mitigation solution for a chosen 2-color FPA approach. Establish feasibility of mitigation method and determine expected efficacy as a function of radiation environment.

PHASE II: Develop prototype of a noise-mitigated and radiation hardened 2-color FPA. Test device in a suitable radiation environment. Demonstrate and document FPA performance using the prototype mitigation technology compared to that achieved using the underlying unmitigated 2-color FPA. Demonstrate the ability to manufacture the radiation-mitigated FPA and implement the design in the KW sensor.

PHASE III: Transition the noise-mitigated FPA technology to mass production. There is a great deal of interest in multicolor sensors for a variety of seeker and satellite-based sensor systems with a need to operate in the presence of radiation environments. Partnership with traditional DOD prime-contractors may be pursued since the government applications will receive immediate benefit from a successful technology development program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Compact, multi-color optical sensors that can operate in a radiation environment will find a wide variety of commercial and national security applications in space-based environmental/remote sensing and monitoring systems, space surveillance systems, and weather satellites.

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Kalma, A.H. “Nuclear and Space Radiation Effects in Infrared Detectors,” Proc. SPIE, 217, 186, 1980.
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KEYWORDS: Sensors, Focal Plane Array, FPA, 2-color seeker, radiation hardening, radiation effects mitigation, photo-detectors, in-pixel, nuclear survivability, protons, gammas, betas, neutrons.

MDA05-027 TITLE: Resistless Fabrication and Radiation Characterization for Microelectronics with less than 65 nanometer Features

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

ACQUISITION PROGRAM: BMDS-MDA/MP/GM/AS/SS/AB/TH

OBJECTIVE: Develop a tool allowing fabrication of advanced semiconductor devices without the need for resist thereby avoiding the high front-end, fixed costs. Also, develop an in-situ wafer level characterization capability using this technology to assess single event effects susceptibility.

DESCRIPTION: The continuing increase in performance in microelectronics is made possible by the steadily decreasing size of transistors, summarized in the popular press as Moore’s law. The key contributor to this improvement has been the lithography process which defines the intricate structures of the silicon chip. In the past, these small features were defined by masked lithography onto resist covered semiconductor wafer. Current manufacturing produces features shorter than the wavelength of the exposing light, at the expense of process robustness and complex mask structures. The resistless approach bypasses the requirements for the tapeout, and the entire and wafer preparation/clean process for lithography on each level. Eliminating theses steps opens the door to flexible, scalable and distributed manufacturing to effectively reducing the up-front fixed costs; thus broadening the US semiconductor industry. This approach is particularly suited for low production rates (e.g. tens of wafers) such as needed for many military/space systems and application specific integrated circuits (ASICs) and therefore should address advantages in radiation hardened semiconductor processing. The basic requirement for a resistless manufacturing tool is a throughput of at least two wafers (300 mm dia.) per hour with features below 65 nm. Overlay accuracy and dimensional control are to be compatible with the usual conventional semiconductor manufacturing requirements applicable to a given feature size. Exposing beams may be photons or charged particles. The developed technology should provide an additional capability for wafer level device single event effects (SEE) characterization to demonstrate operation under simulated heavy ion and nuclear particle radiation environments.

PHASE I: Define component approach and architecture. Identify key subcomponents (beam switching). Evaluate approach for throughput, feature size, overlay, dimensional control, critical charge deposition energy and device capture cross section with statistically significant repetition.

PHASE II: Provide a detailed design for a complete system meeting the above requirements. Fabricate a minimum assembly, and demonstrate feature size, overlay, dimensional control, and scalability for throughput of one wafer level per hour. Provide a prototype ASIC chip for electrical performance and SEE radiation testing that validates energy versus cross sectional capability with and without overlayers like metalization.

PHASE III: The technology developed will apply to integrated circuit designs having the relatively low production ASIC volumes of the Ballistic Missile Defense System including Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) and the initial engineering lots developed for high volume commercial markets.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology developed will have a significant impact on the breakthrough of current commercial microelectronics technology and apply to manufacturing of advanced microelectronics for commercial market. These less than 65 nanometer features are increasingly more susceptible to SEE and this topic will assess quality control features within new devices to assure uniform radiation hard manufacturing producibility.

REFERENCES:
1. http://www.sematech.org/public/resources/litho/ngl/maskless0801/output.htm.
2. http://public.itrs.net/

KEYWORDS: Lithography, Resistless Processing, Direct-Write, Radiation Hardening, Semiconductor Fabrication, Manufacturing Producibility and Single Event Effects.

MDA05-028 TITLE: Radiation Hardened Fiber Optic Gyro Components

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

ACQUISITION PROGRAM: BMDS-MDA/SS/AS

OBJECTIVE: The overall objective of this effort is to investigate schemes, technologies and/or novel manufacturing processes to develop high performance fiber optic gyro components that will provide an increased level of resistance to damage induced by space environment radiation and is capable of meeting the goals of the STSS program.

DESCRIPTION: Current state-of-the-art Fiber Optic Gyros (FOGs) exhibit a susceptibility to damage from space environment radiation and may be incapable of surviving the natural radiation environment for the projected design-life of the STSS and other space systems.

STSS is interested in developing or certifying radiation hardened critical components for fiber optic gyros (FOGs) to support the next generation of satellites. Components must be able to demonstrate hardening against protons and total dose of 300 kRads (Si) at a minimum for the expected seven year life requirement while providing the overall system measurement accuracy necessary to support the mission. Identified critical components include, but are not limited to, optical fiber, light source (including doped fiber light sources), photo diodes, Integrated Optical chips, and couplers. The offeror may select one or more of these critical components to develop.

System level Performance Goals (FOGs): Bias Drift Stability, 1 ó, 8 hr: < 0.001 deg/hr, Scale Factor Error (Long-term): < 10 ppm, Angular Random Walk: < 0.0001 deg/ (hr)1/2, Angular Rate capability: > 0.5 rad/s (w/o change in measurement mode), Angular Acceleration Capability: > 0.5 rad/s2 (w/o change in measurement mode), Operating temperature range: -54 to 32°C,Survivable temperature range: -60 to 71°C
Radiation Hardness (total dose): > 300 Krad.

PHASE I: Identify and investigate materials, unique device designs, novel architectures, and/or production process changes or additions suitable for fiber optic gyro component fabrication lines that will result in significant improvement in the intrinsic resistance to damage from space environment radiation effects and capability to provide required inertial angular accuracy. A sound basis must also be shown for the radiation hardness capability of the treatment.

Where ever possible, modeling, simulation and analysis should be performed to support the offeror's conclusions. Although not required in Phase I, prototype hardware and testing is highly encouraged to validate offeror's modeling and analysis efforts.

Offerors are strongly encouraged to work with system and payload 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 intrinsic radiation hardening of Fiber Optic Gyros (FOGs). In Phase II, the contractor is required to have radiation testing performed to verify that hardening to protons and 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 and payload 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.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Fiber optic gyros (FOGs) are employed widely in both military and commercial satellites. Results from this program will be FOGs and components that have greatly increased intrinsic resistance to radiation damage to provide both military and commercial users longer on-orbit satellite lifetime and increased performance. In addition, these technologies have application to missiles for targeting and navigation, and laser communication.

REFERENCES:

Challenges in Dynamics, System Identification, Control and Handling Qualities for Land, Air, Sea and Space Vehicles, RTO Systems Concepts and Integration (SCI) Symposium, Berlin, Germany, on 13-15 May 2002

KEYWORDS: Satellite, Fiber Optic Gyro, Radiation Hardening

MDA05-029 TITLE: Radiation Hard Electronic Components

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: BMDS-MDA/SS, GM, AB, TH, AS, MP

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, general-purpose (GP) and digital signal processors (DSPs) may be incapable of reliably operating 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 system and payload design requirements. This topic seeks the development of one or more of these components capable of enduring and reliably operating in BMDS mission environment. Specifically, the goal is to achieve near-current-commercial product performance while being capable of surviving 300Krad total dose. We seek innovative concepts that use radiation-hardening by process, by design, by architecture or a combination of these approaches.

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 system and payload 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 they should have working relationships with, and support from system and payload contractors. 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 for use in the Space Tracking and Surveillance System, other MDA and DoD systems, or commercial applications. The offerors are encouraged to further seek 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 systems, which include commercial satellites. 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:

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

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

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.

MDA05-030 TITLE: Radiation Hard, High Precision, Agile Star Tracker

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

ACQUISITION PROGRAM: BMDS-MDA/SS/AS

OBJECTIVE: The overall objective of this effort is to investigate schemes and technologies and/or develop a concept design for a star tracker that will provide an increased level of resistance to damage induced by space environment radiation and is capable of meeting the goals of the STSS program.

DESCRIPTION: Current state-of-the-art Star Trackers exhibit a susceptibility to damage from space environment radiation and may be incapable of surviving the natural radiation environment for the projected design-life of the STSS and other space systems. The desire is for continued, high performance following accumulation of 300kRad(Si) of dose (proton and ionizing). Additionally, they have problems maintaining high precision during a spacecraft slew.

The projected radiation environment for these 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 star tracker performance from beginning of life values (i.e. End of Life > 0.70 * Beginning of Life performance). The end of life performance goal is to provide inertial pointing measurement error of < 1 arc-second. In addition to radiation, other space environmental effects, like extreme temperature fluctuations, must be tolerated while providing required performance.

Optical coatings can be severely degraded by both radiation and by extreme temperatures (or significant temperature fluxuations), and when they become damaged or delaminate, they cannot be remotely repaired. This leads to inoperability of the devices for which they are used. Specifically sought are coatings and materials that have increased resistance to damaging space environmental conditions and provide longer on-orbit operation. Materials of interest are indium gallium arsenide and silicon for the visible-near IR waveband.

Detector/focal plane arrarys are also subject to damage by the space environment. Significant past efforts, as well as on-going research, has accomplished much in terms of quantifying the damage extent, morphology, phenomenology and sensor lifetime associated with radiation effects to CCD arrays. CCD-based, or other sensors such as CMOS active pixel sensor devices or visible band PIN hybrids, that exhibit increased resistance to space environment radiation damage effects are highly desirable.

Also sought in this solicitation is the development of an agile star tracker that can continue to operate at “track” rate slews up to 2 degrees/second while tracking. This will require either a “lost in space” feature to rapidly recover from higher rate “acquisition slews” when the star tracker will be unable to operate or be able to acquire data from onboard gyros to provide an initial estimate of position upon completion of the acquisition slew and system transitions to track rate slews when the star tracker will have to operate again.

This solicitation is broad based, from architecture changes to components to full systems. Specifically sought are new and innovative schemes and technologies that involve modified production processes, improved or new materials, altered chip packaging, unique sensor types or designs or other innovative options that will increase the intrinsic resistance of star tracker sensors to ionizing radiation damage. Increased performance during spacecraft slew is highly desirable.

Any proposal submitted must focus on one specific area: the detector/focal plane/sensor, coatings, OR an integrated unit. An offeror may submit multiple proposals, 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 star tracker component fabrication lines that will result in significant improvement in the intrinsic resistance to damage from space environment radiation effects and capability to provide accurate position location data in the slew mode.

Significant improvements to radiation and thermal adherence durability of antireflective treatments over those currently used for Star Tracker optics will be demonstrated. The contractor shall demonstrate these improvements over repeated thermal excursions from –65 to +65 degrees Celsius from room temperature. A sound basis must also be shown for the radiation hardness capability of the treatment.

Offerors are strongly encouraged to work with system and payload 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 intrinsic radiation hardening of Star Trackers. In Phase II, the contractor is required to have radiation testing performed to verify that hardening to protons and 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 and payload 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.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Star trackers are employed widely in both military and commercial satellites. Results from this program will be Star trackers and components that have greatly increased intrinsic resistance to radiation damage to provide both military and commercial users longer on-orbit satellite lifetime and increased performance. In addition, these technologies have application to aircraft and missiles for targeting and navigation, and laser communication.

REFERENCES:

1. R. W. Bezooijen, “SIRTF autonomous star tracker,” Proc. SPIE Vol. 4850, p. 108-121, Mar 2003
2. A.K. Mainzer, E.T. Young, “On-orbit performance testing of the pointing calibration and reference sensor for the Spitzer Space Telescope”, Proc. SPIE Vol. 5487, p. 93-100, October 2004
3. J.P. Spratt, R.E. Leadon, J.Henley, W. Byers, R. Bredthauer and R. Groulx, “P-Channel CCDs for Radiation Hardened Star Trackers”, Presented at the Heart Conference, San Antonio TX, March 2001
4. Spratt, J.P., B.C. Passenheim, R.E. Leadon, S. Clark, and D.J. Strobel. "Effectiveness of IC Shielded Packages Against Space Radiation", T-NS, pp. 2018-2025, December 1997
5. J. Janesick, G. Soli, T. Elliott, and S. Collins, "The Effects of Proton Damage on Charge-Coupled Devices," Proc. SPIE, Vol. 1447, pp. 87-108, 1991
6. “Surface Plasmon Holography”, AIP Conf. Proc. No. 65, pp. 415-418, 1980
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8. “Aztec Surface-Relief Volume Diffractive Structure”, J. Opt. Soc. Am. A, Vol. 7, pp. 1529-1544, 1990

KEYWORDS: Satellite, Star Tracker, Radiation Hardening, Antireflection, Visible sensor

MDA05-031 TITLE: <u>Advanced Materials for Radiation Hardening</u>

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

ACQUISITION PROGRAM: BMDS-MDA/GM/TH/MP

OBJECTIVE: Develop innovative component and system design concepts which utilize advanced materials to reduce or produce a net zero increase in mass of the BMDS missile systems while providing a means to increase the radiation hardness level.

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. Advanced materials, composite structures with shielding layers, and/or coatings may provide a net zero impact or a reduction in mass while increasing the radiation hardness of these missile systems without the traditional corresponding mass penalty. Particular areas of interest are structures, housings, mirrors, seeker optics, and electronics. Systems of interest include all BMDS kill vehicles and space-based platforms.

PHASE I: Conduct research and experimental efforts to demonstrate proof-of-principle of proposed concepts using advanced materials, composite materials with shielding layers, and/or coatings to improve radiation hardness of missile subsystems/components 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 material performance characteristics and a net zero impact or a reduction in mass. Consider implications for practical handling and fabrication of materials after radiation hardening.

PHASE II: Demonstrate feasibility of proposed concept/technology; identify and address technological hurdles. Finalize Phase I design and develop a prototype component utilizing radiation hardened concept demonstrated in Phase I. 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, home-land security sector, and power and automotive industries.

REFERENCES:
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2. Glastone, Samuel, The Effects of Nuclear Weapons, USAEC, USGPO, Washington D.C., 1957.

KEYWORDS: Transient radiation; single event effects; composites, advanced materials, radiation hardening, mirrors, optics, electronics, natural space radiation

MDA05-032 TITLE: Development of Advanced Radar Technologies for Missile Defense

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: BMDS-TH/GM

OBJECTIVE: Identify, develop, and demonstrate advances in phased array radar technologies that will support existing Missile Defense (MD), and other, radar system architectures and will enable revolutionary radar performance and cost enhancements to future radar architectures.

DESCRIPTION: The MD radar threats envisioned for the near- and far-term are a challenging mixture of countermeasures that include chaff, jamming, low observable RVs, balloons, coatings, anti-simulation, and simulation, among other countermeasures, that will require novel approaches to the discrimination problem. This phased array radar technology research effort is focused on technologies to defeat evolving threats (to include advanced Electronic Counter Measures (ECM), maneuvering and reduced signature reentry vehicles while operating in a nuclear environment), by developing technologies that support improved performance capability, transportability, supportability, reliability, availability, and system survivability. Key areas of research include advanced T/R modules, lightweight antennas, wideband, multichannel, and multimode digital receiver/exciters. Advanced radar T/R modules would provide an increase to radar power-aperture product and bandwidth to enable improved search, track and discrimination capability and to reduce weight, and power dissipation. Advanced, light weight, antennas that demonstrate a two-fold reduction in both cost and volume while demonstrating a sensitivity improvement of 4-10 times and a 4-8 time improvement in the operating bandwidth are needed. Antennas should include the use of lightweight materials, and multi-aperture transmit and receive coherence technologies for transportable, distributed apertures. They would also include technologies to achieve long time delay (true time delay) functionality in a very small, lightweight, and low-cost MMIC package. Wideband, multichannel, multimode Digital Receiver/Exciter (DREX) technologies are needed that can produce a 10-30dB dynamic range improvement, a 2-4 time instantaneous bandwidth improvement, and improved phase/amplitude control). 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 advanced radar technologies that are scalable to desired missile defense radar system requirements.

PHASE II: Develop and demonstrate prototype radar technologies which meet or exceed missile defense requirements. Conduct hardware and/or software tests to evaluate the performance of the technology in a realistic environment.

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

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Private sector applications exist for advanced radar technologies throughout commercial industries. Commercial radars, communications equipment, and other portable systems will have dual use potential for this development.

REFERENCES:

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2. R. Mailloux, “Phased Array Antenna Handbook”, Artech House, 1994
3. D. Pozar, “Microwave Engineering”, Willey, 2005

KEYWORDS: Sensor, Radar, Signal Processing, T/R Modules, Phased Arrays, Receiver/Exciter, Discrimination, Countermeasures, Fusion

MDA05-033 TITLE: Technologies for Low Power Density Phased Array Radars

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: BMDS-GM

OBJECTIVE: Develop innovative chip and array technologies capable of supporting affordable low power density arrays for Ground-based Midcourse Defense (GMD) X-band radars, Sea Based X-band (SBX) radars, and future block Ballistic Missile Defense System (BMDS) radars. The focus of this research is to provide more compact, reliable, efficient, low cost semiconductor and/or other material solutions that will support affordable full field-of-view (FOV) X-band radars while decreasing the hardware, logistics, and associated operating costs required by current systems.

