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

INTRODUCTION

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

Dr. Douglas Deason
Director, Advanced Research
E-mail: sbirsttr@mda.mil
Phone: (256) 955-2020

MDA/DVR
Bldg 5224, Martin Road
Redstone Arsenal, AL 35898

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

Proposals not conforming to the terms of this Solicitation will not be considered. MDA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded. Only Government personnel will evaluate proposals.

Questions about SBIR and Solicitation Topics:
Refer to Section 1.5 of the DoD solicitation at www.dodsbir.net/solicitation.

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

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

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

Conflicts of Interest:
Refer to Section 1.4 of the DoD solicitation at: www.dodsbir.net/solicitation.

PHASE I GUIDELINES

MDA intends for the Phase I effort to determine the merit and technical feasibility of the concept. Phase I proposals may be submitted for a period of performance of 6 months and a base amount not to exceed $100,000. The Phase I Option may be submitted for a period of performance of 6 months and an amount not to exceed $50,000. A list of the topics currently eligible for proposal submission is included below, followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics originated from the MDA Programs and are directly linked to their core research and development requirements.

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

PHASE I PROPOSAL SUBMISSION CHECKLIST

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

____1. The following have been submitted electronically through the DoD submission site by 6 a.m. (ET) 27 June 2012.

_____ a. DoD Proposal Cover Sheet

_____ b. Technical Proposal (**DOES NOT EXCEED 20 PAGES**): *Any pages submitted beyond this will not be evaluated. Your cost proposal and Company Commercialization Report DO NOT count toward your maximum page limit. Proposal Coversheets DO count toward your maximum page limit.*

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

_____ d. DoD Company Commercialization Report (required even if your firm has no prior SBIRs).

_____ e. Cost Proposal **(Online cost proposal form is REQUIRED by MDA)**

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

USE OF FOREIGN NATIONALS

See Section 2.3 of the DoD program solicitation for the definition of a Foreign National (also known as Foreign Persons.)

ALL offerors proposing to use foreign nationals MUST disclose this information regardless of whether the topic is subject to ITAR restrictions. See Section 3.5, b.(7) of the program solicitation for required information.

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

ITAR RESTRICTIONS

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

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

PHASE I PROPOSAL SUBMISSION

The DoD SBIR/STTR Proposal Submission system (available at http://www.dodsbir.net/submission) will lead you through the preparation and submission of your proposal. Read the front section of the DoD solicitation, including Section 3.5, for detailed instructions on proposal format and program requirements. Proposals not conforming to the terms of this solicitation will not be considered.

MAXIMUM PAGE LIMIT FOR MDA IS 20 PAGES

Any pages submitted beyond the page limit will not be evaluated. Your Cost Proposal and Company Commercialization Report DO NOT count toward your maximum page limit. Proposal coversheets, which will be added electronically by the DoD submission site as page 1 and page 2, DO count toward your maximum page limit.

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

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

A firm-fixed-price Phase I Cost Proposal ($150,000 maximum, including option) must be submitted in detail online. Proposers that participate in this Solicitation must complete the Phase I Cost Proposal not to exceed the maximum dollar amount of $100,000 and a Phase I Option Cost Proposal (if applicable) not to exceed the maximum dollar amount of $50,000. Phase I and Phase I Option costs must be shown separately but may be presented side-by-side on a single Cost Proposal. The Cost Proposal DOES NOT count toward the 20-page Phase I proposal limitation.

MDA PROPOSAL EVALUATIONS

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. MDA reserves the right to award none, one, or more than one contract under any topic. MDA is not responsible for any money expended by the proposer before award of any contract. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

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

MDA will use the Phase II Evaluation criteria in Section 4.3 of the DoD solicitation, including potential benefit to BMDS and ability to transition the technology into an identified BMDS, in inviting, assessing and selecting for award those proposals offering the best value to the Government.

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

Please note that potential benefit to the BMDS will be considered throughout all the evaluation criteria and in the best value trade-off analysis. When combined, the stated evaluation criteria are significantly more important than cost or price. Where technical evaluations are essentially equal in merit, cost or price to the government will be considered in determining the successful offeror.

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

Qualified advocacy letters will count towards the proposal page limit and will be evaluated towards criterion C. Advocacy letters are not required for Phase I or Phase II. Consistent with Section 3-209 of DoD 5500.7-R, Joint Ethics Regulation, which as a general rule prohibits endorsement and preferential treatment of a non-federal entity, product, service or enterprise by DoD or DoD employees in their official capacities, letters from government personnel will NOT be considered during the evaluation process.

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

INFORMATION ON PROPOSAL STATUS

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

IMPORTANT: We anticipate having all the proposals evaluated and Phase I selection and non-selection notifications distributed in the September 2012 timeframe. All questions concerning the evaluation and selection process should be directed to the MDA SBIR/STTR PMO.

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

MDA SUBMISSION OF FINAL REPORTS

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

PHASE II GUIDELINES

This Solicitation solicits Phase I proposals. For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts, and have successfully completed their Phase I efforts, may be invited to submit a Phase II proposal. 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 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/STTR PMO.

Please Note: You may only propose up to the total cost for which you are invited. Contract structure for the Phase II contract is at the discretion of the contracting officer after negotiations with the small business.

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

PHASE II PROPOSAL SUBMISSION

Eligible firms should follow the Phase II proposal instructions described in Section 3.0 of the program solicitation and specific instructions provided in the Phase II invitation. Invitations for Phase II proposals are generally issued at or near the Phase I contract completion, with the Phase II proposals generally due one month later. In accordance with SBA policy, MDA reserves the right to negotiate mutually acceptable Phase II proposal submission dates with individual Phase I awardees, accomplish proposal reviews expeditiously, and proceed with Phase II awards. If you have been invited to submit a Phase II proposal, please see the MDA SBIR/STTR Web site http://www.mdasbir.com for further instructions.

MDA FAST TRACK DATES AND REQUIREMENTS

Introduction: For more detailed information and guidance regarding the DoD Fast Track Program, please refer to Section 4.5 of the solicitation and the Web site links provide there. MDA's Phase II Fast

Track Program is focused on transition of technology. The Fast Track Program provides matching SBIR/STTR funds to eligible firms that attract investment funds from a DoD acquisition program, a non-SBIR/non-STTR government program or private sector investments. Phase II awards under Fast Track will be for $1.0M maximum, unless specified by the Director MDA Advanced Research.

- For companies that have never received a Phase II SBIR award from DoD or any other federal agency, the minimum matching rate is 25 cents for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $1,000,000, it must obtain matching funds from the investor of $250,000.)
- For all other companies, the minimum matching rate is 1 dollar for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $1,000,000, it must obtain matching funds from the investor of $1,000,000.)

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

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

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

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

MDA SBIR/STTR PHASE II TRANSITION PROGRAM

Introduction: To encourage transition of SBIR and STTR projects into the BMDS, the MDA's Phase II Transition Program provides matching SBIR and STTR funds to expand an existing Phase II contract that attracts investment funds from a DoD acquisition program, a non-SBIR/non-STTR government program or private sector investments. The Phase II Transition Program allows for an existing Phase II SBIR or STTR contract to be extended for up to one year per Phase II Transition application, to perform additional research and development. Phase II Transition matching funds will be provided on a one-for-one basis up to a maximum amount of $500,000 of SBIR or STTR funds in accordance with DoD Phase II Enhancement policy at Section 4.6 of the DoD Solicitation. Phase II Transition funding can only be applied to an active DoD Phase II SBIR or STTR contract.

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

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

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

2012 PHASE I KEY DATES (PROJECTION)

NDIA's Annual Missile Defense Small Business Programs and SBIR/STTR Programs Conference (Huntsville, AL) .... May 8-9, 2012
Phase I Evaluations .... July – September 2012*
Selection and Non-Selection Notifications Distributed .... September 2012*
Contract Award Goal .... November 2012*

The Phase II Transition Program Solicitation is ***generally*** announced via http://www.mdasbir.com in the Spring timeframe.

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

MDA SBIR 12.2 Topic Index

MDA SBIR 12.2 Topic Index By Research Area

MDA SBIR 12.2 Topic Descriptions

MDA12-001 TITLE: Novel Planning Algorithms for Hybrid Land and Sea Platform Sensor Coordination

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

ACQUISITION PROGRAM: MDA/AB

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: This Topic seeks research and development of innovative planning algorithms toward improving sensor coordination of a hybrid Aegis BMD System. The result of this effort should be adaptable planning algorithms that recommend options for optimizing Ship Operating Area (SOA) toward defending a given area against a missile raid (multiple targets). Research should include, but not be limited to, exploring concepts of advanced learning, sensor coordination and adaptive applications (i.e., Bioinspired algorithm for managing the sensor resources, Information-Based Decision Making and others)

DESCRIPTION: Existing planners use sensor kinematic models together with selected geographic constraints that provide support in determining the placement/SOA for Sea-based assets. As more assets become available, and particularly in the case where some are Earth fixed and others are mobile, existing approaches need to become real-time adaptable and optimal. This becomes increasingly critical when these assets are planning for a coordinated raid of threats launched in close proximity and closely in time. As a result, the Missile Defense Agency (MDA) is seeking the development of novel, highly effective planning algorithms and associated models to provide optimal positioning solutions for a hybrid Aegis BMD system comprised of both land-based and sea-based assets. These algorithms must take into account operational constraints of each sensor asset type, and produce optimal yet adaptable Sea-based positioning solutions in real time.

The focus should be on developing an adaptable planning algorithm that would optimize SOA when incorporating land based and mobile sensor sources to handle a raid environment (multiple targets). These new planning algorithms must be able to recommend sensor assets that minimize the number of required sensors for a given coverage, maximize the effectiveness of each sensor given its performance and resource constraints, and optimize the probability of successful engagements (Pes) for each Aegis BMD firing asset (whether land-based or sea-based). Generic Aegis BMD Data will be provided that will assist The small business in this effort.