DESCRIPTION: Low power density phased array antennas incorporating innovative chip and array technologies have the potential for enabling more affordable radars capable of robust mission and basing support. Material and/or circuit developments leading to reductions in power density and enabling full field of view beam steering, elimination of grating lobes, increases in bandwidth and efficiencies, and reduction in cost and footprint based on advanced SiGe or other materials are desired. By introducing power output stages fabricated from advanced semiconductor materials there is the possibility of implementing low cost transmit/receive (T/R) modules on a chip that could reduce power density, increase bandwidth, decrease losses, and/or increase efficiency while eliminating much of the waste heat generated by inefficient Transmit/Receive (T/R) Modules. Light weight, low cost antennas employing advanced ceramic materials capable of significantly increasing the FOV, bandwidth, and efficiency are also of interest.

PHASE I: Develop and conduct proof-of-principle demonstrations of technologies that could reduce power density, increase bandwidth, decrease losses, and/or increase efficiency at an affordable price.

PHASE II: Update/develop technology based on Phase I results and demonstrate technology in a realistic 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 technology is applicable in radar and communications systems for the commercial marketplace.

REFERENCES:
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3. A.S. Kishk, Yan Yin, and A.W. Glisson, 'Conical Dielectric Resonator Antennas for Wideband Applications," IEEE Transactions on Antennas and Propagation, January 2002
4. Y.M.M. Antar and Z. Fan, "Theoretical Investigations of Aperture-Coupled Rectangular Dielectric Resonator Antenna," IEE Proceedings, Microwaves, Antennas and Propagation, Vol. 143, No. 2, pp 113-123, April 1996

KEYWORDS: Lithography; circuit design; transmit/receive modules; power amplifiers, X-Band Radar, UEWR

MDA05-034 TITLE: Innovative Radar System Concepts and Architectures

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: BMDS-AS/TH/AB/GM/MP

OBJECTIVE: The Missile Defense Agency (MDA) is seeking novel, innovative, cost effective, and manufacturable radar system design concepts providing enhanced surveillance and fire control for ballistic missile defense. Components and subsystems will support advanced radar systems.

DESCRIPTION: Requirements for ballistic missile defense drive radar system design in terms of sensitivity, bandwidth, polarization and time occupancy. Current radars meet requirements, but are expensive and often compromise performance to be affordable. The MDA is seeking innovative radar system concepts and architectures that provide the necessary capabilities in a more affordable, manufacturable, and flexible manner. Concepts are solicited which support distributed aperture operation (bi-static or multi-static), coherent distributed aperture operation, passive coherent location, high frequency and over-the-horizon concepts, and photonic-based architectures. Concepts and architectures supporting open system standards, interchangeable sub-systems, and software reuse are highly desired. Innovative architectures supporting efficient manufacturing and innovative manufacturing techniques are desired. Concepts supporting surface-based (land or sea) or airborne operation are equally desired. Concepts are solicited which provide the necessary sensitivity, bandwidth, and resources through a combination of transmit power and scalable aperture area. Alternatives to traditional "brick" architectures are highly desired. Innovative technologies and manufacturing techniques are desired for power amplifiers and materials, advanced packaging (including non-hermetic packaging), advanced interconnects, silicon-based RF components, highly integrated T/R chips, time-delay units, thermal management, commercial-based microwave substrates, and light weight structures. Advanced receiver/exciter technologies and sub-systems are necessary to support the desired advanced capabilities. It is envisioned that future radars will require multiple channels per sub-array and 10s to 100s of sub-arrays per array face. Adaptive digital beamforming and arbitrary waveform capabilities will stress receiver and exciter technologies in bandwidth, dynamic range, power consumption, and cost. Technologies and concepts are sought that support generation of wide bandwidth, spectrally clean, arbitrary waveforms, and reception and digitization of such signals. Interests include low-power single-chip receivers and exciters utilizing silicon-based technologies, photonic technologies (e.g. time delay units), and low and high power phase shifter technologies (e.g. MEMs, thin film ferrites, PIN diodes, etc). Sub-system proposals should address development of standard interfaces to permit technology refresh and upgrades. Technologies and concepts are desired which support high-throughput, low-power signal processing to support adaptive digital beamforming and high time-bandwidth product pulse compression waveforms. Concepts must have well defined open interfaces that readily support scaling and upgrades. Digital hardware, software, and photonic-based technologies are of equal interest.

PHASE I: Develop and demonstrate the feasibility of the proposed concept or architecture 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 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: Enhancements to the architectures of radar systems that improve discrimination, reduce power consumption and quantization errors, increase functionality, reduce sidelobes, reduce and remove the heat generated, and operate over multiple bands are directly applicable to any commercial radar system, such as air traffic control and weather radars as well as to communications equipment. There are numerous military applications as well outside of MDA, especially in instrumentation radar for phenomenological measurements and radars used for space surveillance.

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9. Tsui, "Digital Techniques for Wideband Receivers" Artech House, 2001
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KEYWORDS: Distributed Apertures, STAP, MIMO, spatio-temporal coding, manufacturing, open systems, photonics, phased array, GaAs, GaN, SiC, manufacturing, T/R Module, Low Power Density, open systems, thermal management, packaging, beamforming, signal processing, digital array radar, adaptive processing, FPGA, ASIC, antenna array, radar.

MDA05-035   TITLE: <u>Innovative Radar/RF Sensors and Signal processing</u>

TECHNOLOGY AREAS: Information Systems, Materials

ACQUISITION PROGRAM: MP/GM

OBJECTIVE: MDA is seeking innovative products that improve Sensor and Telemetry System capability, reliability and producibility in Ballistic Missile Defense systems. These Sensor Systems include Telemetry Systems, Software Defined Radio, Radar RF systems, Radar Signal Processing, Imaging sensors, Imaging Processing systems and Data Fusion systems. Innovations include, but are not limited to, application or modification to existing products whether Commercial-off-the-shelf (COTS) or Military-off-the-shelf (MOTS) that are applied in creative ways to MDA systems, subsystems, or component requirements. Of particular interest are improvements in near-term design, fabrication and production of key GMD radar components.

DESCRIPTION: Many piece parts of the Missile Defense System have not transitioned into a production environment and are fabricated in an R&D or laboratory environment. This causes them to be subject to expensive, time-consuming custom integration into the actual systems. MDA is seeking innovative approaches that will allow economically feasible acquisition of new process technologies for components of the ballistic missile defense system. This can range from improvements in fabrication of advanced materials through innovative application of methods and tools to improve manufacturing processes and procedures on current systems and subsystems. MDA is also interested in process technology that facilitates the transition of a product (breadboard, brass board or prototype) from an R&D environment to any manufacturing environment (commercial, defense or both). Of special interest are innovations that can be developed/demonstrated or inserted into X-band Radar systems.

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

• Advanced gallium arsenide (GaAs) and wide band gap (WBG) high power amplifiers/devices in the frequency range from UHF through Ka Band. The goal of this focus area is to improve process yields by 100% by effecting improvements at the various process steps including: reduction of defects in wafer manufacturing; high yield discrete device production and characterization, as well as performance improvements; and amplifier module manufacturability, miniaturization and reliability. Improvements at each stage can enhance performance, extend service life, and/or reduce production costs.

• Solid State Transmitters such as IMPATT diode and WBG transistor based design, manufacturability, reliability improvements that enhance performance or lower production costs. The goal of this focus is design for manufacturing (DFM) to reduce the costs of manufacturing by up to 50%.

• Thermal Management systems such as improvements in subsystem active and passive cooling, heat conduction and related manufacturability improvements that enhance performance or lower production costs. The goal of this focus area is to improve thermal management at the radar T/R module-level by more than 50% to permit use of higher-power devices.

• Software defined waveform generators and receivers such as programmable telemetry transceivers, associated software reliability and manufacturability that enhance performance or lower production costs. The goal of this focus are is the reduction of acquisition and life-cycle costs by as much as 100% through increases in commonality between the various missile systems in use as well as incremental improvements in radar system performance through the implementation of wideband waveforms.

• MMIC packaging and High-Density Interconnects (HDI) such as three-dimensional high-density interconnect, flip-chip, and high frequency/high power density packaging designs and manufacturability improvements. The goal of this focus is the reduction of acquisition and life-cycle costs by as much as 100% through enhancements in packaging.

• Multi-band frequency agile data links such as reprogrammable multiband radio frequency data links which provides interoperability between multiple platforms with little or no modifications and least possible cost by permitting adaptation to the specific data link requirements through software loading. The goal of this focus is the reduction of acquisition and life-cycle costs by as much as 100% through increases in commonality between the various missile systems in use.

• Multi-band Antennas such as phased array antenna structure, adaptive beamforming, and wideband T/R modules design and manufacturing improvements. This includes Radiating Elements for X-band phased array radars that are low cost, high efficiency, lightweight, and easily manufactured to tolerances. The goal of this focus is design for manufacturing (DFM) to reduce the costs of antenna system manufacturing by up to 50% by use of advanced materials and T/R module-level design-for-manufacturing techniques.

• Advanced Signal Processors utilizing technologies such as Fourier optic, optical system and component, sensor array, A/D converter, processor and algorithm designs and manufacturability improvements or miniaturization that enhance performance or lower production costs. 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.

• Flow Motion Sensors such as high integration single of multichip system, algorithm or sensor array designs and manufacturability improvements that enhance performance or lower production costs. The goal of this focus is a 50% improvement in image processing throughput and 50% reduction in life-cycle costs.

• Wide instantaneous bandwidth processing of multiple waveforms such as Pseudorandom noise (PRN) code, chaotic waveform and ultra-wideband modulation format designs or implementations that enhance performance or lower production costs. The goal of this focus is a 50% improvement in radar target discrimination and tracking capability.

PHASE I: Develop conceptual framework and demonstrate potential utility for Sensor System product design or modification that will improve performance, lower cost, or increase reliability of BMD element systems, subsystems, or components. Develop a plan for implementing promising approaches for insertion into BMD subsystems and components.

PHASE II: Validate the feasibility of a Sensor System product technology by demonstrating its use in the 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. 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: Successfully demonstrate new open/modular, non-proprietary, Sensor System product technology. 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 one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Sensor Systems are widely used in commercial industry and would benefit in areas including: solid-state air traffic control radars; high power amplifiers for cellular telephone base stations, thermal management materials for the electronics industry; semiconductor device developments and mixed signal devices for the telecommunications industry, high power density packaging designs for cellular telephones and hand held computers. Many of the technologies under this topic would be directly applicable to the commercial space telecommunications industry including RF data links for high bandwidth satellite communications.

REFERENCES:
http://www.acq.osd.mil/bmdo/bmdolink/html/, http://www.acq.osd.mil/bmdo/bmdolink/html/basics.html.

MDA05-036 TITLE: Reliable, Lightweight, Low Cost, and Volume Efficient Electrical Circuitry Development that Facilitates Integration and Checkout for the Space Tracking and Surveillance System (STSS)

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

ACQUISITION PROGRAM: BMDS-MDA/SS

OBJECTIVE: Dramatically improve the current STSS avionics configuration thru the use of innovative flexible circuit/harnessing. Concepts must improve reliability and reduce mass/volume while decreasing integration time and facilitating checkout.

DESCRIPTION: The satellite wiring harness is an unwelcome but necessary complication in the design of a spacecraft. Conventional satellite electronic harness configurations utilize heavy and cumbersome cabling and connectors. These types of cables do not facilitate system level integration, have limited test and diagnostic capability, require heavy brackets to properly install, are time consuming to manufacture, and consume a significant portion of the satellite's payload budget. Historically, conventional cabling is unreliable and has been a significant contributor to integration, checkout, and even flight-level anomalies. Large platforms such as GPS have hundreds of pounds of cables and connectors. While it is not possible to have a completely wireless spacecraft, many wires, especially those dedicated to low data rate functions, can be eliminated through innovative streamlined fabrication techniques that involve superposition of communication traces onto the power distribution grid itself. This topic seeks creative strategies for utilizing existing power connections as a low-bandwidth health and status network, to eliminate dozens to hundreds of wires in a complex system. It will be necessary to develop extremely miniature, low-power, and robust circuitry and modules to do this. Proposed concepts should create circuit multifunctionality via distributed sensing, embedded processing capabilities, etc. and must significantly reduce fabrication, integration, and checkout timelines while enhancing reliability.

PHASE I: Design and develop an Engineering Development Unit (EDU) for the proposed circuitry concept. The EDU will be tested to characterize performance and to assist in developing a Phase II circuit design strategy. Proposed circuitry concepts should be functionally tested in an STSS type environment that includes, but is not limited to: vibration, thermal vacuum, thermal management, electromagnetic interference, and strain. Offerors are strongly encouraged to work with STSS system and payload contractors to understand the circuit 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 STSS circuit harness. The prototype harness should be tested in accordance with STSS parameters. If fabrication, integration, and testing are successful, the contractor should be prepared to design and fabricate circuitry to a complete STSS avionics requirement. 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 avionics applications where issues exist regarding electronic circuitry reliability, mass, volume, and integration time. STSS and other MDA programs could efficiently procure tailored circuitry for their systems via the phase III.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Innovations in flexible circuitry are pervasive and could easily transfer to the commercial sector. Industry is always pushing for lighter, smaller, and better-performing electronics for the home, office, or other areas of consideration such as satellites, weaponry, etc. The technologies developed under the proposed topic would assist the commercial industry to achieve these goals.

REFERENCES :

1. "Multifunctional Structures", presented at the AIAA Space 2001 Conference in Albuquerque, NM, 28-30 August 2001.
2. Yamar Electronic Ltd. website, www.yamar.com, 2005, Tel Aviv, Israel.
3. "Design & Testing of Multifunctional Structure Concept", presented at the 41st Annual Structural Design and Materials AIAA and ASME Conference, 4 April 2000, Atlanta, GA.
4. "Multifunctional Structures Technology Demonstration on NMO Deep Space 1", presented at the Deep Space 1 Technology Validation Symposium, 9 February 00, Pasadena, California.
5. "Overview of Multifunctional Structure Efforts at the Air Force Research Laboratory", presented at the Space 2000 & Robotics 2000 Conference, Albuquerque, NM 28 February 1999.

KEYWORDS: Satellite avionics, harnessing, satellite circuitry, flexible circuitry, multifunctional circuitry, smart circuits

MDA05-037 TITLE: Broad Multi-Frequency Discrimination

TECHNOLOGY AREAS: Sensors, Space Platforms

ACQUISITION PROGRAM: BMDS-MDA AB/AS/BC/GM/SE/TH

OBJECTIVE: Identify, develop, and demonstrate advanced and innovative multi-frequency and multi-band sensor techniques to improve the performance and affordability for discrimination of ballistic missile threats in increasingly complex countermeasures environments

DESCRIPTION: Advances in key sensor technologies can greatly increase the potential ability to perform robust, high-confidence discrimination on ballistic missile reentry vehicles. These critical technologies include the use of multi-frequencies and multi-bands to provide improved discrimination features including finer resolution. Level of discrimination improvements desired is greater than a k factor of 4. These new capabilities require:

• Globally accurate timing necessary to provide the ability to control timing/coherence, and hence phase angle, accurately over long periods of time and over large regions of space. Precise timing enables the capability to operate coherent, multi-static, and ultra-wideband sensing systems that are supported by ultra-wideband communications.

• Advanced computing capability to provide inexpensive, rugged, reliable high-speed processors and large-scale memory components. These digital systems will allow work performed by expensive special purpose electronics to be performed by general-purpose electronics controlled by special-purpose software. These hardware and software characteristics support the ability to field and maintain high-performance military systems much more affordably than in the recent past.

Technology innovations sought should allow for the synthesis, design, and demonstration of discrimination systems that exploit modern component technologies to provide discrimination products that are flexible, robust, effective, producible, and less expensive to maintain and upgrade than the current discrimination techniques. These approaches may have some or all of the following characteristics:

• Ultra-wideband over multi-wavelength spectra,
• Multi-static and multi-sensor configurations,
• Lightweight (especially the antennas)
• Highly integrated,
• Coherent, adaptive operation of ensembles of sensors,
• Extensive use of COTS parts and assemblies.

Multi-frequency techniques proposed may provide significant discrimination options as well as providing a highly robust capability to mitigate the effects of jamming. The focus of this research area is a near-term application to S-Band and X-Band frequencies. However, proposals will also be entertained that address the potential for application across all BMDS radar systems. If successful, this research will have extensive application to the BMDS on numerous radar programs across a broad RF spectrum: a) UHF, e.g. the Ground-Based Midcourse Defense (GMD) Upgraded Early Warning Radar at Beale; b) L-Band, e.g. the GMD Cobra Dane Radar; c) S-band, with the Aegis SPY1-radar; d) X-Band, including Army THAAD and GMD X-Band Radar programs. The resource efficient, multi-frequency waveform and discrimination algorithms that result from this research will have wide application and could significantly enhance integrated BMDS performance.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of advanced multi-frequency sensor hardware discrimination technology to improve the discrimination of ballistic missile and cruise-missile threats.