When a single sensor is tasked with collecting measurements on a single target, the management of the sensor's available resources does not pose any challenge. However, in situations where multiple sensors are directed to collect measurements on multiple targets, the decision process that determines which sensors to collect measurements on within a given area to cover can be difficult. The sensor coordination/ management problem becomes more difficult as the number of targets relative to the number of sensors increases. The problem is further exacerbated when targets and sensors are not arranged in a favorable geometric position [1]. Innovative concepts and models should be explored and proposed that would optimize planning for engagement success.

Things to consider toward developing these models are minimizing required sensor resources in a threat raid environment, minimizing the probability of target leakage and maximizing target raid annihilation. These models should potentially be applicable to other BMDS (Ballistic Missile Denfense System) weapon systems such as THAAD (Terminal High Altitude Area Defense), GMD (Ground-Based Midcourse Defense) and PATRIOT (Phased Array Tracking Radar to Intercept on Target).

PHASE I: Develop noval planning algorithms for positioning sea-based assets, that includes adding land based sensor assets along with other mobile sensor assets, which is geared toward defending a given area against a missile raid (multiple targets). These algorithms should determine the optimal positioning of land-based and sea-based

BMD assets such as generic S-band and X-band radars, interceptors of various capabilities, notional IR sensors and any required communication relays to cover a given defended area.

Develop a proof of concept design; identify designs and test capabilities and conduct feasibility assessment for the proposed algorithms. Phase I work should clearly validate the viability of the proposed solution. Phase I should also result in a clear concept of operations document.

PHASE II: Based on the results and findings of Phase I, utilize Aegis BMD assets as an intial testbed to develop the planning models that can provide calculated and graphical output of optimal placement for Aegis BMD assets. After development of the planning algorithms, exercise the models using real world data, including actual Aegis BMD asset characteristics. Planning algorithms should be scalable to other BMDS platforms such as GMD and THAAD.

The Phase II objective will be to validate a new technology solution that MDA users and prime contractors can transition in Phase III. Validate the feasibility of the Phase I concept by development and demonstrations that will be tested to ensure performance objectives are met. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration subsystem. The goal of the Phase II effort is to demonstrate technology solution viability.

PHASE III: In this phase, the contractor will apply the innovations demonstrated in the first two phases to one or more MDA systems, subsystems, or components. The objective of Phase III is to demonstrate the scalability of the developed technology, transition the component technology to the MDA system integrator or payload contractor, mature it for operational insertion, and demonstrate the technology in an operational level environment.

COMMERCIALIZATION: The contractor will pursue commercialization of the various technologies and models developed in Phase II for potential commercial uses in such diverse fields as air traffic control, weather systems, and other tracking applications.

REFERENCES:
1) Lamber, & Sinno, “Bioinspired Resource Management for Multi-Sensor target Tracking Systems,” MIT Lincoln Laboratory Project Report MD-26, June 20, 2011

2) John M. Dolan, Mahesh Saptharishi, C. S. Oliver, Christopher P. Diehl, Alvaro Soto, and Pradeep K. Khosla, “Network of Collaborating Mobile and Stationary Sensors”, Proceedings of SPIE 4232, 331 (2001).

3) Felicity Dormon, Valerie Leung, Dave Nicholson, Ellie Siva, and Mark Williams, “Information-Based Decision Making Over a Data Fusion Network”, Proc. SPIE 5809, 100 (2005).

KEYWORDS: Optimization algorithms, computer modeling, computer graphics

MDA12-002 TITLE: Radar Waveforms to Discern Remote Object Attributes

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

ACQUISITION PROGRAM: MDA/AB

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop signal waveform characteristics and processing algorithms that will deduce sensor-invariant attributes of a tracked object so that it can be classified, discriminated and evaluated for engagement. Physics-based approaches are sought for broadest utility and general applicability.

DESCRIPTION: The Missile Defense Agency (MDA) is seeking the development of enhanced radio frequency (RF) signal waveform characteristics and associated processing algorithms to improve Aegis BMD engagement capability in raid environments. Tracking information beyond target position and velocity is needed to discern sensor-independent taxonomy of missile threats and the intent of closely spaced targets.

To date most RF techniques have concentrated on target detection and tracking (i.e., position and velocity over time). Employing novel RF waveform characteristics such as modulation, timing and phasing to deduce other target characteristics such as its reflective, emissive, inertial and material properties could significantly enhance radar effectiveness and increase the probability of engagement success. To be most effective, however, new RF waveform characteristics should require minimal changes to the radar hardware and use RF data processing algorithms that can be implemented in existing signal processors.

Although enhanced RF data processing algorithms specific to Aegis may be able to provide some additional target characteristics, the approach for this effort should be primarily physics-based (i.e., centered on the use of novel RF waveform characteristics) for broadest utility and general applicability.

PHASE I: Develop and Design new RF waveforms with novel characteristics that can help deduce target characteristics beyond just position and velocity. Develop a non-operational model showing how the new RF waveform characteristics can deduce such target characteristics as reflectivity, emissive properties, material construction, and others characteristics. Include the associated processing algorithms that will support the new RF waveforms.

These new RF waveform characteristics must be largely compatible with the existing AN/SPY-1 radar, and the associated algorithms must be supported using existing Aegis BMD signal processing capabilities.

The output of the Phase I shall be a proof of concept design/study; identify designs/models and test capabilities, and conduct a feasibility assessment for the proposed model, technique, and/or methods. Phase I work should clearly validate the viability of the proposed solution. Phase I should also result in a clear concept of operations document.

PHASE II: Based on the results and findings of Phase I, develop and refine the novel RF waveform designs, increase the capabilities of the associated algorithms, and exercise the enhanced non-operational model to evaluate the effectiveness of the new RF waveforms. Then demonstrate the capability of an operational or a slightly modified SPY-1 radar to support the new RF waveforms during target detection and tracking, and measure any increase in overall radar effectiveness.

The Phase II objective will be to validate a new technology solution that MDA users and prime contractors can transition in phase III. Validate the feasibility of the Phase I concept by development and demonstrations that will be tested to ensure performance objectives are met. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration subsystem. The goal of the Phase II effort is to demonstrate technology solution viability.

PHASE III: In this phase, the contractor will apply the innovations demonstrated in the first two phases to one or more MDA systems, subsystems, or components. The objective of Phase III is to demonstrate the scalability of the developed technology, transition the component technology to the MDA system integrator or payload contractor, mature it for operational insertion, and demonstrate the technology in an operational level environment.

COMMERCIALIZATION: The contractor will pursue commercialization of the various technologies and models developed in Phase II for potential commercial uses in such diverse fields as air traffic control, weather systems, and other tracking applications.

REFERENCES:
1. Mahafza, B.," Radar Systems Analysis Using MATLAB," Chapman, 2nd Edition, 2005

2. D. M. Pozar, "Microwave Engineering", Wiley, 2005

3. Davis Knox Barton, “Radar System Analysis and Modeling, Vol 1, Artech House, 2005

KEYWORDS: RF waveforms, RF signal processing, computer modeling

MDA12-003 TITLE: 3G and 4G Communication System Interference Remediation Techniques

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: MDA/AB

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: This research seeks novel algorithms and signal processing techniques that will minimize Aegis-to-3G & 4G and 3G & 4G-to Aegis interference. Space-time, adaptive and other approaches are sought for broadest utility and generality.

DESCRIPTION: The Missile Defense Agency (MDA) is seeking the development of novel RF modulation, timing and phasing as well as orthogonal and bi-static arrangements to increase Aegis BMD compatibility with evolving civilian 3G and 4G communication systems worldwide. This effort should include the development of advanced algorithms and enhanced signal processing techniques to increase the Aegis BMD coexistence margin with these civilian networks. Preferably these novel RF changes, advanced algorithms and enhanced signal processing techniques should be implemented with no changes to the Aegis BMD radar and signal processing hardware.

Global mobile communication network carrier bands are beginning to encroach on operational US Government Civil and DOD weather and fire control radars, including the AN/SPY-1, X-band radar used by Aegis BMD. Straightforward geometric and aperture techniques solve the plurality of interference challenges. However, it is desired to further develop, implement, verify and field both novel RF waveforms and advanced signal processing algorithms that can modify Aegis transmit and receive operations to come as close to non-interaction with these networks as possible.

The initial effort should involve the investigation via calculations and experiments of new RF waveform characteristics that could enhance Aegis BMD coexistence with civilian 3G and 4G communication networks. This should also include the development of associated signal processing algorithms. The effort should also include the development of new advanced signal processing techniques for use on existing SPY-1 RF waveforms in order to enhance the desired coexistence margin. Finally, the effectiveness of any new RF waveform characteristics and signal processing techniques should be demonstrated via unclassified modeling and simulation.

PHASE I: Perform an investigation and research of new RF waveform characteristics that could enhance Aegis BMD coexistence with civilian 3G and 4G communication networks. Design innovative RF techniques (i.e. modulation, timing and phasing) that can help increase AN/SPY-1 S-band radar compatibility with civilian 3G and 4G communication networks. These new RF waveforms must be largely compatible with the existing AN/SPY-1 S-band radar. Include the associated processing algorithms that will support the new RF waveforms.

The output of the Phase I shall be a proof of concept design/study; identify designs/models and test capabilities, and conduct a feasibility assessment for the proposed model, technique, and/or methods. Phase I work should clearly validate the viability of the proposed solution. Phase I should also result in a clear concept of operations document.

PHASE II: Based on the results and findings of Phase I, refine the RF changes, and increase the capabilities of the advanced algorithms and enhanced signal processing techniques. Then demonstrate their effectiveness using operational SPY-1 radar in RF environments shared with various 3G and 4G networks used worldwide. Develop an unclassified model showing the effectiveness of these RF waveform changes, advanced algorithms and enhanced signal processing techniques to increase the SPY-1 Radar coexistence margin with these networks.