PHASE II: Develop and demonstrate brass board prototype sensor systems to demonstrate performance and implementation feasibility (in hardware) of candidate techniques.

PHASE III: Apply discrimination techniques to deployable prototype sensor systems suitable for field demonstrations.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Applications that exist for inexpensive, lightweight, discrimination systems include air traffic control applications, medical applications to differentiate changes in tissues.

REFERENCES:

1. www.mda.mil
2. www.ucsusa.org

KEYWORDS: Discrimination, Target Recognition, COTS, Lightweight, Affordable

MDA05-038 TITLE: Advanced Radar Data Fusion

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: BMDS-MDA – AB/AS/BC/GM/SE/TH

OBJECTIVE: Develop robust algorithms, software, and/or hardware necessary to collect, process, and fuse information from multiple radars (either at the same or different frequencies) and/or other sensors to form a single integrated picture of the battlespace. 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 may provide 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. Algorithms, 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: 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.

3-D Imaging with Multi-Sensors. Of particular 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 would also be useful..

PHASE I: Develop and conduct proof-of-principle demonstrations of advanced radar 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 Radars. 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 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 weather radar applications.

REFERENCES:

1. Martinez, David, et.al., “Wideband Networked Sensors”, MIT Lincoln Labs, http://www.fas.org/spp/military/program/track/martinez.pdf, October 2000
2. D. Hall and James Llinas, “An Introduction to Multisensor Data Fusion,” Proceedings of the IEEE, 85 (No. 1) 1997
3. D.C. Cowley and B. Shafai, “Registration in Multi-Sensor Data Fusion and Tracking,” Proceedings of the American Control Conference, June 1993
4. Y. Bar-Shalom and W.D. Blair, Editors, Multi-Target/Multi-Sensor Tracking: Applications and Advances, Vol. III, Artech House, Norwood, MA, 2000
5. T. Sakamoto and T. Sato, “A fast Algorithm of 3-dimensional Imaging for Pulsed Radar Systems,” Proceedings IEEE 2004 Antennas and Propagation Society Symposium, Vol. 2, 20-25 June 2004
6. W. Streilein, et al. “Fused Multi-Sensor Mining for Feature Foundation Data,” Proceeding of Third International Conference of Information Fusion, Vol. 1, 10-13, July 2000

KEYWORDS: Sensor Fusion; Data Fusion; Sensor Integration; Signal Processing; Algorithm; Multi-Sensor, 3-D Imaging

MDA05-039 TITLE: Influence of Discrimination Capability on Sensor Task Planning

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: BMDS-MDA – AB/AS/BC/GM/SE/TH

OBJECTIVE: Investigate techniques for assessing sensor or element’s discrimination capability to support sensor tasking along a threat timeline maximizing BMDS discrimination capability. Certain mobile elements will need to assess their operating area to maximize sensor discrimination capability while optimizing run times to reach a re-planning goal of an hour on a PC based or single board computing environment. Separately, Discrimination Capability Assessment for Sensor Task planning must help planning and threat assignment function in a timeline to support an engagement. Therefore Discrimination Capability Assessment must be accomplished within five minutes on a PC based or single board computing environment to support more rapid operation requirements of the future.

DESCRIPTION: Both in planning and prosecution of a multi-element mission, Command, Control, Battle Management and Communications (C2BMC) will need to evaluate the sensor most capable of providing critical discrimination information. Each sensor has unique feature measure and measurement quality capability. Some of these sensors may be resource constrain especially in certain scenarios. This topic seeks rapid assessment techniques for evaluating a sensor or elements ability to support the discrimination challenge. In the planning mode the techniques must help establish position, orientation and/or operating area. The online techniques must access different sensors ability to produce time critical data for discrimination success with in objective timelines above. To determine discrimination capability of an element would normally take high fidelity simulation and optimization. The approaches should address simplifying assumption and resulting confidences in decision.

Subtopic: Aegis BMD (MDA/AB) is a mobile asset that performs its mission within an operating area. Also, its mobility can be used to maximize discrimination success for different operating area. This work will focus on techniques to achieve this analysis within a reasonable planning timeline. This topic is focused on both techniques of simplification of analysis to estimate performance while simplifying computations as well as possible efficient search techniques to map out an operating area with out assessing all points within a ship operating grid. This work will have to assess the impact to the quality of the planning due to the simplifying assumptions while focusing on a run time goal of an hour. The planner must address both medium band as well as wideband feature capability. The planner must address at least search sectors, energy management, feature availability, discrimination success within an engagement or hand over timeline.

PHASE I: The contractor should propose and illustrate computational savings with the techniques proposed. The contractor will also perform assessment to bound techniques impact on engagement success predictions.

PHASE II: The contractor will develop a planning tool that performs its assessment within four hours and objective within two hours. The planning tool will be developed to the point of predicting ship operation area in an Aegis

BMD flight test. The Discrimination capability assessment tool to support sensor task planning will be developed to run offline in advance of a flight mission within one hour and within 30 minutes objective.

PHASE III: The contractor will transition the intellectual property of the techniques use for evaluation and inclusion by Prime Contractors of elements or C2BMC with a government specified computational environment. The Discrimination capability assessment tool will also be evaluated for Hercules Testbed evaluation.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The optimization techniques may have and impact of evaluation techniques case matrix control in Operations Research. There could possibly be a result that could impact memory usage or assessment of critical data to be kept in memory which would have broad application.

REFERENCES:
1. August Rihaczek, Steven Hershkwitz, Radar Resolution and Complex-Image Analysis, Norwood, MA, ARTECH HOUSE, 1996.
2. http://www.lexingtoninstitute.org/defense/rnsf4.htm
Discrimination, Sensor Task Planning, Mission Planning, optimization, computational efficiency.

KEYWORDS: Discrimination, Sensor Task Planning, Mission Planning, optimization, computational efficiency.

MDA05-040 TITLE: Discrimination Damage Assessment

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

ACQUISITION PROGRAM: BMDS-MDA – AB/AS/BC/GM/SE/TH

OBJECTIVE: Investigate techniques for assessing damage to targets in post-intercept debris clouds and extraction of targets following non-lethal intercepts. This effort should propose both RF and EO/IR algorithms and, where appropriate, analyze success of fused solutions.

DESCRIPTION: The BMDS is a system of systems to defend against ballistic missiles of all ranges through layered defense and distributed fire control. Elements like Aegis BMD (MDA/AB) and airborne laser (MDA/AL) are designed for early intercept opportunities, such as boost or near apogee intercepts. Elements like THAAD, Patriot and Ground-based Midcourse Defense (MDA/GM) provide a second layer in either midcourse or terminal phases. All elements are required to assess the results of their engagements. The results of the engagement can dramatically change the discrimination and engagement problem for downrange elements. Hit Assessment is a well understood field among the elements of the BMDS, with many algorithms in advanced test or deployed. The determination of the presence of viable targets in a debris cloud after a non-lethal hit is equally important.

This topic develops techniques, features and measurements to evaluate the damage to intercepted objects and develops techniques for extracting re-engageable objects in the post-intercept debris cloud. For Radars, measurement techniques include waveforms and their characteristics (e.g. Bandwidth, Pulse Repetition Frequency, and Coherent Processing). For EO/IR, measurement techniques may be both technology and processing techniques (New focal plane approach, Multi-frame processing approaches). Often within a region of operations there will be multiple elements that have opportunities of engagement at different parts of the timeline. Beyond evaluation of an element's engagement is evaluation of how the results of an engagement impact other elements later in the engagement timeline. Target damage and the impact on target extraction and discrimination features normally used by the downrange systems must be analyzed.

Techniques will be evaluated for their ability to characterize re-engageable objects within a debris field. Secondly, the ability of the technique to evaluate the size or complexity of a cavity created by an intercept will be a measure of effectiveness. Finally, is the ability of a technique to indicate corruption of a discrimination feature for another system within the BMDS.

Subtopic: The RF techniques should be evaluated for other frequency bands and the limited bandwidths and lower duty radars of Aegis BMD and Cobra Dane.

Subtopic: Automated Processing of Coherent Wide-Band Radar Data for Hit/Kill Assessment. Identify whether the RV was hit and to determine the level of damage for cueing C2BMC. This task seeks to enhance autonomous sensor hit, damage, and kill assessment, which will provide information to help combatant commander determine a re-engagement strategy.

Subtopic: Process Visible/IR Sensor Data for Hit/Kill Assessment. Identify whether the RV was hit and determine the level of damage for cueing C2BMC. Intercepts may occur in locations with little or poor radar coverage. Additionally, radars might be required to support additional intercepts, while visible or IR sensors might be available to conduct hit assessment. This task seeks to develop visible and IR hit assessments, damage assessment, and kill assessment algorithms.

PHASE I: The contractor should develop the theoretical basis for the proposed technique that answers a topic/subtopic above, to include identification of the sensor capability assumptions, anticipated process and system interaction of their approach. For RF algorithms, the analysis should show dependency on bandwidth, radar band, and PRF. For EOIR techniques, the analysis should evaluate band dependency, pixel resolution and range of the phenomena.

PHASE II: The contractor should develop/update the technology to enable a relevant demonstration and explore the parameter sensitivity of the technique. Techniques applicable to a particular system, such as Aegis BMD, should evaluate the technique with the sensor specific waveforms. Where the technique is supported evaluation of non-lethal post-intercept data collection will be used.

PHASE III: The contractor will work to integrate the technology into the BMDS system in coordinate 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 POTENTIAL: RF based satellite or Space Shuttle damage assessment, NASA. RF based damage assessment for remote police robots.

REFERENCES:
1. Eugene Knott, John Shaeffer, Michael T. Tuley, Radar Cross Section, Second Edition, Norwood, MA, ARTECH HOUSE, 1993.
2. August Rihaczek, Steven Hershkwitz, Radar Resolution and Complex-Image Analysis, Norwood, MA, ARTECH HOUSE, 1996.

KEYWORDS: Damage assessment, discrimination, kill assessment, S-band radar

MDA05-041 TITLE: Advanced Signal Processing for Improved Feature Extraction

TECHNOLOGY AREAS:

ACQUISITION PROGRAM: BMDS-AB/AS/BC/GM/SE/TH

OBJECTIVE: The objective of this research and development effort is to develop advanced signal processing techniques to induce or enhance discrimination features.

DESCRIPTION: Advanced countermeasures will be deployed against midcourse defense weapons in order to generate difficulties in discriminating the real warhead from the decoys. These countermeasures may be spread over large areas (clusters >30 km2), or in the vicinity of suspected lethal objects and must be intercepted or correctly interrogated in order to create a highly reliable defense. The number of threat objects into the clusters can range from up to 200.

Subtopic 1: Develop enhanced Physics-based feature-extraction algorithm to identify characteristics of objects, e.g. Size, Shape, Material properties, thermodynamics, etc. Some existing feature extraction algorithms provide erroneous results for some observation geometries. This task seeks to develop more accurate feature extraction algorithms based on measurable physical properties that can be used for lethal object discrimination.

Subtopic 2: In order to achieve high probabilities of designation (>90%), k-factors in excess of 5 are required. Therefore, this topic calls for new innovative technologies that increase the ability to discriminate the decoys from the warhead and if possible eliminate the decoys and/or the warhead. Advanced threats include high traffic and penetration aids, anti-simulation threats, etc. This project involves the technology necessary to develop improved midcourse sensors and weapons ability to discriminate lethal objects from other associated objects.

Subtopic 3: Finally ultra-wideband/multiband signal/data processing technologies and concepts are needed to increase discrimination k-factor by 2-4 times and decrease the vulnerability to RF countermeasures. This includes Multiband (MB), Ultra-wideband (UWB), and Synthetic Ultra-wideband (S-UWB) discrimination technologies to provide 2-8 times increase in the available instantaneous and total operational bandwidths.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed concepts.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed concepts; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Develop technology that has direct insertion potential into the BMDS midcourse elements.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would have applicability to commercial space platforms, high altitude communication platforms, etc.

REFERENCES :
1. Joseph Z. Ben-Asher,Isaac Yaesh, “Advances in Missile Guidance Theory” Volume 180, Progress in Astronautics and Aeronautics, 1998.

2. J.S. Przemieniecki, “Critical Technologies for National Defense”, AIAA Education Series, 1991.

KEYWORDS: discrimination, kill vehicle, counter measures.

MDA05-042 TITLE: <u>High Temperature Multispectral Infrared Scene Generation Technology</u>

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

ACQUISITION PROGRAM: BMDS-MDA/TE/AS/KI/SB

OBJECTIVE: Develop novel infrared emissive technologies, delivering apparent temperatures at high dynamic range to provide realistic stimulation, enabling development of MDA IR sensors.

DESCRIPTION: The Missile Defense Agency (MDA) requires technology to stimulate the advanced IR systems under development for numerous different applications. This includes calibration sources and arrays for projection techniques, in which digital information is then fed into a calibrated projection system for presentation to a dual-band interceptor sensor. This requirement is becoming DoD and Industry wide with the need for calibration and stimulation systems for the rapidly proliferating applications of infrared imaging. The technology to accomplish this and to achieve the required dynamic range and apparent temperatures does not exist either in industry or academia. This topic is to develop core device and material technologies enabling future critical capability development.

Current Infrared (IR) projector/calibration source technology has focused on use of Resistor Arrays and resistively heated blackbody targets to realistically simulate dynamic infrared objects and backgrounds at temperatures up to 700 Kelvin. Current technology based on resistive arrays has many benefits including flicker-less emission, broadband output, greater than 512 by 512 pixel spatial resolution, and high frame rates. However, the dynamic range of this technology does not provide for radiometric duplication of the full range of target scenarios likely to be encountered by future MDA weapons systems. Current arrays have limitations in output, limiting the apparent temperature, and suffer from droop across the array due to resistive losses at high current operating conditions. Simply put, current designs fail due to overheating at the temperatures required to emulate high temperatures. The array or point sources are usually projected through a large collimator to illuminate the sensor under test, which views the target array or point sources at “infinity”. To simulate small higher temperature objects (unresolved plumes, flares, fires, etc.) for projection into sensor apertures, large resistive-element heated, cavity-type, blackbody sources are often used.

Technology investigations over the last several years either have not yielded a suitable technology approach or were dynamic range/ spectrally limited. Several possible multispectral approaches were identified but the technical risk or infrastructure cost for development was prohibitive. Alternative, moderate cost methods are needed to represent multi-band images of extremely hot targets hot engine exhausts or rocket plumes, and infrared countermeasures. Innovative approaches are required for simulation of spatially extended objects whose apparent temperature may exceed 3000K. For the purpose of defining approaches, the projector should provide at least two bandpasses, two-microns wide anywhere within the 2-14 micron band. Ideally, the projection concept should be able to achieve at least 512x512 spatial resolution provided by current low temperature projectors, provide a non-temporally-modulated output, and, if pixelated, achieve pixel response times of less than 1.25 msec. For nonresolved targets novel high-apparent temperature emissive devices, capable of high frequency brightness modulation, to replace existing resistance-heated blackbody cavity sources are needed. These sources in conjunction with collimating optics provide modulated, real-time representation of point target radiances during hardware-in-the-loop testing of infrared and visible missile defense sensors. Operation in both ambient (laboratory) and cryogenic chamber operation creates significant development risk. The cryogenic environment imposes extreme conditions on the projector such that typical off the shelf electronic devices do no operate in that environment. Highly innovative development is need to produce devices that produce 3000 Kelvin radiometric output while surviving in a 20 Kelvin environment. Dynamic ranges of over 16 bits are needed with precision control of the radiance of dim and bright objects against a cold space background (high black contrast and low noise floors).

Innovative design approaches are critical to providing the needed 3000 Kelvin apparent radiometric output while staying within the physical limits of material properties. A key development need is to represent a scene with both point and extended sources including varying radiometric output and not simply a hot source.

PHASE I: Identify and investigate breakthrough IR emitter material/device foundation technologies leading to a high dynamic range multispectral infrared calibration sources. Develop and establish through simulation and analysis the trade space for meeting a variety of waveband and dynamic range requirements. A proof of concept demonstration is desired with a small number of elements of the critical technology being developed. Address innovative, environmentally robust source approaches (ambient to 70K environments) to spectrally code the output for each pixel to output a unique spectrum per pixel during each frame or change to a spectral narrow band output per pixel frame-to-frame.

PHASE II: Develop and demonstrate a proof of concept technology demonstration arrays for transition in Phase III to different IR multispectral calibration and stimulation systems. Prototype a multiband emissive array demonstration projection module operating from ambient to cryogenic temperature. Demonstrate closed loop operation with a representative IR focal plane sensor to validate the technology for MDA IR sensor/algorithm development and validation needs with ability to modify output spectrum.

PHASE III: Transition technology to use in IR stimulation and calibration systems for military and commercial application. Develop and demonstrate system specific arrays and point source capabilities for

PRIVATE SECTOR COMMERCIAL POTENTIAL: The entire is sensor development community for military, aviation, medical, automotive and industrial applications needs the technology in different form for their application. All targeting, guidances, and warning sensor programs relying on infrared sensors against high contrast targets would benefit. Warning systems being installed on commercial airliners as protection against missile attach would greatly benefit from this technology in testing system responses. Commercial products designed for fire fighting or search and rescue could use this product for developmental testing or training. For example, a system that could present a cool distributed object (human) in a an image of a burning room could be used both the test fire rescue devices as well as training firefighters in use of IR devices in a safe environment. The multispectral capability of this emissive technology is also of high value for spectroscopy of gases for medical and environmental monitoring, semiconductor inspection, off indicators, printing, commercial and military night vision are other applications.