The Phase II objective will be to validate a new technology solution that MDA users and prime contractors can transition in phase III. Validate the feasibility of the Phase I concept by development and demonstrations that will be tested to ensure performance objectives are met. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration subsystem. The goal of the Phase II effort is to demonstrate technology solution viability.

PHASE III: In this phase, the contractor will apply the innovations demonstrated in the first two phases to one or more MDA systems, subsystems, or components. The objective of Phase III is to demonstrate the scalability of the developed technology, transition the component technology to the MDA system integrator or payload contractor, mature it for operational insertion, and demonstrate the technology in an operational level environment.

COMMERCIALIZATION: The contractor will pursue commercialization of the various technologies and models developed in Phase II for potential commercial uses in such diverse fields as air traffic control, weather systems, and other tracking applications.

REFERENCES:

1. Mahafza, B.," Radar Systems Analysis Using MATLAB," Chapman, 2nd Edition, 2005

2. D. M. Pozar, "Microwave Engineering", Wiley, 2005

3. Davis Knox Barton, "Radar System Analysis and Modeling, Vol 1, Artech House, 2005

KEYWORDS: RF characteristics, signal processing, radio interference, computer modeling

MDA12-004 TITLE: Asset Pairing for Battle Management

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace

ACQUISITION PROGRAM: C2BMC Spiral 8.4

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: To develop system optimization algorithms to enable effective fire control solutions in challenging environments. Design a procedure to task the right sensor at the right time for a selected target.

DESCRIPTION: Given a diverse inventory of missile assets, as well as a sensor suite that may be able to view the target from different viewing angles, phenomenologies, accuracies and timelines, determine which sensor(s) can best obtain the required track quality for a selected interceptor. Of particular interest are raid scenarios where multiple targets need to be engaged, sensor assets may be heavily loaded and must be managed efficiently and interceptor inventory must be utilized wisely. The intelligent sensor - weapon pairing will enable the collection of requisite information for launch, track, and discrimination given the missile system capability, flyout profile and timeline.

For the Phased Adaptive Approach, the BMDS is focusing on more complex engagements to achieve capabilities against MRBMs, IRBMS and LRBMs using Aegis Weapon System missiles or GBI, as well as sensors including AN/TPY-2 and PTSS. The system, with a small number of sensors, will be required to handle potentially hundreds of objects and it is critical that the sensors be tasked to provide quality launch information for a given target to the weapon system to enable efficient threat destruction with minimal wastage of resources. This effort addresses the sensor tasking assignment and raid resource optimization needs of C2BMC.

Asset pairing is related to sensor resource management, weapon resource management, resource optimization and fire control. However, for this solicitation, we are looking for increased efficiencies when the sensor selection is a function of the weapons and their geometries, capabilities and timelines. Sensor resource management has been exhaustively studied with respect to obtaining adequate track quality, when a weapon has been selected and the timeline is known. This development has led to a performance gap, with sensors and weapons being optimized separately instead of jointly. This task seeks to wring out greater efficiencies when optimizing for the engagement instead of compartmentalizing the functions to optimize separately. This joint optimization approach has not been investigated for the missile defense arena, and we seek to develop innovative solutions, as well as leverage past efforts, to expand the scope to optimizing system performance.

The researcher may assume that, although the targets are dynamic, their positions can be estimated to a given degree of accuracy. Some sensors may be stationary, and some may be dynamic, but any motions will be known. The flyout basket for a given interceptor and weapon system can be assumed known. Some sensors will view one target, some will be able to view many, but Field of View (FOV) will be known for each sensor, as well as response time. Given a window of potential engagement, the researcher can decide when to engage within that timeline. It can also be assumed that the tracks will be successfully correlated between sensors.

PHASE I: Develop and demonstrate feasibility of the proposed sensor – weapon pairing algorithms for fixed site radar sensors and a simple satellite constellation, and a moderate number of tracked objects. The algorithm shall take a given set of target trajectories, sensors and weapon systems, with flyout windows for each missile (ownship) and engagement type, and determine which sensors are assigned to which weapon systems (multiple Aegis ships) to engage which targets with timing optimized for track quality and engagement.

PHASE II: Refine and update concept(s) based on Phase I results and demonstrate the proof of principle technology in a realistic environment using agency provided engagements. Demonstrate the technology's ability real-time in a stressed environment; with few sensors, and many targets. A government testbed will be available at no cost if the scientist wishes to utilize the facility for high fidelity testing.

PHASE III: Demonstrate the new technologies via operation as part of a complete system or operation in a system-level test bed to allow for testing and evaluation in realistic scenarios. Market technologies developed under this solicitation to relevant missile defense elements directly, or transition them through vendors.

COMMERICALIZATION: The contractor will pursue commercialization of the various technologies and optimization components developed in Phase II for potential commercial and military uses in many areas such as automated processing, robotics, medical industry, and in manufacturing processes.