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KEYWORDS: HWIL, Blackbody Source, Infrared resistor array, Infrared Scene Projection, IR LED, Light Emitting Diode, IR laser diode, room temperature IR diode, negative luminescence.

MDA05-043 TITLE: Next Generation Technologies for Sensor Hardware-in-the-Loop (HWIL) Testing

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

ACQUISITION PROGRAM: BMDS-MDA/TE/SE/AS

OBJECTIVE: Develop next generation technology base to enable closed loop evaluation of next generation MDA sensors, signal processing and algorithms.

DESCRIPTION: The development of next generation sensors and signal processing for detection, tracking and identification of targets for MDA systems is technology limited by the capabilities and lack of technology used to evaluate these advanced components. The goal of this topic is to identify and create new innovative technologies to address missile engagement real time scene projection and generation technology for MDA weapons systems. Current projection systems are insufficient because of technology limitations. An example would be in the areas of infrared projector arrays, micro mirror arrays, cryogenic collimating optics, computer workstations and motion tables. Limitations include small dynamic range (only up to 800C), large power consumption, strict alignment and calibration requirements, expensive scene generation graphics hardware, and limited high frequency motion control. New technology is needed in the areas of efficient, non-resistive emissive or reflective flickerless non pulse width modulated light source arrays and frequency-agile source arrays and cryogenic chamber optical interfaces. Additionally, to drive new and existing HWIL projectors, new technology for very high frame-rate (1000 fps), greater than 512 by 512 spatial resolution, and high dynamic range (16 bits) physics-based PC based scene generation graphics capability are needed for externally synchronized and massively parallel real-time graphics simulation hardware.

The technology for enabling advanced projector concepts should allow testing of a sensor having a broad bandpass or having one or more narrow band-passes. For current sensor application this would focus on the 2 to 12 micrometer band or in the 140 nanometer to 1 micrometer band. The projection concept should be able to achieve pixel response times of less than 1.25 millisecond and apparent target temperatures in excess of 3000C. Evolving requirements for image laser and radar systems are also stressing the need for new technologies to address these shortfalls in capability.

PHASE I: Real time HWIL projection component technology investigation and sub component technology demonstration. Analysis of proposed solution in context of existing technologies. Demonstrate critical technology component element performance in a laboratory breadboard experiment. Technology concepts should address the pathway to transition from ambient laboratory settings to space vacuum chamber cryogenic sensor test environments.

PHASE II: Develop prototype component technologies and integrate to the level necessary to demonstrate the ability to achieve a phase III technology insertion for program specific test system requirements. Since each MDA program has unique sensor system test requirements and the many different contractor and government test facilities require different configurations the phase II technology prototype/demonstration should try to address the innovations that would impact the highest priority and also the most widely needed core capabilities.. Integrate projector component technologies into a prototype projector system with optical and electrical/computer interfaces and collimating optics to couple to an actual or simulated seeker.

PHASE III: Design refinement and product transition to the different interceptor/sensor system teams for focused development of integrated sensor stimulation systems use for developmental seeker/sensor and guidance algorithm evaluation. Transition of technology to commercial test systems developers, synthetic simulation vendors for upgrade and insertion into legacy test capabilities.

PRIVATE SECTOR COMMERCIAL POTENTIAL: These technology advances will benefit many DoD sensor programs and enable the ability of many prime contractors which need such advances to overcome technology risks. Other commercial beneficiaries include suppliers of sensor systems for state and municipal law enforcement, and the automotive and marine industries. These technologies will enable important advances in sensor development for all industrial, scientific, military, and medical applications. Commercial products designed for fire fighting or search and rescue could use this product for developmental testing or training. With the revolutionary technology enabled here numerous insertion opportunities exist for distributed simulation for military, law enforcement, driving, surgical, and industrial simulators where real time simulated sensor-human interaction is required.

MDA05-044 TITLE: Advanced Data Derived Missile Related Signature Phenomenology Simulation Techniques

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS-MDA/MS

OBJECTIVE: The missile exhaust plume radiant emission produces key observables that can provide useful discriminants used for early detection, tracking, identification and cueing to MDA's midcourse and terminal defense systems. In addition, the plume spatial distribution is used for plume-to-hard body handover and aim-point selection for MDA's boost phase defense systems. Because the knowledge of the plume helps to accurately perform these MDA functions, investing resources to advance the state of the art in modeling and simulating propulsion related signatures is still required. The objective of this effort is to develop an innovative fast data-driven approach to accurately simulate “real world” plume effects as observed by a missile in flight to support sensor and algorithm design for boost ascent. These data-driven engineering models will enable on-going advanced modeling efforts that are computationally intensive and not fully mature.

DESCRIPTION: Current propulsion related flowfield and signature tools cannot properly capture the trends as observed by missile defense sensors and other observation platforms. This effort will look at innovative data-driven and first principle techniques that can emulate these observed trends shown in missile signature data. This effort will reexamine the complex passive optical data sets and determine what underlying phenomenology is responsible for the observations such as angle of attack, booster segmentation, staging events, sensor self-blinding, chuffing, afterburning sustainment/shutdown and high altitude enhancement plumes. Specifically, innovative methods analyzing plume signature data using observations collected from multiple sensors are of high interest to capture the tomography of the plumes structure.

PHASE I: In this phase, several plume optical plume data sets shall be reviewed and at least one observed phenomena shall be modeled using physics-based data-driven techniques. At a minimum, the model must be able to account for spatial and spectral resolution effects that might be observed by an interceptor as it approaches a target during an endgame closing sequence. Data-driven techniques shall be developed to be compatible or augment existing scene generation tools developed by MDA such as SSGM, BEST, CHAMP and FLITES. If multiple measuring platforms observed the same event, tomography techniques to pull out plume features and structures should also be demonstrated.

PHASE II: Identify important “real world” phenomenology signature processes that are required to model the complex phenomena and prioritize their importance to MDA system design, development and testing. Primary programs of interest are boost phase defense and modeling and simulation. Demonstrate that the new or updated data-driven code/modules can predict the most dominant processes for both spatially resolved images as well as total intensity. Deliver the documentation, software and validation/demonstrations for incorporation with current MDA scene generation techniques.

PHASE III: Transition advanced methodology into BEST or other plume signature models used to support MDA elements. Apply software to a variety of missile threat systems as well as other problems of interest to MDA.

PRIVATE SECTOR COMMERCIAL POTENTIAL: These data-driven modeling techniques can be transitioned to other commercial sectors that require approximations for complex modeling.

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2. G. Sutton, and Oscar Biblarz, Rocket Propulsion Elements, Seventh Edition, Wiley Interscience, 2001.

KEYWORDS: rocket performance; two-phase flow, transient plumes; angle of attack, boost phase signatures, scene generation, tomography

MDA05-045 TITLE: <u>Innovative Plume Signature Methodology for Low Thrust Propulsion Systems</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS-MDA/MS

OBJECTIVE: Small divert attitude control thrusters that are used on MDA¡¦s interceptors and surveillance satellites can produce large plumes and create infrared (0.7-25ƒÝm) emissions and scattering media that can change the foreground observed by their acquisition and tracking sensors as well as their end-game seekers. The objective of this effort is to develop an accurate capability to predict signatures from low thrust (<1000lbf) propulsion systems that can provide risk mitigation strategies for MDA systems.

DESCRIPTION: Over the past several years, new plume signature modeling efforts have been focused on high thrust axially-directed propulsion systems (>30,000 lbf). This effort is focused to resolving the complex phenomena related to lower thrust (<1000 lbf) propulsion sub-systems. These lower thrust propulsion devices have unique features not typically treated in the large thruster analyses. Specifically, this innovative research effort will account for systems using amine and double-based propellant systems commonly used in interceptors as attitude and divert control systems and vernier thrusters used for vectoring. As an example, monopropellant hydrazine thrusters commonly use a catalyst bed to decompose their fuel into N2, H2 and NH3. The complex non-equilibrium decomposition chemistry is not currently treated with standard high thrust models and will require theoretical and/or experimental laboratory investigations to properly characterize. Secondly, since low thrust engines are commonly used in rarefied high altitude environments, the emissions from the engine exhaust are collisionally excited and therefore require accurate collision cross-sections to predict the excitation, dissociation and quenching processes for the radiating species. Thirdly, low thrust bi-propellant engines can produce significant amounts of propellant droplets that can flow out the nozzle and provide scattering centers for solar and earthshine external sources. All of these phenomenology issues, as well as others, must be treated to properly model the signature emissions from these low thrust systems. The physics and chemistry required to understand these phenomena must be developed into modules/models a) to accurately predict these critical features that have been observed by seekers used on MDA interceptors, and b) to provide risk reduction for current and future algorithm and sensor development.

PHASE I: For a low thrust propellant system at high altitude, identify the chemical and physical phenomena that is required to model and properly account for the complete process from propellant combustion through plume signature emissions. Once identified, at a minimum, prioritize the importance of each phenomena as a function of altitude, velocity, and spectral band. Finally, select one important complex mechanism and demonstrate a theoretical or experimental innovative methodology to model or characterize the phenomena.

PHASE II: Identify all phenomenology signature processes that are required to model low thrust propellant systems. Demonstrate that the new or updated code/modules can predict the most dominant chemical and physical processes. Deliver the documentation, software and validation/demonstrations for MDA use. Further, maximum practical use of existing plume software is desired to reduce both development and validation costs.

PHASE III: Transition advanced methodology into BEST or other plume signature models used to support MDA elements. Apply software to a variety of missile interceptor systems as well as other problems of interest to MDA.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercial satellite companies require advanced software to predict contamination effects due to plume effluents.

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1. Simmons, F.S. Rocket Exhaust Plume Phenomenology, AIAA, Reston, VA, 2000
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3. M. Braunstein and J. A. Cline, ¡§Progress on Parallelizing a General Purpose Direct Simulation Monte Carlo (DSMC) Code for High Performance Computing Applications¡¨ AMOS 2003 TECHNICAL CONFERENCE, 10 September, 2003

KEYWORDS: nozzles; exit plane; rocket performance; two-phase flow, reacting flow; plumes: boost phase signatures: plume contamination: divert, attitude, and reaction control thrusters; low thrust engines.

MDA05-046 TITLE: Missile Plume Signature Evolution

TECHNOLOGY AREAS: Battlespace, Weapons

ACQUISITION PROGRAM: BMDS-MDA/MS

OBJECTIVE: Implement a fully-automated on-line real-time physics-based simulation tool for evolutionary/transient missile plume signatures using an innovative time-continuous multi-scale computation method for nonsteady flow and nonequilibrium radiation that is suitable for incorporation in MDA battlespace environment simulations.

DESCRIPTION: A missile plume signature is inherently nonsteady even for constant thrust conditions (magnitude and direction) due to variable ambient conditions (density and velocity) resulting from acceleration and ascent. The ambient variations control the spatial/temporal evolution of the extended plume with impact on the length/width characteristics at lower/higher altitudes and on the fundamental physical transition (afterburning to enhancement) at intermediate altitudes.

Existing plume simulation tools (for steady/nonsteady thrust conditions) assume constant ambient conditions as in a ground static test. An advanced simulation capability is required to account for variable ambient conditions inherent in missile flight. The required methodology must simulate from first principles the time-continuous multi-scale nonsteady plume signature characteristics (spatial-spectral; evolutionary-transient) throughout and beyond the boost phase (e.g., tailoff, persistence). The simulation must incorporate rigorous physical models and efficient numerical methods to enable reliable robust fully-automated on-line computations to support real-time dynamic engagement simulations.

PHASE I: Demonstrate the technical feasibility and proof-of-concept for continuous real-time simulation of missile plume signature evolution from launch to burnout. Quantify the signature impact of missile acceleration and ascent.

PHASE II: Develop, demonstrate, and deliver a real-time simulation capability for nonsteady plume signature evolution due to missile acceleration and ascent and transients due to propulsion and maneuvers. Quantify the fidelity of simulated spectral, spatial, temporal characteristics.

PHASE III: Adapt the tool for implementation in the MDA Battlespace Environments and Signatures Toolkit (BEST). Apply the simulation for flight data analysis and intercept engagement simulation.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This methodology has general utility for practical efficient simulation of nonsteady flow/radiation phenomena in diverse industry applications.

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KEYWORDS: missile boost, extended plumes, optical signatures, non-steady evolution, time-continuous, engagement simulation, real-time

MDA05-047 TITLE: Object Recreation from Facet Representation to IGES and Primitive Representations

TECHNOLOGY AREAS: Information Systems, Battlespace

ACQUISITION PROGRAM: BMDS-MDA/MS

OBJECTIVE: Develop a method to generate a primitive or curved-surface representation of a target from a facet-based model.

DESCRIPTION: The hardbody target modeling community often uses a facet representation to describe the target. This representation is appropriate for many rendering algorithms and signature generation codes, but it does not directly support other approaches that use a primitive based representation of the target, and it does not allow easy reconfiguration of the target without going back to the CAD (Computer-Aided Design) or CAD-type tool used to generate the facet model. This means that the facet generation process is essentially a one-way process.

What are needed are methods and techniques to generate a primitive or curved-surface representation of a target from a facet-based model. The process should be fully-automated or as automated as possible. This will allow the user who only has a facet model to generate the corresponding model in primitive or IGES (Initial Graphics Exchange Specification) representations.

The methods and techniques that are developed must be suitable for incorporation into MDA's Battlespace Environment and Signatures Toolkit (BEST), which is a new physics-based scene generation code capable of accurately modeling the spectral signatures of a wide variety of natural backgrounds and targets as observed in any battlespace environment from ground to space. BEST includes a tool that allows the user to build custom hardbody targets from primitive shapes (e.g., cylinders, cones, frustra, half- spheres, plates, etc). The methods and techniques developed for the target model format conversion must work seamlessly with the BEST target model tool (the Entity Creation Tool).

PHASE I: The contractor will develop the overall methodology to take a facet model, with material assignments, and generate corresponding primitive and IGES descriptions. The contractor will demonstrate the technique on a small number of basic targets. The contractor will also devise and use an appropriate metric to judge the quality of the conversion.

PHASE II: The contractor will automate the conversion process and extend the number of target types and shapes that may be converted to include all types and shapes that are available in the BEST Entity Creation Tool. The contractor will demonstrate the technique on a number of basic and complex targets of their choosing and use appropriate metrics to illustrate the quality of the conversion. The contractor will also demonstrate the capabilities of the tool using facet files provided by the Government. The contractor will develop an interface of this product to BEST.

PHASE III: The contractor will incorporate the conversion tool into BEST. The contractor will demonstrate the robustness of the target format conversion process within BEST by performing facet-to-primitive-to-facet and facet-to-IGES-to-facet conversions on a wide range of simple and complex targets, including several facet models provided by the Government. The contractor must demonstrate that the original target model parameters, including material properties, can be recovered to a level of detail that the target signature of the recreated facet file is (for all intents and purposes) indistinguishable from the signature of the original facet file when both target models are used in the same BEST simulation.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The target model conversion methods and tools developed under this effort are widely applicable to the mechanical and aerospace engineering industries where CAD modeling is an integral part of the development of any new flight or target detection system. The robust format conversions developed would be particularly useful for complex engineering activities that involve multiple organizations using multiple software modeling systems and techniques on multiple computer platforms.

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1. Information on the IGES format is available on the National Institute of Standards and Technology web site (http://www.nist.gov/iges).
2. BEST User's Manual (Release 1.2, January 2005) is available on the Battlespace Environment & Signature Toolkit web site (https://vader.nrl.navy.mil). Note: access to this site requires registration. See web site for registration form.

KEYWORDS: Hardbody Models, Target Models, Facets, Primitives, IGES, Modeling and Simulation

MDA05-048 TITLE: Integrated Design of Hit-to-Kill Interceptor Guidance and Control Systems for Ballistic Missile Defense

TECHNOLOGY AREAS: Air Platform, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS-MDA/AB

OBJECTIVE: Develop integrated methods for missile guidance, control and estimation system design for ballistic missile defense interceptors with hit-to-kill capability. Demonstrate, via simulation, an improved level of performance (50% or greater hit accuracy) for the integrated design against ballistic missile targets.

DESCRIPTION: Integrated design methodologies are desired to improve the accuracy of anti-ballistic missile weapon systems, and also to decrease the time it takes to go from weapon concept to prototype. Previous research has demonstrated that an integrated design methodology for the guidance, control and estimation systems can yield significant improvements in interceptor performance. The goal of the current research can be quantified as a substantial (50% or higher) increase in interceptor miss distance accuracy relative to existing systems, together with a more streamlined and cost-effective design process.

The objective of this SBIR is to demonstrate the integrated synthesis of guidance, estimation and control systems for a specified missile concept. Proposed design methodologies must start from a given configuration description and set of specifications for vehicle, sensors and actuators, and must demonstrate the complete synthesis of the various components of the integrated system.

Examination of multiple guidance and control integrated design techniques is desired that effectively deal with the ballistic missile target. Incorporation of newly emerged nonlinear guidance and control methods such as the State Dependent Riccati Equation method, Feedback Linearization, Finite Horizon Linear Quadratic design and other techniques should also be considered for the integrated design. Investigations should also include examination of new guidance laws which compensate for target maneuvers and fire control errors.

The effectiveness of the integrated design should be demonstrated with a sufficiently realistic nonlinear system model of the candidate interceptor missile. A primary figure of merit should be interceptor hit-to-kill performance against the ballistic missile target, and the benefits of the integrated synthesis must be convincingly demonstrated.

PHASE I: Demonstrate a preliminary integrated guidance-control-estimation system design using representative missile and target models. Demonstrate by simulation that hit-to-kill performance is achievable against maneuvering ballistic missiles.

PHASE II: Evaluate alternative integrated guidance-control-estimation design architectures. Assess the performance of each and down select a chosen design. Fully exercise the selected integrated design for the selected missile over the complete engagement envelope.

PHASE III: Transition research to missile system designer(s). Participate with development contractor(s) in performing hardware-in-the-loop testing of an integrated design, and in verifying performance of the design via demonstration flight testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: In the military realm, this technology has direct application to Ballistic Missile Defense systems such as Aegis BMD (SM-3), THAAD, and Kinetic Intercept programs. Besides the obvious military aerospace role, advanced algorithms for integrated design have several direct applications in the commercial sector. This cutting-edge algorithm technology can be applied in any system application requiring the careful integration of sensing, decision making, guidance, path planning, and motion control. Some possible commercial examples include civilian aviation, autonomous vehicles (e.g., for fighting forest fires), manufacturing robotics, maritime systems, petroleum industry (e.g., systems for underwater exploration and monitoring/repair of oil rigs), environmental protection, security monitoring, next generation personal transportation (e.g., SEGWAY) and others.

Other technologies being developed for missile defense that would appear to be "very different" are finding commercial application. For example, SBIR technology being developed for ballistic missile target discrimination is now being looked at for biotech applications. Thus, many dual-use possibilities exist.

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KEYWORDS: integrated guidance and control, ballistic missile defense, hit-to-kill, missiles, guidance laws, algorithms

MDA05-049 TITLE: Real-time Ladar Scene Rendering and Projection Component Technologies

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

ACQUISITION PROGRAM: BMDS-MDA/TE/AS/MS

OBJECTIVE: Develop innovative high performance integrated optical and waveform generation components for dynamic scene projection for ladar sensors.

DESCRIPTION: New imaging laser radar sensors are being developed by the MDA for BMD applications which require a 3D image (data cube) to be projected for each frame. Imaging ladar is also rapidly evolving in the areas of robotics, tele-surgery, unmanned air/sea vehicles, and for autonomous vehicle applications (terrestrial and space). Ladar sensors measure the spatially distributed time delay and intensity or frequency shift associated with a laser pulse reflecting off of background and target objects. To enable the development of these systems a waveform generator for each unique detector in the sensor array is required.

The development of these new sensors require closed loop signal injection capabilities far beyond any passive sensor stimulator so far developed. An inexpensive approach to representing the dynamically changing return distribution is required to enable the development and testing of ladar detectors and signal processing. Different modes of operation are under investigation including, direct detection angle/angle/range; range resolved Doppler; and Geiger mode sensor systems. This technical goal is to investigate the possibility of integration of high speed digital to analog waveform generation components that would lead to massively parallel arrays integrated directly with the optoelectronic components. The potential payoff would be to realize a 10,000 to 1 size and cost reduction.

The use of current technology components would require over a 1000 equipment racks of signal generation equipment and optical sources to stimulate a single focal plane array laser radar detector. The MDA application of this topic is to identify, design and build innovative ladar scene generation components that can be used to project laser signals into the optics of the ladar receiver simulating a real world return including atmosphere, hardbody, plumes, debris, and countermeasures.

In a typical scenario the ladar sensor firing of the laser pulse would trigger the projector. Based on current scene content (ranges, velocities, and intensities) calculated by an external scene generation computer, the multi-function ladar scene projector would generate a convolved waveform return pulses into each projector pixel at the appropriate time so as to allow the ladar receiver to 'see' an appropriate picture. The concept under investigation is for the 3D "scene" to be generated by a computer to drive a multi-function ladar scene projector that is based on the relative geometry between the sensor and the background/target objects.

Innovative and low cost approaches are required for the optical sources and for the arbitrary waveform synthesizers and control electronics that drive the sources. Concepts for investigation may include either high-speed laser diode-modulator arrays or electro-optic modulator arrays. Dynamic ranges of over 60dB are required with intensities from 1.5 milliwatt to 1 nanowatt per pixel return. Very linearized optical sources are required with precision programmable delayed response and extremely high extinction ratios. Wavelengths vary depending on application but innovative broadband component development should consider operation from 500 nanometers to 2400 nanometers with 1064 and 1550 nanometers as an initial goal.

The eventual goal is to be able to simulate return to a ladar sensor at 10 to 1000 Hz frame-rate. Sensors under development are being considered with resolutions up to 512 by 512 pixels. Return pulse timing accuracy on the order of 500 picoseconds is desired. Modulation speeds of up to 2GHz are envisioned. Segmented arbitrary waveform memory with drive electronics is needed to represent multiple returns per pixel at different ranges out to many hundreds of kilometers. Uniformity corrected intensity resolution of at least 14-bits is desired over the full dynamic range of intensities. Power dissipation, cost per channel, and waveform precision are driving technical challenges for end goal system performance.

PHASE I: The initial effort will investigate and demonstrate innovative approaches to developing integrated analog lightwave modules and signal synthesis technologies. A conceptual concept should be developed to show how the innovative technologies can potentially be to develop a low cost multi-mode ladar signal simulator.

PHASE II: The phase II effort will build and test the innovative different Photonic components and investigate large-scale integration and use of high density packaging technologies. The ultimate goal is a multichannel chip level integration prototype leading to the phase III potential of a very high-density system with a minimum of 256 channels integrated with pulse to pulse programmable arbitrary waveform memory. Demonstration will include sources, modulators, driver integrated with power, control, cooling and individual channel non-uniformity adjustment.

PHASE III: Phase III will transition the technology into different MDA/DoD and NASA laser radar system development programs enabling each project to develop, build and deliver an integrated multi-function ladar stimulator for their unique application. The technology will also be of interest to the phased array radar community and optical free-space/fiber telecommunications community for both operational waveform generation as well as cost efficient/high performance switching system test applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology developed will not only benefit ladar scene projection challenges but will also advance the speed and compactness of components used for ladar sensor systems. Othere potential applications include components for the fiber optic –free space optical communication industry. Commercial/military applications include threat system simulators for test/training ranges, 2D and 3D digitizing systems, and high-density communications cross-connect switching buffers. Other potential commercial applications include digital cinema, phased array radar control for air traffic control, and medical imaging.

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KEYWORDS: HWIL, Ladar Projector, Ladar/Radar Simulator, Arbitrary waveform generation, VCSEL driver, Semiconductor optical amplifier, Polymer fiber modulator, Phased array, Analog photonics, RF photonics.

MDA05-050 TITLE: <u>Multi-sensor tracking techniques</u>

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: BMDS-MDA/BC/AS/GM/SE

OBJECTIVES: Develop advanced, innovative, robust, real-time algorithms and software for multi-sensor tracking that mitigates sensor residual bias, inaccurate sensor track reporting, mitigates new or unobserved target capabilities and improves correlation performance across all threat classes and environments.

DESCRIPTION: Timely and accurate fusion of data collected from multiple sensors may provide a more accurate picture of the adversary threat than any single sensor operating independently. The goal of the multi-sensor tracking is data association and fusion that operates on a combination of sensor reports from sensors with various accuracy and phenomenology. Additionally, the method should be consistent with existing message capability and communications infrastructure, or provide justification as to the benefit achieved from a new approach. The proposed effort should address one or more of the following technical areas. All efforts should address the data latency, processing load and time of the method. One; identify and track of out-of-plane maneuvering boosting targets. Two; develop mitigation for spatial and temporal registration of sensors. Three; develop methods to improve network tracking that minimize data throughput within and between sensors. Four; address cross-domain translation capability of messages in sensor native format.

PHASE I: Develop the mathematical basis for and provide a demonstration of advanced multi-sensor tracking topics.

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 operating 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, complex manufacturing processes, and weather applications.

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KEYWORDS: Bias Removal, Multi-sensor, Tracklets, Correlation, Sensor Fusion

MDA05-051 TITLE: Software Formalisms

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS/BC

OBJECTIVE: Provide innovative tools and techniques to enable development of specifications in logic; i.e., lightweight software formalisms, to achieve lower software development cost and risk.

DESCRIPTION: Formal methods in software development are important to achieving correctness, consistency, and understanding during the software development process. This research aims to achieve many of the benefits of using formal methods without the full rigor (e.g., cost) of formal methods by developing tools and techniques for "lightweight" software formalisms to achieve lower software development cost and risk. The integration of Missile Defense elements and components into a cohesive Ballistic Missile Defense System (BMDS) requires extensive software development, deployment, and sustainment. New software specification development processes to utilize lightweight software formalisms for defining logic, coupled with UML and other object oriented techniques, would greatly benefit the capability to develop the BMDS software lowering risk, including the re-engineering costs associated with obsolescence. The ability to utilize lightweight software formalisms for specification of a large, complex system is vital to controlling overall system cost and development risks. A mechanism for entering, executing, and analyzing system requirements using logic and key, emerging software formalism technology, is needed to support the up-front decision making capability for cost effective acquisition.

PHASE I: Determine the needs of a light weight software formalism, logic based methodology. Define requirements specification tool and notation, and perform a feasibility study to determine that such trade studies can be executed on high level requirements early in the design process. This feasibility study may include a conceptual demonstration.

PHASE II: Implement a prototype version of the requirements specification/execution process. This shall be demonstrated by performing a series of trade studies on an example requirements specification of interest to the government.

PHASE III: Demonstrate a new lightweight software formalism logic process technology, and near-term application to the BMDS integrating element system software development process. This pilot project shall 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: The proposed work will be useful in any circumstance where the execution of software driven specification can lead to early trade-off analyses in design. The applications of this technology could potentially be far reaching with large market potential.

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KEYWORDS: Obsolescence; Re-engineering; Executable Specifications; High Level Languages; Requirements Analysis; Trade-off Analysis

MDA05-052 TITLE: Automated Software Analysis and Visualization

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Enable automated analysis and visualization of the architecture of large, complex, mixed programming language software systems.

DESCRPTION: Extracting and analyzing large, complex software systems implemented in multiple programming languages and employing multiple inter-process communication mechanisms is a very man-intensive endeavor. Software architecture is typically buried in the sometimes millions of lines of code in a software system. In addition, as software evolves, it often loses its modularity, which makes it more difficult to understand and maintain. The result is that reusing, integrating, maintaining and refactoring such software is costly, time consuming and prone to error. An effective means of extracting and visualizing software architecture and an automated software analysis capability would reduce costs, time and errors.

Automating software analysis requires automatic derivation of software models from large, mixed-language source code bases; representing the software in a modeling language amenable to software analysis and visualization; enabling direct access to source code via the model; and providing the ability to visualize, search and browse the model. The technologies employed should be amenable to future, automated identification of key concerns (or aspects) of software in support of reuse, integration and rearchitecture.

PHASE I: Conduct research to define key component technologies that enable automated analysis and architecture visualization of large, complex software systems implemented in multiple programming languages. Define an architecture for integrating component technologies and metrics to evaluate an automated analysis capability. The key technologies, architecture and metrics, as well as a plan for Phase II, will be described in a technical report. Where feasible, component technologies should also be demonstrated in this phase.
PHASE II: Develop and integrate component software analysis and visualization technologies in a prototype with a scalable architecture, based on the plan devised in Phase I. Test the technologies on a large, mixed programming language source code base, and provide an assessment of the analysis performance.
PHASE III: Mature the prototype into an advanced software engineering analysis product, prepared for both Navy and commercial application.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This technology is applicable the reengineering, integration and maintenance of large, complex, mixed-language software systems. Example industries facing this problem include: transportation, energy distribution, communications, banking, health care, state and local tax authorities, accounting organizations and other commercial software developers.

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KEYWORDS: Software Reengineering, Automated Software Analysis, Software Engineering, Software Architecture, Software Modularity, Software Modeling

MDA05-053 TITLE: Highly Distributed and Fault Tolerant Data Management

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a prototype peer-to-peer eXtensible Markup Language (XML) database that is robust, scalable, self-organizing, secure, highly available, and tunable, and will efficiently support a rich set of queries. Such a database, low in cost, reliable, and high-performance, is well suited to the operational needs of MDA and other DoD operations

DESCRIPTION: A traditional centralized database system suffers from four drawbacks: it forms a single point of failure for an entire system, thus requiring complex fault-tolerance mechanisms; it is a bottleneck, necessitating special efforts to handle queries in parallel; it is extremely difficult to tune for an intended use; and it offers a relational view of data, which more flexible XML technology is rapidly rendering obsolete. Replicated distributed databases address the first three drawbacks and XML database research the last. Peer-to-peer (P2P) systems provide a new paradigm for structuring large-scale distributed computer systems due to scaling, fault-tolerance, and robustness. However, typical P2P systems, both music sharing systems and academic prototypes, provide little security and cannot support sophisticated queries. Furthermore, P2P query is typically tied to routing algorithms; implementing novel search techniques requires redesign of the entire P2P network. These problems have impeded the development of practical P2P information systems, especially for mission-critical applications. Development in security, query processing, and architecture are to build a secure XML database that will give the Air Force a combination of features no existing system can offer. It will provide highly parallel access, grow simply by adding new hosts, and automatically adjust loads as hosts join or leave the P2P network. It will present no single point of failure to chance or enemy attack. Developing such a database will require large-scale software development and integration, algorithm and interface design, and database research.

PHASE I: Feasibility investigation and design of a distributed, fault tolerant database with initial prototype: like P2P XML database with simple queries

PHASE II: Building on Phase I results, develop a family of expressive, highly efficient, distributed indexes for a P2P database. Develop novel P2P-specific query optimization and distributed query processing algorithms for joins, aggregations, and keyword selections. Define suitable notions of consistency for P2P databases. Demonstrate performance measurement on a world-wide distributed computing network for scalability, fault-tolerance, and adaptivity.

PHASE III: Provide distributed database capabilities to provide robustness, security, scalability to operations like Joint Battlespace Infosphere (JBI) or remote communication systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This database system could be applied in any work environment that desires distributed capabilities; like companies that provide search tools.

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KEYWORDS: Peer-to-Peer, Distributed, Database, security, robustness, scalability, XML

MDA05-054 TITLE: Agile Data Visualization for Systems-of-Systems

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS-MDA/BC

OBJECTIVE: Develop the tools and techniques to enable rapid and flexible data visualization of federated data from multiple domains leveraging a unifying ontology of the relevant concepts from the different domains. New and customizable representations of data from a broad range of sources must be easily employed by non-engineering personnel. The goal of these tools and techniques is to enable rapid and actionable understanding of system-of-systems data.

DESCRIPTION: The need for enterprise information integration is widely recognized in both the commercial and government worlds. DoD's approach, defined in the DoD Net-Centric Data Strategy, aims to make data from multiple, divergent domains visible and accessible. To achieve this goal increasing numbers of new and legacy DoD systems are being integrated into federated systems-of-systems, providing greater access to large volumes of data that span multiple domains. The strategy also encourages the use of ontologies as the basis for shared understanding of the data. Finally it recognizes the need for this integrated data to be usable for unanticipated users and applications, as well as for those that have been predefined. It is this need to effectively use the integrated data in unanticipated ways that is the focus of this topic.

The Command, Control, Battle Management, Communication's (C2BMC) role is to enable an integrated, layered missile defense across and within Combatant Command structures, and to enable the U.S. and its allies to defend against ballistic missile threats over all phases of flight. To perform its mission MDA-BC and its contractors must actively work with many other organizations and across numerous domains to develop, deploy, and operate an integrated Ballistic Missile Defense System (BMDS). The diversity of organizations and associated data sources involved in this venture significantly increases the need for rapid and flexible data visualization of federated data from multiple domains. Decisions must often be based upon diverse factors and sometimes be made in near real time.

Integrated data from multiple domains is highly advantageous for decision-makers who need a timely, cohesive, and complete understanding of schedules, readiness, threats, and a wide variety of other metrics that are critical to the quality of their decisions. However, simply integrating the data does not directly yield viable visualization and analytic capabilities necessary to gain an adequate understanding. This problem is further complicated by the multi-domain nature of the integrated data where the underlying conceptual basis of the data can be very different. For example, the temporal nature of schedules is very different from the quantitative nature of financial data. Ontologies, which may provide insight into these conceptual relationships, offer a potential framework for a generic approach to visualization and analysis that can deal with unanticipated users and applications.

Research is needed into how federated systems-of-systems data can be rapidly and flexibly visualized to facilitate understanding and effective decision making. Building custom vertical applications is generally cost and time prohibitive, thus tools and techniques must be developed to enable the construction and re-use of ad-hoc data visualization. These capabilities need to be provided to non-engineering personnel without data mining skills or extensive training. New tools are needed to seamlessly and easily leverage data from a broad range of sources spanning multiple domains.

PHASE I: Develop the requirements, general usage scenarios and candidate architecture for an agile system-of-systems data visualization capability that leverages an ontology of the integrated data. It should support both in-depth analysis and rapid decisions. Consideration must be given to data navigation, latency, security, and visualization sharing.

PHASE II: Develop a full scale implementation of the federated system-of-systems generic data visualization capability and employ it in a suitable trial environment. Solutions must be aligned with the DoD guidance and leverage existing COTS / GOTS capabilities where applicable. Special emphasis shall be placed upon the balance between advanced features and ease-of-use.