REFERENCES:
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KEYWORDS: Asset Pairing, Sensor Resource Management, Weapon –Target pairing, Sensor – Weapon pairing, Optimization

MDA12-005 TITLE: RF-IR Data Fusion for Track and Data Correlation

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: C2BMC Spiral 8.4

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: To develop new methods for multi-sensor target handover and characterization.

DESCRIPTION: For radars fielded by the Missile Defense System, there is a given set of available features that were developed for acquisition, track and discrimination of targets. Similarly, for electro-optic/infrared sensors there are standard features which have been developed for acquisition, track and discrimination. These features may not be the optimal features for target correlation between sensors. Thus, this task seeks the development of either innovative new features to aid multi-sensor track correlation, or innovative data fusion techniques with the existing features to aid correlation. Additionally, realizing that the RF features for discrimination exploit a given set of target attributes, and similarly for the EOIR, we seek innovative data fusion processes to better characterize the target.

The first subtask, correlation of objects between sensors, is a very important handover function in multi-sensor, multi-target data fusion, particularly when sensors are sparse and overlapping coverage may not occur. This can become complicated when different types of sensor systems (RF versus EOIR) are viewing the same objects. Success in this subtask will be a demonstration of improved handover, compared with a metric only procedure, from EO/IR to RF sensors and from RF to EO/IR, when multiple objects are in the respective scenes. Appropriate sensor geometries with respect to target will need to be considered.

The second, or alternate, subtask will be the development of data fusion techniques to combine information from the disparate sensors - to understand the appropriate contributions to target identity from the various sources. Object classification schemes may be considered, however, they must be robust to objects not in the training set, and various subsets of available features. Other techniques, such as Bayes net approaches or influence diagrams, are also welcome to explore innovative, robust methods for target characterization from multi-sensor features. Success will be a demonstration of target characterization in RF, in EO/IR, then together, to demonstrate how a target can be more accurately characterized using a combination of RF and EO/IR measurements.

Previous efforts have not dealt with the long ranges and specific available features for the MDA engagement for data fusion, and correlation is a major outstanding challenge. EOIR sensors are relatively new to the sensor suite for MDA, as well, and present new challenges for exploitation.

The researcher may include multiple EO/IR bands as well as several radar frequencies, if desired in their analyses. However, targets will be at ranges that will cause them to appear on, at most, one pixel for the EO/IR focal plane.

PHASE I: Develop and demonstrate, through proof-of-principle tests, target correlation or characterization improvements using measurement data from disparate sensors.

PHASE II: Refine and update concept(s) based on Phase I results and demonstrate the technology in a realistic environment using agency provided engagements. Demonstrate the technology's ability real-time in a stressed environment; with few sensors, and many targets.

PHASE III: Demonstrate the new technologies via operation as part of a complete system or operation in a system-level test bed to allow for testing and evaluation in realistic scenarios. Market technologies developed under this solicitation to relevant missile defense elements directly, or transition them through vendors.

COMMERICALIZATION: The contractor will pursue commercialization of the various technologies and optimization components developed in Phase II for potential commercial and military uses in many areas such as automated processing, robotics, medical industry, and in manufacturing processes.

REFERENCES:
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12. Tenenbaum, J.B, Griffiths, T.L. & Kemp, C. (2006). Theory-based Bayesian models of inductive learning and reasoning. Trends in Cognitive Science, vol. 10, 309-318.

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KEYWORDS: Data Fusion, Track Correlation, RF-IR Fusion, Sensor Exploitation, Integrated Discrimination

MDA12-006 TITLE: <u>Anti-Tamper Technology for Missile Defense</u>

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

ACQUISITION PROGRAM: DEB, AB, TH, GM, SN

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OBJECTIVE: Zero Power/Ultra-Low Power X-Ray Sensors - Development of a zero power/ultra-low power x-ray sensing technology for use at the printed circuit board level or integrated circuit level, for the protection of critical technology from exploitation.

DESCRIPTION: The Agency issued a directive necessitating the protection of Critical Program Information (CPI) from unintentional transfer and the policy for the implementation of Anti-Tamper (AT) technology on MDA acquisition and associated technology programs. AT technology consists of engineering activities that result in the prevention and/or delayed exploitation of critical technologies in U.S. weapons systems. The purpose is to add longevity to critical technology by deterring efforts to reverse-engineer, exploit, or develop countermeasures against a system or component. Though the particular solution may be tailored for individual applications, the concept and methodology of the solution should be applicable to various Commercial Off-The-Shelf (COTS) and military hardware. Preference will be given to solutions that provide protection for Critical Technologies without introducing additional risks or costs to the weapon platform and its mission. Additionally, attention will be focused on a low (or no) power requirement; the covertness of the technology; personal and mission safety; minimal impact to semiconductor manufacturing processes; minimal impact to system availability and maintainability; and seamless integration in the BMDS weapon platform. As a result, the MDA will maintain a technological edge in support of the warfighter.