PHASE III: Due to the proliferation of data sources and the need to effectively understand and use the integrated information from them, agile data visualization could have immediate and wide use in the government. Successful deployment of agile data visualization for systems-of-systems to a specific DOD environment will significantly enhance the utility of data in new and legacy systems. Agile data visualization would directly improve information use in decision support needed to operate any vital mission.

PRIVATE SECTOR COMMERCIAL POTENTIAL: A robust implementation of this capability could easily be applied to the multitude of business organizations where visualization and analysis of federated data is required. Candidate commercial partners include firms providing Enterprise Information Integration, Message-Oriented Middleware, or Data Warehouse solutions.

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KEYWORDS: Information Technology, Ontology, Data Mining, Data Visualization, Fusion, C4ISR, System-of-System Architectures.

MDA05-055 TITLE: Automated Software Analysis and Visualization

Duplicate: Please submit proposals to MDA05-052

MDA05-056 TITLE: Test-Ready Model for Flexible System-of-Systems

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS-MDA/BC

OBJECTIVE: Develop specification and verification techniques for complex software-intensive system-of-systems acquisitions that produce a dependable functional model, which is verifiable and test-ready (i.e., that exhibits predictable behavior and fault tolerance during runtime).

DESCRIPTION: Software is becoming increasingly more critical and complex in system-of-systems acquisition. Since acquisition life-cycles, failure models, and verification methods that have performed satisfactorily for hardware systems are not always optimal for systems that include a significant software component, the identification and evaluation of better specification and verification techniques for system-of-systems is a never-ending search in defense acquisition.

Our current acquisition techniques are failing to support system developers in producing systems with predictable behavior. This problem is especially acute for flexible systems of systems that have many possible configurations, and must exhibit predictable behavior in all of them. Almost exclusively, acquisition organizations rely on exhaustive testing prior to fielding the completed product to assess system behavior. This approach becomes ineffective when the number of possible system configurations gets large, and the actual system configuration may not be known ahead of time. We must find new acquisition methods for producing dependable system-of-systems that exhibit predictable behavior and fault tolerance during runtime. For this effort, we define a dependable system as one that provides the appropriate levels of correctness and robustness in accomplishing its required services in the operational environment with respect to availability, consistency, reliability, safety, and maintainability of the system.

For this effort, we would like to identify the process and procedures that developers would follow to employ tools such as formal methods to develop and validate a test-ready model of a system. Formal specifications can help developers find defects in specifications and designs earlier than they would be otherwise and greatly reduce the incidence of mistakes in interpreting and implementing correct requirements and designs. (N.B.: For this research, we define a formal specification as the precise definition of a system behavior that is typically expressed in mathematical terms.) Such specifications should support validation and verification methods that can address large sets of possible configurations with a single generalized analysis. Additionally, the development and verification of formal specifications can support the development of error-handling specifications to appropriately manage runtime errors and logic breaks.

The development of formal specifications in a test-ready model can lead to a significantly high level of confidence in the implementation phase of a software development. The development of formal specifications typically clarifies the specification, surfaces latent errors and ambiguities, and supports the shaping of the desired system behaviors.

PHASE I: Develop a methodology that supports the development of a test-ready model of a system-of-systems that includes the desired behaviors of the system-of-systems with respect to a variety of possible configurations as well as desired fault tolerance behaviors.

PHASE II: Develop a test-ready model for a system-of-systems that tests system behaviors and error-handling procedures in the model for all valid and invalid inputs. Assess the test coverage of the test-ready model with respect to exhaustive testing. Update the proposed methodology from Phase I for use by acquisition organizations that desire to develop a test-ready model to verify system behaviors prior to committing to system production and code development.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This database system could be applied in any work environment that desires distributed capabilities; like companies that provide search tools.

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MDA05-057 TITLE: Advanced Data Fusion

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: BMDS-MDA/BC

OBJECTIVES: Develop advanced, innovative, robust, real-time algorithms and software for enhanced discrimination data fusion and optimal weapon and sensor management in support of ballistic missile defense situational awareness, sensor planning and engagement planning across all threat classes and environments.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) is currently a loose collection of various sensors and weapons with differing capabilities. As the BMDS transforms from a collection of autonomous systems to a network-centric system of systems, the BMDS requires advances in data fusion and resource management. To achieve this there needs to be coordination among the various distributed sensor and weapon systems. Proposed advances should provide niche capability improvements in one or more of the following topical areas. Architectures need to provide for integration of all topical areas. First, discrimination data fusion approaches are desired that operate on a combination of measurements, physical observables (features), track states, and identification likelihoods to produce a highly accurate integrated picture of the battle space. Methods should be well-grounded in mathematical decision theory, e.g. Bayesian networks, dempster-shafer, fuzzy logic and should be able to operate with little or no intelligence data. Second, distributed sensor management approaches are desired that coordinate the collection of data in support of weapon engagement and situational awareness. In particular, optimization routines should address the optimization function and how various constraints will be incorporated into a real-time solution. Third, weapon engagement planning approached are desired that quickly and robustly develop weapon engagement plans that provide near-optimal use of weapon resources in response to observations made and planned on the battlefield.

PHASE I: Develop the mathematical basis for and provide a demonstration of advanced data fusion 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 operating 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, complex manufacturing processes, and weather applications.

REFERENCES:
1. Martinez, David et al. "Wideband Networked Sensors", MIT Lincoln Labs, http://www.fas.org/spp/military/program/track/martinez.pdf, Oct 2000

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

KEYWORDS: Sensor Fusion; Data Fusion; Discrimination Fusion; Resource Management; Multi-sensor

MDA05-058 TITLE: Advanced Command & Control Information Processing

TECHNOLOGY AREAS: Information Systems, Battlespace, Human Systems

ACQUISITION PROGRAM: BMDS-MDA – BC/AS/GM/SE

OBJECTVE: Develop information processing and representation tools to maximize the utility of data collected by distributed BMDS sensors. This development includes key technologies to enhance data capture, processing, retrieval and analysis including:

- Capture of multiple sensor data streams (e.g. video, motion, location, audio including interface to military radio communication modes); selective storage in appropriate formats and resolutions; data protection; multiple user interfaces (including options for a hands-free, spoken language interface) for sensor control, data entry, and data access.
- Interpretation of raw data through vision processing, linguistic interpretation, and motion/location extraction; automatic recognition and classification of objects, scenes, and activities through exploitation of multiple sensory inputs and use of contextual inferences.
- Metadata extraction and association; identification of events and states; creation of higher order representations of activities, scenes and patterns; segmentation of recorded data.
- User interfaces for offline editing; interfaces for metadata-keyed browsing, video/audio playback, and data querying; visualization of data content including displays of physical and logical relationships; information correlation and analysis tools. Development of interfaces for both laptop-based systems and soldier-worn systems are sought.

This research investigates novel techniques for the display of complex information.

DESCRIPTION: In a net-centric, sensor-rich environment, the speed of command may be compromised by too much data and not enough information. Command and Control (C2) forms the foundation for operational decision-makers—from a show of force to a major regional conflict. Software intensive C2 systems must provide decision-makers with the right information at the right place at the right time, with a single point of access to real or near real time information and planning data.

Especially for MDA, time is critical when getting information from the real world, into sensors, across a network, and eventually into a processed format that is easily digested and acted upon by decision-makers. Sensors, networks, and processors are all advancing to the point where their latencies are low enough for real-time operations. However, the human on the end of the system has a limited input bandwidth that is fixed and not increasing with advancing computing speeds. This bottleneck can be eased by making data easier to visualize, so the human doing the C2 spends more time processing useful information and less time internally processing the metadata associated with information from different data sources with different formats.

An advanced C2 information processing system must leverage communications and information processing assets to provide an automated performance of planning, scheduling, monitoring and global execution of MDA's mission.

PHASE I: Development of general ontology and knowledge representations for objects, events and activities; development of mission or task-specific representations; learning tools and infrastructure to support the ongoing co-development of ontological data structures and the perception/interpretation components. Existing DOD taxonomies for visual information and military report data fields should be considered for integration into higher-level military information infrastructure. Identify proposed technology and process that will render the desired results. Conduct analytical and experimental efforts to demonstrate proof-of-principle and establish basic performance criteria and areas for further refinement in Phase II.

PHASE II: Demonstrate feasibility and applicability of proposed technology. Efforts must incorporate an ability to “learn” from experiences, so that performance improves as it accumulates knowledge and experience. Verification of the system's learning process should highlight interfaces and tools for users to teach, tune, reinforce, and adjust. Ideally, examples will be demonstrated to illustrate the mechanics of the system actually expanding its sensor-derived knowledge base, learning new object/event classes, or improving its classification accuracy. The system should also support an embedded explanation capability allowing the user to learn why the system’s reasoning. Demonstrate the approach in a convincing environment, such as the Experimentation Laboratory (X-Lab) at the Joint National Integration Center (JNIC) in Colorado Springs, CO. Include simulated or actual connections to sensors available, connection to X-Lab test facilities using actual protocols, or at least actual topologies and interfaces. Test with geographically distant connections if possible, to simulate real latencies, or simulated links within the X-Lab if longer connections are not possible.

PHASE III: Develop the critical technology components so that they can be directly inserted into a potential BMDS system.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Machine learning, represents a research area with numerous commercial applications, including Man/Machine interfaces, automated translations and distributed database synchronization. Company executives would benefit from a system that allows them to quickly visualize data of different types from sensors and tracking elements placed throughout their supply chain. The raw data is difficult to decipher, but this kind of visualization technology would enable them to efficiently monitor and control product flows. This technology could be used to aid security monitoring. Efficient visualization using different sensors, such as video surveillance, motion sensors, audio monitoring, and heat detection, could be combined to form one complete view of a situation. Another potential application would be searching through many different types of media for specific references to certain ideas or people. This could be useful to lawyers searching through emails, audio recordings, and documents for specific types of evidence. Alternatively, the technology could be used to display data that has already been assembled in a convincingly simple way to make it easily understood by others.

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KEYWORDS: Information Processing, Automatic Recognition, Metadata Extraction, Machine Learning, Dynamic Data Base, Machine Reasoning

MDA05-059 TITLE: Logistics Technology for BMDS System

TECHNOLOGY AREAS: Materials/Processes, Battlespace, Human Systems

ACQUISITION PROGRAM: BMDS-MDA/BC

OBJECTIVE: Develop technology that will significantly improve the Ballistic Missile Defense System’s (BMDS) sustainment in the areas of supportability, deployability, affordability, and suitability while reducing the system’s logistics footprint and associated costs.

DESCRIPTION: Achieve substantial reductions in the following performance-based metrics for BMDS Elements and Components: Mean Time To Repair, Mean Time Between Critical Failure, and Mean Logistics Delay Time.

Definitions:

Mean Time To Repair (MTTR): The average time required to bring the system from a failed state to an operable state. Assumes maintenance personnel and spares are on hand. Typically includes fault isolation, removal and replacement of the failed item(s), and checkout.

Mean Time Between Critical Failures (MTBCF): The average time between failures that cause a loss of function that the Element or Component defines as "critical."

Mean Logistics Delay Time (MLDT): The average administrative and logistics delay time. Includes delay time for spares, delay time for support equipment, delay time for personnel, delay time for facilities, transportation delay time, and Administrative Delay Time (ADT).

In all cases, "Time" means "Operating Time."

In all cases, "Critical Failure" means those failures that would result in a C-3 or C-4 GSORTS rating as defined by CJSM 3150.02, Global Status of Resources and Training (GSORTS).

Narrative: The Operations and Support (O&S) cost of a fielded weapon system typically accounts for 60-70% of that system's life-cycle cost. Traditional methods of sustaining a weapon system usually results in steadily increasing values of MTTR and MLDT over time, resulting in significantly higher O&S costs. The BMDS risk associated with this scenario is twofold. First, the developmental response to the technological challenges associated with ballistic missile defense could be adversely affected if excessive O&S costs impact available funding. Second, current lack of logistics integration at the system level could result in one element's optimizing its own logistics performance while inadvertently sub-optimizing another's. The purpose of this SBIR will be to research and develop new techniques and tools that will substantially reduce the MTTR and MLDT values of the BMDS during fielding, as well as costs and footprint associated with material distribution. The goal of this SBIR will be to improve by an order of magnitude the planning, design, acquisition, deployment, and support of the BMDS through the use of innovative technology and process re-engineering. Solutions must contain the ability to capture performance-based metrics. This SBIR will also consider leveraging any currently existing Commercial Off The Shelf (COTS) technologies that will aid in obtaining the above-mentioned goal. While commercial products may provide partial solutions, research into combining technologies (e.g. active and passive Radio Frequency Identification (RFID)) with innovative process improvement should form the basis for possible solutions. Other traditional O&S cost drivers, such as effective management of Diminishing Manufacturing Sources (DMS) may also be addressed. Of particular importance is the ability to maintain visibility of critical sustainment assets for mobile/deployable BMDS units, i.e. "warehouse to warfighter." Return on Investment (ROI) should be addressed in readiness improvement terms as well as those associated with ownership cost reduction.

PHASE I: The first phase will result in a final report which documents a requirements analysis, proposed design, projected payoff, commercialization strategy, and a plan for Phase II.

PHASE II: The second phase will result in a prototype technique/tool, a field test to demonstrate its feasibility and payoff, a cost/benefit analysis, and associated documentation. The prototype may be a software/hardware tool that improves a specific dimension of logistics support.

PHASE III: Commercialization and transition/transfer of the developed technique/tool to the military and commercial markets.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Any technique or tool developed by this SBIR that successfully reduces the MTTR and MLDT values for the BMDS can be applied to virtually any product marketed by the private sector. The companies seen as most benefiting from this SBIR will be those in the manufacturing sector, and those involved in performance-based contractor logistics support for both DoD and private entities.

REFERENCES:
1. DOD Joint Vision 2010, DTIC Accession Number AD-A311 168 www.dtic.mil/doctrine/jv2010/
2. DOD Logistics Strategic Plan, www.acq.osd.mil/log/mdm/lsp98.htm
3. F Global Engagement, DTIC Accession Number AD-A318 235, www.xp.hq.af.mil/xpx/21/nuvis.htm

KEYWORDS: Supply, Planning, Logistics, Deployment, Maintenance, Sustainment, Acquisition, Transportation, Life Cycle Costs

MDA05-060 TITLE: Maintenance/ Monitoring Support Information Tools

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

ACQUISITION PROGRAM: BMDS-MDA/GM

OBJECTIVE: Develop an automated and graphically oriented Maintenance Support Tool (MST) for distributed systems, especially GMD component sub-systems, incorporating intelligent agent or expert system type technologies that provide rapid access to pertinent data resources.

DESCRIPTION: Computer controlled machines/equipment continually generate operating data, such as sensor logs, command logs, activity logs and error code logs, that act as a record their operating history. Such data can be represented mathematically to describe the state of a machine/ system/ sub-system at a point in time and can be quite extensive. Although much of the information needed by maintainers exists in databases, network maps, equipment user manuals, and on-line management information bases (MIBs), the information resources typically do not use artificial intelligence technologies to support maintainer efforts to quickly resolve specific problems. A user-oriented graphical decision support system incorporating advanced information processing (i.e. Expert Systems, Knowledge Based Systems, …), is needed to give the user both a "big-picture" overview capability to instantly recognize impending and current faults and the ability to rapidly drill down into detailed views of identified problem areas.

Effective maintenance of distributed systems requires that maintenance and support operators have comprehensive information, readily available, of the state of the sub-system and its components, implications of anomalous conditions, and the proper tools and procedures for prognosis, diagnosis, and repair of failed components. Such a tool would interface to a wide variety of sensors and data sources (databases, manuals, etc.), provide accurate, up-to-date status/analysis on equipment, and provide context-driven links to relevant items in databases, manuals, procedure libraries, and spares inventories. It will be capable of hosting on maintenance facility workstations, and, with appropriate connectivity, on portable devices carried by maintenance personnel into the field.

This would apply to diverse systems such as communications systems, facilities, silos, and missiles. Example applications of the kind of tasks to be monitored and supported are:

Communication system support:
• High Power Amplifiers, servos, modems, frequency conversion equipment,
• Facilities – HVAC, power, lighting, computers, shielding …
• Security equipment

Interceptor silo support:
• Detection and quantification of the amount of dust and other particulate or condensate that collects on the mirrors of the optical train in the EKV sunshade enclosure.
• Detect common types of hypergolic fuels and oxidizers including monomethylhydrazine (MMH), unsymmetric dimethylhydrazine (UDMH), and nitrogen tetroxide (NTO).
• Detect and record the shocks, vibrations, relative humidity and temperature that the GBI is subjected to during transportation, storage and while in silo emplacement.

The Maintenance/ Monitoring Support Information Tools should be readily integrateable with existing components and should be easily modified or reconfigured for use in a wide range of environments such as manufacturing, storage, transport, silo emplacement, etc.

PHASE I: Define a representative MST system and its resources, lay out an adaptable interface architecture, and interfaces to underlying data access & reasoning tools. In conjunction, available historical data will be analyzed in a preliminary assessment of the adequacy of the representative dataset.

PHASE II: Using historical operational data, adapt the system to support selected GMD sub-system components. These support tools will be refined for accuracy using live data sets, and demonstrated in a test field environment.