Recent developments in nanotechnology sensors and micro-electromechanical systems (MEMS) [1-8] offer opportunities for creating ultra-low power sensors to detect tampering and reverse engineering. The purpose of this SBIR is to develop tampering/reverse engineering x-ray sensors for the printed circuit board or integrated circuit level, that require zero power or near zero power (in the 0.1 to 1 microwatt range). Energy harvesting technologies may be used in conjunction with the development of ultra-low power x-ray sensor technologies, but must constitute less than 20% of the development effort. Sensor orientation effects must be considered in the development. MDA is not interested in the utilization of low duty cycle sensors to reduce power consumption (e.g. 1 % duty cycle at 0.1 milliwatts gives 1 microwatt average power consumption). Additionally, MDA is not interested in materials that require visual inspection for tamper detection, nor in material coatings for printed circuit boards or integrated circuits. Participation in this SBIR is limited to US citizens and US persons.

PHASE I: Research and develop a prototype zero power/ultra-low power x-ray sensor (< 1 microwatt continuous power consumption) for tamper detection and reverse engineering detection. Simple prototypes should be used to demonstrate the feasibility of the zero power/ultra-low power sensor; the prototypes may be complemented by simulations or models, as appropriate. Estimate the power consumption of the proposed sensor technology and estimate its sensitivity to detecting a tamper event. Estimate the range of probing intensities and wavelengths that the sensor will detect. Provide a Phase I final report to the government point of contact. A partnership with a current or potential supplier of MDA systems, subsystems, or components is highly desirable.

PHASE II: Based on the Phase I research; develop, demonstrate and validate a prototype zero power or ultra-low power x-ray sensor. A partnership with a current or potential supplier of MDA systems, subsystems, or components is highly desirable. For an ultra-low power x-ray sensor development, research and develop methods to further decrease power consumption. An independent lab is to test and evaluate the zero power/ultra-low power x-ray sensor technology. A copy of the test report is to be provided to the government point of contact. This test and evaluation is a potential opportunity for future commercialization. The contractor shall also identify any anticipated commercial benefit or application opportunities of the innovation. Deliver to the government point of contact, two x-ray sensor evaluation boards, and all required software tools for testing and evaluation. Provide an on-site two day sensor system seminar at an MDA facility. Provide a Phase II final report to the government point of contact.

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

COMMERCIALIZATION: Anti Tamper technologies have numerous applications to printed circuit boards used by DoD contractors in MDA and other Military systems. Commercial electronics for personal, aviation, and automobile use will benefit from these technologies. Partcular interest has been found in the ISR community to prevent exploitation of military resources.

REFERENCES:

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2. ASTM Standard E1255-09 Standard Practice for Radioscopy; ASTM International, West Conshohocken, PA; http://www.astm.org.

3. American Society for Nondestructive Testing; NDT Handbook and Digital Imaging Conference proceedings available at http://www.asnt.org.

4. K. Bourzac: "A Cheap, Plastic X-Ray Imager," 20 Mar. 2009. http://www.technologyreview.com/biomedicine/22314/.

5. J. Androulakis, et al.: "Dimensional Reduction: A Design Tool for New Radiation Detection Materials," Advanced Materials, 23:4163-4167 (22 Sep 2011).

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KEYWORDS: x-ray, sensor, nanotechnology, ultra-low power, integrated circuit, nanomaterials, plasmonics, tamper resistant, reverse engineering, anti-tamper

MDA12-007 TITLE: Techniques for Performing Warhead Characterization

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: MDA/DES

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OBJECTIVE: Develop an innovative, low cost approach to capture full-hemisphere, open-air, fragment mass, geometry and velocity information during arena and sled warhead characterization tests.

DESCRIPTION: MDA is interested in developing techniques to improve the data collection, decrease the time required, and reduce the cost associated with performing ground-based warhead characterization. Warhead characterization tests adhere to the guidelines and procedures described in the Joint Munitions Effectiveness Manual (JMEM). The present method of warhead characterization is costly, labor intensive, and produces only a small amount of the required data. For arena tests, a warhead is placed in the center of an arena consisting of any combination of blast-pressure gages and fragment collection media. Fragment collection media (often celotex bundles) placed behind "switch screens" are placed just above ground level and arc around the warhead at a radius that is a function of the net explosive weight. These screens record the time of impact for the fragments that make contact with the screens and the fragments are captured in the celotex material for subsequent measurement (weight, shape) and analysis. While the bundle radius ensures their survival during blast-pressure impingement, the celotex bundles occupy only a small slice of the total hemisphere. As such, only a fraction of the fragments are captured for inclusion in the subsequent warhead characterization analysis. Weeks of tedious and error-prone labor are necessary to locate, recover, weigh, and describe the geometry of each fragment entering the bundles. Many small fragments are not recovered and few if any individual fragments recovered are mapped to their specific velocities or switch screen entry points/times. In order to develop a more-complete dataset for user consumption, raw warhead test data is subjected to a series of assumptions, averages, rotations, and summarizations to produce an approximation of the true warhead's fragment mass and velocity field. While checks and balances are in place to assure that overall data appear reasonable, individual fragment masses/geometries remain uncoupled from their velocities and many of the smaller fragments are simply not included in the dataset.