PHASE III: An automated solution for data integration, transformation, and application will be established. The resulting prognostic system will be deployed across the Missile Defense System and further refined for support capability and to expand the target data bases.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The ability to support rapid recovery from machine/equipment events has significant commercial potential in aircraft, power, manufacturing, processing, transportation, and other industrial applications where such capability would allow companies to improve safety, reduce downtime, and lower the direct maintenance cost of physical assets.

REFERENCES:
1. Intelligent Database Systems, Bertino, Catania, and Zarri. Addison-Wesley (is USA), 2001 ACM Press division of Association for Computing Machinery Inc.
2. Karl Reichard, Mike Van Dyke, and Ken Maynard, “Application of Sensor Fusion and Signal Classification Techniques in a Distributed Machinery Condition Monitoring System,” Proceedings of SPIE, Volume 4051, 25-28 April 2000, pp329-336.
3. William H. Press, et al, Numerical Recipes in C, Cambridge, UK: Cambridge University Press 1988.
4. Schmidt, Eckart W. Hydrazine and its Derivatives: Preparation, Properties, Applications. New York: Wiley-Interscience, 1984.
5. Fire, Explosion, Compatibility, and Safety Hazards of Hypergols – Monomethylhydrazine. American Institute of Aeronautics and Astronautics Special Project Report, AIAA SP-085-1999

KEYWORDS: interactive, graphical, expert systems, knowledge based systems, maintenance tools, hypergolic, hydrazine, nitrogen tetroxide, sensing, detection, mitigation.

MDA05-061 TITLE: Structured Approach for Business Case Planning of Missile Defense Systems

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: BMDS/DM

OBJECTIVE: Develop and demonstrate an analytical approach for establishing Return-On-Investment (ROI) for a credible Business Case Analysis (BCA) on missile defense systems and other Department of Defense (DoD) weapon systems.

DESCRIPTION: The development of a credible, well-documented financial justification is critical to effective continuation of any commercial or defense-sector program. The availability of a consistent, effective budgeting process will ensure technology and system initiatives for missile defense systems can be evaluated, documented and developed into an integrated Business Case Analysis which can be used to support Program Objective Memorandum (POM) input to the DoD budget or program justification for congressional reviews. A BCA is a comprehensive financial analysis of system or development alternatives that enables a decision maker to review the ROI of the system alternatives. The BCA links these investment decisions to the organization’s strategic plans and depicts its revised financial position after undertaking the investment project.

The goal of this research is to provide a Business Case Analysis framework, analytical process and prototype computer tool-set for use in developing and justifying a system/technology Return-on-Investment for the Missile Defense Agency (MDA), other DOD programs, as well as commercial industry. This research effort will develop innovative capabilities that employ the latest information technologies to bring the best community-accepted cost models, data, modeling and simulation, and engineering analyses together in a comprehensive financial plan. The research will support performance/risk trades that clearly highlight the benefits and value of the developments or investment options. Current analysis processes are typically not specifically focused on developing a logical financial/benefit analysis that enables a credible program justification. This research topic is directed at that needed capability.

This research, methodology development and prototype toolset is relevant to all defense systems and can be used effectively by the MDA and its associated industry partners. Effective and credible cost and engineering analysis tools and methods are needed to assess the affordability of proposed investments and present them as a credible business case justification. This research effort will apply (DoD) and industry-accepted affordability models/tools with community-accepted data and engineering/simulation evaluations, to assess the long-term life-cycle affordability of weapon system programs. Where necessary, existing DoD-accepted parametric cost models will be refined or enhanced to ensure they accurately reflect development, production, and operational support costs of the programs including modern ballistic missiles, detection, tracking, and sensor systems. The capability will enable senior managers to conduct credible cost and ROI estimates for the proposed investments. This analysis capability will focus on projects that have both technical and economic merit, rather than conducting longer analysis efforts on technical proposals that ultimately are not affordable. It will also assist senior MDA staff in obtaining a system justification package that will be credible for all levels of DoD and Congressional review. The proposed methodologies and computer tools will be flexible enough to be used by multiple organizations within the DoD and industry and be capable of executing on commercial-off-the-shelf computer workstations. Graphical depiction of results and output from the toolset will comply with industry standards.

PHASE I: Phase I research activity will include: 1) development of business case analysis requirements, 2) development of a design concept to assess, integrate and present return-on-investment information for missile defense acquisitions, and 3) a proof-of-concept demonstration of key enabling technologies to test the feasibility of software tools and user interfaces.

PHASE II: The researcher will design, develop, and demonstrate a structured process and a prototype tool to create a Business Case Analysis (BCA) on investment alternatives and provide information in an effective format for presentation and decision support. The research will use Pilot Sites in other DoD and/or industry organizations to illustrate the functionality of the tool and to obtain feedback on its operation and user interface. Within the MDA, this prototype methodology and toolset will be used in a “real-world” problem such as a study of sensor options or defensive architecture options to ensure the tool functionality will benefit the MDA, and can be easily applied to other DoD and industry organizations. The researcher will also detail the plan for Phase III effort.

PHASE III: The desired product of Phase III is a robust methodology and toolset for Business Case Analysis (BCA) in support of the MDA and other defense and commercial product development and manufacturing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Methodologies for Business Case Analysis (BCA) that incorporate affordability models/tools with community-accepted data and engineering/simulation evaluations of systems are applicable to all manufacturing industries, and to communication and information systems. Any industry or service organization that prepares a yearly budget for submission to a higher-level authority can benefit from this capability.

REFERENCES:

1. DoD Financial Management Regulation (DoD 7000.14-R),
http://www.dod.mil/comptroller/fmr/

2. OMB Circular A-11, Preparation, Submission and Execution of the Budget (Revised 07/25/2003), Office of Management and Budget
http://www.whitehouse.gov/omb/circulars/a11/02toc.html

KEYWORDS: Affordability; Cost Analysis; Business Case Analysis; Return-on-Investment; Budget Justification

MDA05-062 TITLE: Advanced, Low Cost, Integrated Avionics

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS - MDA/TH/GMD

OBJECTIVE: The objective of this research and development effort is to develop innovative high performance avionics through an integrated design that will enhance the capability of interceptor seekers, flight computer and guidance sensors, while reducing the cost and increasing the computational performance.

DESCRIPTION: The term "advanced avionics" represents a broad category of technology, generally taken to include the infrared seeker/image processor, flight computer, and guidance and navigation sensors including the Inertial Measurement Unit (IMU) and Global Positioning System (GPS) receiver, etc. Improvements in avionics processing architecture are required to enable advanced seeker image processing, data compression and sensor fusion algorithms, while maintaining or reducing weight and power dissipation. Integrated GPS on the missile is desired to provide greater flexibility in launcher placement, improved guidance accuracy, missile autonomy and integrated operations. The development of advanced integrated avionics architectures could yield component-level form, fit, and functional component improvements to support the next generation THAAD system with high density stacking electronic technologies highly desirable. In addition, as the interceptor's seeker migrates toward a strap-down seeker/IMU configuration, these subsystems will need to be made less sensitive to shock and vibration due to the higher environments they will experience. Small, extremely sensitive, high dynamic range accelerometers that are impervious to sock and vibration are also needed. Furthermore, the THAAD flight computer features four MIPS CPUs, and the flight software architecture is highly tuned to that configuration. The four CPU MIPS architecture must be preserved in future processor upgrades to avoid the cost of re-hosting or re-formatting this software.

Small (less than 70 cu. in.), lightweight (less than 1 kg), low cost inertial sensors that provide low-latency, corrected angular rate data at 15-20 kHz, with similar or improved angular drift rates are desired. The cost of these subsystems can approach as much as 50% of the overall cost of the missile. Proposed designs should strive for twice the performance at half the cost. Therefore, performance goals for the advanced designs should be in the range of 20-200 mega pixels per second, with processor speeds in the gigahertz range, IMU data rates in the 20 kHz range, and a cost target of 25% of overall missile cost.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed technology to enhance avionics performance. Proposed designs should strive for twice the performance at half the cost of current technology, and strongly suggest a growth opportunity for further performance increases and cost reduction.

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 Theater missile defense systems such as THAAD, and GMD concepts.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would have applicability to automobile industry, communication satellites, and at the computer industry.

REFERENCES:
1. J. Soderkvist, “Micro machined Gyroscopes” 7th ICSS Sensors Actua., pp.638-41, 1994.
2. H.Helvajian, “Microengineering Aerospace Systems” The Aerospace Press, American Institute of Aeronautics and Astronautics, 1999.

KEYWORDS: interceptor, avionics, accelerometer, electronics.

MDA05-063 TITLE: HWIL Channel Simulator for Communication System Testing

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Battlespace

ACQUISITION PROGRAM: BMDS - GM

OBJECTIVE: The objective of this program is to research innovative hardware and software technologies necessary to efficiently and cost effectively incorporate easy-to-use hardware-in-the-loop (HWIL) fading channel simulation technology to test communication systems for severely disturbed trans-ionospheric propagation paths.

DESCRIPTION: MDA/GMD is developing various military communications systems to operate over a wide range of conditions. RF signals propagated through regions of the ionosphere can be distorted by high altitude nuclear effects (HANE). Modems receiving such signals will experience significantly degraded performance [1]. Because such highly-disturbed propagation conditions are not common in the natural environment, engineers cannot draw upon prior field experience to design modems specifically mitigated for those channel conditions. Rather, engineers must rely on fading channel models developed by the strategic communications community, such as those described by Bogusch [1]. Furthermore, engineers must rely on HWIL channel simulators using these HANE-related fading channel models for developmental testing as well as modem acceptance testing. To this end, MDA seeks innovative approaches to design a HWIL fading channel simulator that supports the following:

Simulate a wide range of time varying/fading channels models including:
1. Commercial benign channels
2. Defense Threat Reduction Agency flat fading and frequency-selective fading
3. Accept channel descriptions in Time Domain or Frequency Domain (Scintillation Index S4, Decorrelation Time Constant Tauo, Dopper Spread, …)
4. Model (in software) those same conditions at baseband (digital I/O)
5. Support for wide signal bandwidths (up to 100 MHz)
6. Inclusion of influence of antennas on signals from frequency-selective fading channels
7. Emulation of slowly-varying average total-electron-concentration (TEC) effects
8. Inclusion of dispersion in TEC effects
9. Real-time parametric generation of pseudo-random fading realizations & TEC profiles
10. Emulation of propagation delay and Doppler shifts arising from platform dynamics
11. Support insertion of time & frequency errors to simulate real world clock and frequency reference errors, and to support signal acquisition testing
12. Support for multiple channels for diversity receivers and Multiple In/Multiple Out (MIMO) communication system architectures
13. Adapt to different IF or RF Frequencies (via upgradeable modules if necessary)
14. Support transceiver-to-simulator RF interfaces between 70 MHz and 44 GHz
15. Remotely controllable through standard interfaces (e.g., Ethernet, GPIB, USB, etc.)
16. Be easy to use, easy to calibrate and portable

Successful bidders will have demonstrated a comprehensive knowledge of issues related to HWIL communications systems testing and fading channel modeling.

PHASE I: Describe hardware and software simulator architecture. Demonstrate basic software implementation for fading channel operation. Develop analysis procedure to show that the model implementation will provide valid channel statistics. Document work in a report, and provide a Phase II development and demonstration plan.

PHASE II: Develop, demonstrate, and validate a fading channel test capability compatible with the GMD IFCS modems and MDA AS modems.

PHASE III: Transition/transfer developed products to GMD system.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This technology has potential applications for testing various military and commercial space communications systems.

REFERENCES:
Robert L. Bogusch, Digital Communications in Fading and Jamming – COMLNK User’s Manual, Mission Research Corporation Report no. MRC-R-1607A, 21 September 2001

KEYWORDS: HWIL cahnnel simulator, Fading Channels

MDA05-064 TITLE: XML Cross-Domain Voice Collaboration

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS-BC

OBJECTIVE: Provide a capability to enable cross-domain voice communication to facilitate collaboration using the latest Voice over IP (VoIP) and XML technologies.

DESCRIPTION: IP networks at various sites are now handling an increasing number of voice calls. Voice over IP (VoIP) is being used in different security domains on their respected networks; Top Secret - JWICS, Secret - SIPRNET, and Unclassified - NIPRNET. This technology is working well with-in each domain, but a JWICS user can't call someone on the SIPRNET and visa versa. This cross domain requirement was recently voiced by STRATCOM. A Cross Domain Solution (CDS) is needed to enable cross domain phone calls via VoIP with another security domain. Several new technologies have recently surfaced that provide enhancements to voice collaboration techniques using XML. Such technologies include VoiceXML, SALT, XHTML, SSML, and SRGS. Current implementations of VoIP have security issues associated with them including eavesdropping, identity theft, identity fraud, toll fraud, the compromise of call integrity and denial of service. These technical challenges are issues of concern that need to be addressed whether the calls are intra-domain or inter-domain. A solution in this technology area is a growth market which is ripe for innovation as information sharing and cross-domain collaboration are fundamental components of the Air Force Transformation and our Nation’s vigilant transformation towards improved homeland security.

PHASE I: Investigate cross-domain voice collaboration advancement opportunities made possible by maturing VoIP and emerging XML technologies and deliver an innovative prototype solution that addresses at least one of the security issues identified above which will enhance the collaboration of users within two or more separate domains.

PHASE II: Finalize the design of the prototype and conduct the following: 1) Develop and demonstrate operation of the prototype based on the Phase I model. 2) Integrate the prototype into an active cross-domain technology transfer device (guard) which is compliant with DCID 6/3 requirements. 3) Investigate advancement opportunities for further research in cross-domain voice collaboration that can be applied to the prototype.

PHASE III: Military - enhancement to existing cross-domain guarding solutions implemented throughout the DOD, US Intelligence Community, and Coalition forces. Commercial – voice collaboration solutions which enable bridging of intranets within a single company (financial<>legal) or between companies which are part of a consortium.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The prototype developed for the DoD is equally applicable for use in other Federal, State and local Government sectors as well as the commercial sector for bridging communication shortfalls between domains that involve physical or classification separate networks. Such domains include law enforcement agencies and first responders within the Department of Homeland Defense.

REFERENCES:

1. “Adding Voice to XHTML” ; Mccobb, Gerald and Kusnitz, Jeff; Dr Dobb’s Journal, January 2005; pgs. 42-47; http://www.ddj.com
2. “The Ease of VoIP”; Travis, Paul; Information Week, December 6, 2004;page 65; www.informationweek.com

KEYWORDS: Voice over IP (VoIP), XHTML, Voice Extensible Markup Language (VoiceXML), Speech Application Language Tags (SALT), Speech Synthesis Markup Language (SSML); Speech Recognition Grammar Specification (SRGS); Cross-domain voice collaboration

MDA05-065 TITLE: Missile Communication Alternatives and Trades

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

OBJECTIVE: Develop innovative concepts to provide in-flight communications between the BMDS Fire Control and Interceptor/Kill Vehicles such as the GMD-EKV and MKV/CV. Provide analysis of proposed communications solutions within the framework of the 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.

DESCRIPTION: MDA is seeking innovative communications methodologies for future Interceptor/Kill systems. Near term improvements are needed to support evolution from the present interceptor communications system to future missile defense communications architecture(s). Farther-term developments include the design of an MKV RF communications system that allows communication between Multiple Kill Vehicles and a Carrier Vehicle (MKV/CV). Applications include both long range endo/exo-atmospheric (thousands of km) as well as short range exo-atmospheric applications (~50 km). Encryption can be considered transparent for the channel analyses and is not required to be part of this effort.

Software analysis tools and hardware system solutions for these future interceptor in-flight communication applications need to be developed. In particular, in any future MDA communication architecture interceptor in-flight communication solutions will have to provide robust communications links (consider for example, RF, Optical, and dual mode RF/ Optical communications approaches, various relay options, etc.) with the ability to handle hostile channels, including jamming and Nuclear Weapons Effects (e.g. MDA HANE document). In addition, there is a finite set of available RF spectrum options that can be assigned and authorized to any particular communications solution. Communications system design depends heavily on:

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. High EMI/EMP tolerances
5. Jam and SIGINT resistance
6. Interference avoidance with and from the existing COMM systems
7. Transmission during ground and range testing as well as operations
8. Beyond Line Of Sight (BLOS) connectivity
9. The overall cost of a proposed communications solutions

The design requirements for Interceptors and Kill Vehicles are more much more demanding than for small satellites. Low power, small antennas, and hostile channel conditions are hallmarks of the design problem. Any proposed communications schemes must be scaleable as Missile Defense implementation grows in both geographic coverage (locations & platforms) and in hardware (number and type of interceptors). Implications of frequencies recommended such as interference potential, spectrum allocations, etc must be considered for wartime and peacetime operations (e.g. integration, routine tests).

PHASE I: Contractors shall design and develop analytical tools to assist in identifying candidate communications solutions for providing connectivity to missiles and/or kill vehicles within the evolving MDA architecture. Using the analytical tools the contractor shall demonstrate the particular solutions feasibility of meeting Interceptor/Kill Vehicle communication requirements and envelop constraints. The contractor shall also apply the prototype tool suite to identify the strengths/weaknesses associated with different concepts. The output shall be a communications system and hardware analysis which substantiates the proposed solution(s) and provides quantifiable metrics for comparison. Attention shall be paid to ongoing efforts within the DoD for weapons communications connectivity.

PHASE II: The contractor shall select a proposed communications scheme developed in Phase 1 and prototype communications hardware that could be used for two-way communications connectivity (half or full duplex). The proposed schemes must be selected for their optimum mix of performance characteristics as listed above. Contractor shall begin coordination with MDA/GMD/MKV/BC contractors to ensure products will be relevant to ongoing and planned projects.

PHASE III: The offeror shall work with MDA/GMD/MKV/BC 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.

REFERENCES:
1. DARPA Tactical Targeting and Network Technology (TTNT) program http://dtsn.darpa.mil/ixo/programdetail.asp?progid=9
2. DARPA MIMO program, the Transformational Communications Architecture (TCA) from the National Security and Space Architecture (NSSA) office.
3. Irving, L. "Spectrum management: a balancing process", Communications Magazine (IEEE), Volume: 33 , Issue: 12, Dec 1995 Pages:44 - 46.
4. 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.
5. MIL-STD-461, "Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference", military standard, procedure CE106.
6. DD 1494, "Application For Equipment Frequency Allocation", Department of Defense Form.
7. 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.
8. Professor David Jenn, “ATMOSPHERIC NUCLEAR EFFECTS”, Naval Postgraduate School, Monterey, California.
9. Draft Programmatic Environmental Impact Statement, Missile Defense Agency, Volume 1 1 Sep. 2004, http:www.mda.mil/mdalink/pdf/peisvol1.pdf.
10. Draft Programmatic Environmental Impact Statement, Missile Defense Agency, Volume 2, 1 Sep. 2004, http:www.mda.mil/mdalink/pdf/peisvol2.pdf.
11. Defense Threat Reduction Agency website, http:/www.dtra.mil.

KEYWORDS: communications architecture, jamming, nuclear effects, ground terminals, channel trades, RF datalink, spectrum management, spectrum allocation, DD 1494, CE106, NTIA, laser diodes, optics, silicon-carbide amplifiers

MDA05-066 TITLE: Manufacturing Processes for Propulsion Technology

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: BMDS -MDA/MP

OBJECTIVE: MDA is seeking innovative products and technologies that enable wide application for manufacturing improvements in solid and liquid propulsion system components. Such technologies include high temperature materials for both liquid and solid propellant systems and actuator technology. The requirements for high performance in both lower and upper boost phase as well as end game require innovative manufacturing processes to enable these technologies. The Manufacturing and Producibility (MP) Directorate of MDA is seeking low cost and high performance components, material improvements, and manufacturing improvements for both solid propellant and liquid propulsion systems to include rocket motors and divert and attitude control systems (DACS).

DESCRIPTION: High performance propulsion systems in MDA applications require materials that perform with appreciably higher use-temperatures than the available state-of-the-art (SOTA). Specifically, many typical SOTA nozzle and throat materials exhibit unacceptable erosion and mechanical or thermal attributes at temperatures greater than 3000°F. Insulation materials such as ethylene propylene diene monomer (EPDM) rubber can experience excessive charring and generate many particulates and gas species that contaminate the exhaust plume. In addition to materials improvements, there is a need for improvement in actuator technology to include both innovative and alternative actuation techniques as well as high specific stiffness actuator housing components. Specific technologies being sought include:

• High temperature erosion resistant structural materials – Erosion resistant materials such as ceramics, composites, and refractory metals for components such as liners, nozzles, and hot gas paths capable of material operating temperatures greater than 3500°F are desired. The materials shall be useful at pressures greater than 2000 psi and flame temperatures greater than 4500°F for non-aluminized propellant systems and greater than 6000°F for boost motors. The materials shall be able to tolerate rapid thermal gradients such as those experienced at startup. Typical minimum properties are hoop or axial tensile strengths of over 20 ksi (138 MPa).

• High temperature formable insulation material – Solid propellant systems rely on insulation material for many internal components. In most cases, MDA desires very formable insulation material with low outgassing characteristics and the ability to survive high temperatures. In addition to high insulative properties, the material should exhibit increased erosion resistance, minimum particulate generation, and good handling and processing characteristics. Candidate materials shall have increased insulative capability and generate appreciably less offending gas and particulates than filled EPDM insulation. The insulation materials should be easy to emplace and cure to net shape inside motor case structures or be amenable to over-wrapping and post-cure within composite structures. For divert and attitude control system applications, MDA desires insulators without silica and with minimum inorganic fillers to minimize valve clogging.

• Structural insulative materials – Solid propellant DACS interfaces operate from temperatures in excess of 3000°F to others that cannot tolerate temperatures in excess of 300°F for long durations. Preferred structural insulators are those that are load bearing, maintain dimensional stability, do not undergo significant changes such as pyrolysis, have good thermal and fracture toughness, and operate in the 2000°F, 3000°F, and 4000°F temperature categories.

• High temperature seal materials – Solid propellant DACS thruster components as well as some solid rocket motor nozzles are required to be sealed against high temperature gases. Static seals operable at seal temperatures as high as 3000°F and dynamic seals operable as high as 1000°F are of interest. Sealing pressures are in the 2000 to 3000 psi range.

• Material joining technologies – Innovative methods for joining dissimilar materials such as refractory metals, ceramics, and composites that go beyond bolt-together technologies.

• Actuator technology – Low voltage (with a goal of achieving 28 volts) high power density high performance actuators (0.125 inch stroke in <10 msec desired) for 5 to 2000 lbf applications; Actuation technologies that maintain response, stiffness, and precision performance characteristics at high temperatures (>500 deg F functional capability desired); 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 low temperature materials for actuator housings.

PHASE I: Develop concept for demonstration of the proposed propulsion product which will be integrated into an MDA system or subsystem to increase performance, lower cost, or increase reliability. Provide a quantified assessment of proposed technology feasibility and pay-off. Experimental data to support Phase I feasibility and pay-off assessment is desired but not mandatory.

PHASE II: Validate the feasibility of the rocket motor, case, or DACS product technology by demonstrating its use in the operation of prototype items for MDA element systems, subsystems or components. A partnership with the current or potential supplier of BMC element systems, subsystems, or components is highly desirable. Identify any commercial application of technology or opportunities of benefit from using the innovation.

PHASE III: 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.

REFERENCES:
1. George T. Sutton, "Rocket Propulsion Elements; Introduction to the Engineering of Rockets" Seventh Edition, John Willey and Sons, 2001.

2. Missile Defense Agency Link - http://www.acq.osd.mil/mda/mdalink/html/mdalink.html

3. Ballistic Missile Defense Basics - http://www.acq.osd.mil/mda/mdalink/html/basics.html

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

MDA05-067 TITLE: Low Cost, High Performance Liquid Divert and Attitude Control Systems (DACS)

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS-TH

OBJECTIVE: The objective of this research and development effort is to develop innovative low cost, high performance component technologies that will enhance the capability of liquid divert and attitude control systems (DACS) while at the same time reduce the cost of the overall missile system.

DESCRIPTION: Improved DACS technologies are needed to address cost reduction, insensitive munitions and safety requirements, while maximizing the kill vehicle (KV) divert capability and/or reducing the KV weight within restricted geometries. A host of interrelated technologies such as low cost/high performance nozzle materials; non-toxic propellants or other high performance propellants, alternative pressurization schemes, low cost/high performance thruster valves, are of interest. The general scale could be described as a system comprised of tanks, Valves, and thrusters (8 to 10 in number) weighing less than 50 kg and measuring approx 1 meter in length. Individual thrusters would be on the order of 25 cm long by 10 cm diameter. Materials currently used on the DACS system have temperature limits of 2500 0F (limiting the propellant combustion temperature and therefore energy output), are heavy (>10grams/cm3), have limited specific strength (30mPa*mL/gram), and require hundreds of hours of processing time resulting in high production costs. Therefore innovative materials and/or concepts and technologies are needed to increase the temperature limits by a factor of >2 than current systems, are lightweight (<<10grams/cm3), have specific strengths >5 times the currently used materials, have the ability to withstand >5000g @ 2000Hz, provide oxidation resistance and exhibit low permeability (<0.2 standard cm3/sec), and can be processed at a factor of 10 less time than currently used processing techniques. Alternative pressurization schemes should offer ability to maintain relatively low pressures (<1000 psi) during 20 year storage life to improve safety during storage and transportation but retain high response and +/-5% pressure regulation capability at DACS operating pressures of ~1000 psi. Low cost/high performance bi-propellant thruster valves must offer significant reduction in complexity and cost (<50%), while retaining <5 msec response and mass < 100 grams. The ability to test and evaluate the designs to illustrate their improvements in thermal and structural performance should also be an integral part of this effort. Numerous candidates for fit, form and functional component replacements may be available in time to support a near term insertion opportunities.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed technology to enhance DACS performance.

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 THAAD system.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would have applicability to commercial space platforms, thermal protection materials and control surfaces, automobile components such as turbochargers, high temperature environment systems such as recuperators in melt furnaces, jet APU ring motors etc.

REFERENCES:

1. George T. Hutton, "Rocket Propulsion Elements; Introduction to the Engineering of Rockets" Seventh Edition, John Willey and Sons, 2001.

2. Vigor Yang, Thomas B. Brill, and Wu-Zhen Ren, "Solid Propellant Chemistry, Combustion, and Motor Interior Ballistics", AIAA, 2000.

KEYWORDS: interceptor kill vehicle, divert and attitude control, nozzle materials, propellant.

MDA05-068 TITLE: Innovative Axial Propulsion Booster Propellants and Component Technology for Missile Defense Interceptors

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS- MDA/GM, MDA/TH, MDA/MP, MDA/AB

OBJECTIVE: Develop innovative higher performance booster propellant and or component designs, suitable for use in BMDS interceptors, that are: low cost, highly reliable,stable in long term silo storage and require minimal maintenance.

DESCRIPTION: Increased kill mechanism velocity is desired. Specific areas of technology development and maturation are:

• Propellant chemistry - including advanced HTPB propellant formulation to improve specific impulse and density impulse with improved cold temperature operation and storage capability; age-life projection and non-contact or in-situ aging monitoring.

• Motor case technology - high strength, high stiffness and lightweight polymer matrix or metal matrix composite cases and liner/insulation materials and processes. Improvements in producibility and affordability; cases with integral cable raceways. Consumable flexible (EPDM like) insulator materials with near zero particulates and residual char.

• Nozzles- refractory ultra-high temperature materials for non-eroding throats; novel materials and designs for exit cones with decreased processing schedules and lower cost.

• Integral vehicle health monitoring - research into technologies related to "cradle-to-grave" monitoring of solid rocket motor cases, including sensors, fiber optics or conventional wiring, readout electronics, and diagnostic or prognostic software/hardware.

• Ignition safety – The prevention of unintended ignition with 1901A compliant ignition systems.

• Manufacturing Processes – Implementation of Design for Manufacturability and Assembly (DFMA) to include overall solid propellant motor/booster integration. Lightweight mandrel development for graphite composite and metal impregnated fiber cases; Improvements in refractory material processing and affordability.

Target goals for cost reduction are at 50% of current systems, while improving reliability to mid 90%.

PHASE I: Identify candidate materials and designs. Fabricate and characterize materials for component technologies. For propellant improvements, conduct research and experimental efforts to quantify specific impulse, mass fraction, long term storage compatibility of the investigated propellants.

PHASE II: Develop and demonstrate prototype designs of Phase I booster propellant and/or components in a test environment. Develop and document design. Perform appropriate characterization and testing, e.g. sub-scale motor tests, accelerated long term storage compatibility testing. A partnership with the current or potential supplier of BMDS element systems, subsystems, or components is highly desirable. Identify any commercial application of technology or opportunities of benefit from using the innovation.

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

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

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

KEYWORDS: propulsion, materials, chemical compatibly, propellants, insensitive munitions, safety

MDA05-069 TITLE: Highly Controllable Solid Propellant and Rocket Motor Propulsion Technology

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS-AB

OBJECTIVE: Aegis Ballistic Missile Defense (MDA/AB) is seeking concepts for controllable solid propellant systems with applicability ranging from attitude control systems to booster stages. . Technologies of interest include restart capable solid propellant technologies, throttle capable solid propulsion technologies, and hybrid rocket motor technologies

DESCRIPTION: Controllable Solid Rocket Motor Technology will enable greater flexibility in mission planning as well as provide additional capability to the overall BMD system. Current state-of-the-art (SOTA) solid propulsion systems include multiple-pulse motors that provide a measure of motor burn controllability . Systems under development include throttling capable systems that provide an additional increment of controllability to the motor burn profile during a mission. New concepts are desired that will enable high controlabilityof solid propulsion systems in a manner similar to SOTA liquid propulsion technologies (on/off and throttle capable) are desired. Solid propellant systems are preferred for Aegis BMD systems due to safety requirements for ship based systems. Specific technologies being sought include:

• Restartable Solid Propellant Technology – The ability of a solid propellant to be fully extinguished and then restarted is a characteristic that would increase overall system performance of a BMD system. It would also provide additional performance if the rocket motor burn could be stopped and restarted numerous times throughout the mission. Non-propulsive periods should be on the order of 0.5 second to in excess of 3 minutes. This technology could be focused towards small thrust levels from 5 lbf up to and in excess of 10,000 lbf. Restart time after extinguishment is desired to be less than 0.2 seconds in early burn and 0.5 seconds in late burn, when chamber free volumes are higher.

• Throttle Capable Solid Propellant – The capability to vary or control the thrust level of a solid rocket motor through its operation would allow for increased performance of the overall BMD system. Current systems tailor the thrust profile by using grain shapes, multiple grains and inhibitors, but the profile is fixed. Emerging technologies that provide capability to set a thrust level and also vary the thrust level through out the rocket motor burn are technologies of interest. A throttling turndown ratio of >10/1 is required, and a throttling turndown ratio of >20/1 is desired. Turndown ratio is defined as the ratio of maximum to minimum thrust capable from a system.

• Hybrid Propulsion Technology – Technologies related to the use of hybrid (liquid/solid) motors are being sought. The ability to shutdown propellant burning and restart it upon command is desirable. It is also valuable if the thrust level could be controlled using hybrid propulsion technology. Applicability to systems ranging from attitude control systems to booster stages is of interest. Restart time after extinguishment is desired to be less than 0.2 seconds in early burn and 0.5 seconds in late burn, when chamber free volumes are higher. Of additional interest is hybrid packaging compactness and minimum hybrid combustion chamber length.

PHASE I: Develop concept and conduct subscale testing applicable to the propellant technologies and rocket motor designs. Development plan should show path to applicable system integration.

PHASE II: Validate the feasibility of the propellant technologies and rocket motor designs by demonstrating its use in the operation of prototype systems. A partnership with the current or potential supplier of BMD element systems, subsystems, or components is highly desirable. Identify any commercial application of technology or opportunities of benefit from using the innovation. The projected benefits of the innovation to commercial applications should be clearly quantified, as to whether they reduce cost, improve producibility, or performance of products that utilize advanced solid propulsion technology.

PHASE III: Successful demonstration of a new technology. This demonstration should show near-term application to one or more MDA systems, subsystems, or components. This demonstration should also verify the potential for increased system performance.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technologies have application to commercial space launch and upper stage propulsion systems, where propulsion systems must be capable of inserting varying payloads into a multitude of orbits. Currently, this function is provided by cryogenic liquid or toxic hypergolic propulsion systems. The proposed technologies provide the potential to provide space launch controllable propulsion elements at lower cost and reduced handling complexity than current technologies. Additionally, the proposed technologies have potential to provide multi-mission capability to a variety of surface and air launched weapons systems, through the provision of mission-variable controllable thrust output.

REFERENCES:
1. George P. Sutton and Oscar Biblarz, "Rocket Propulsion Elements." 7th Edition, John Wiley & Sons, 2001

2. Philip G, Hill and Carl R. Peterson, "Mechanics and Thermodynamics of Propulsion", Addison-Wesley, 1965

KEYWORDS: Solid Rocket Motors, Divert and Attitude Control System (DACS), Attitude Control System (ACS), Gas Generators, Solid Rocket Booster, Hybrid Rockets

MDA05-070 TITLE: Advanced Divert and Attitude Control (DACS) system for the Multiple (Miniature) Kill Vehicles (MKV)

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS-AS

OBJECTIVE: Develop a low weight, small volume, high performance miniature DACS system and or critical components that could be incorporated into a. miniature kill vehicle.

DESCRIPTION: Miniature interceptors, especially an integrated version of them launched from a single booster that could intercept multiple objects in the exo-atmosphere, have the potential to solve many difficult countermeasure problems. Miniature interceptors weighing less than 3.0 kilograms and costing less than $100K are desired.

Developing a DACS system that can meet weight (<1.4kg wet), volume (<2,000cm3), cost (<$20K) and performance for such an interceptor requires new innovative technologies. Divert velocity performance of better than 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 vehicle is small and requires 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 40 N and response time of 1 to 10 msec. Cost, manufacturability, safety and storability are all important considerations. Technologies of interest include but are not limited to : phase change solid to gas or liquid to gas electrothemal thrusters; monolithic SiC or silicon thrusters using liquid or gel propellants, colloidal thrusters, innovative bipropellant or monopropellant concepts; pulsed detonation rocket engines; micro/MEMS propellant valves, solid propellant multi-pulse or breech concepts. 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.

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.

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.

REFERENCES:
1. Paschal N., Strickland B., Lianos D., " Miniature Kill Vehicle Program", 11th Annual AIAA/BMDO Technology Conference, Monterey, CA, August 2002.
2. Lianos D., Strickland B., " A midcourse Multiple Kill Vehicle Defense Against Submunitions", 6th Annual AIAA/BMDO Technology Readiness Conference, San Diego, CA, August 1997.

KEYWORDS: interceptor, guidance, sensor, MEMS, power sources