All warhead characterizations (and data reduction methods) performed to date have been conservatively-skewed based on a lethality-mindset. As such, true munitions lethalities are higher than is indicated by their arena test scores. This is diametrically opposed to the collateral damage mindset of the United States Central Command (CENTCOM) and the requirement to obtain higher fidelity warhead fragmentation/debris data for much of the current inventory of fielded weapons. Current procedures make high-fidelity re-test prohibitively time consuming, expensive, and technically problematic. Delays in missions can result where high casualties or collateral damage are estimated.

MDA desires an innovative, cost-effective combined sensor/software technology whereby sensors can assess object movement within large hemispherical volumes (< 100 meter radius) at sufficient resolution to detect solid-mass (0.5 gram to 100 kilogram), high-velocity (< 1000 meter/second) particles (numbering up to 5000) originating near the center of the test space, and determine individual fragment velocities. The interrogation method must also be capable of estimating/correlating individual fragment masses to their velocities. The proposed interrogation system must be suitable for open-air outdoor arena, sled testing and/or flight test (where debris can be recovered) and sufficiently robust to handle blast overpressures ranging from 1000 psi near the center of the hemispherical test space to 1 psi near the fringes. In addition to fragment velocity and mass information, the technology must be capable of estimating each fragment's geometry. The proposed interrogation system must be capable of setup by no more than two technicians within a single workday and produce an automated post-test report containing fragment velocity data within hours of the test. Contractors are encouraged to take maximum advantage of commercial off the shelf (COTS) sub-technologies and provide confidence in the proposed approach to meet these requirements.

PHASE I: Develop an innovative, low cost concept for detecting full-hemisphere warhead fragment data using an automated method to detect and map fragment velocity and provide fragment mass estimates during warhead characterization tests. Demonstrate in the software model the ability to detect, track, and derive position and velocity for each debris object. Develop a plan/design for implementing this system in hardware.

PHASE II: Following the development plan outlined in Phase I, design, develop, and implement a warhead characterization system and associated test and data collection software to support a ground-based warhead characterization event. Present the path forward to support a warhead characterization test.

PHASE III: Mature the warhead characterization system developed in Phase II to test-ready status and perform data collection during a warhead characterization test. The contractor will document all results.

COMMERCIALIZATION: The contractor will pursue commercialization of the various technologies developed in Phase II for potential commercial users in the areas of sensors and software capable of high speed, high fidelity temporal and physical position and size measurements. Once proven, the method could also be utilized in any BMDS flight test engagement or other service intercept (aircraft debris, non-hit to kill debris, etc).

REFERENCES:

1. "Testing and Data Reduction Procedures for High-Explosive Munitions," Joint Munitions Effectiveness Manual (JMEM), USAF 61A1-3-7, Revision 2, 8 May 1990.

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KEYWORDS: warhead fragment, intercept debris, fragment velocity, interrogation system, arena test, sled test

MDA12-008 TITLE: Modeling High Explosive (HE) Detonation Response and resulting Debris/Shrapnel Generation from Submunitions Warheads

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: MDA-DEFL

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OBJECTIVE: Develop an innovative, low cost, approach to testing and modeling the HE submunition warhead response for hit-to-kill missile interceptors leveraging first-principle physics methodologies. Modeling of the high and low order HE response should be addressed to assess detonation probability. The selected approach must address HE response to the kinetic energy intercept as well as the material fragmentation. Post-intercept debris generation characteristics (mass, shape, velocity) must also be captured. The methodology employed must be capable of receiving detailed target and penetrator / interceptor models and returning each fragment's geometry, fragment velocity and mass information.

DESCRIPTION: A primary kill mechanism for the Ballistic Missile Defense System (BMDS) systems against weapons carrying high explosives is the detonation of the explosive. Many warhead types have been analyzed and modeled using first-principle techniques, however determining the full spectrum of possible responses of HE submuntions / weapons is poorly understood. Experimental test data that captures the various types of response is very limited or not found in existing databases. Submunition warheads present a challenge to penetrator/interceptors due to packaging, compartmentalized nature of individual warheads,hardened casings and material construction design techniques.

Hit-to-kill BMD systems (AEGIS, THAAD, PAC-3, GMD) have steadily increased their use of high fidelity modeling techniques to evaluate the effectiveness of their systems for predicting shock-to-detonation (STD) phenomena. The current modeling capability does not fully cover reactive events of non-STD nature for threat-relevant submunition warheads. MDA desires a tool to better model HE responses such as unknown-to-detonation (XDT) and deflagration-to-detonation (DDT) events. Physics-based simulation outputs should include lethality estimates (per submunition warhead) and post-intercept debris predictions. This first-principles modeling capability would provide enhancements to the MDA lethality models (KIDD and PEELS) to better capture the range of HE detonation reactions and resulting debris. The modeling techniques and software tools developed under this program must be sufficiently anchored to relevant test data.

PHASE I: Develop an approach for modeling hyper-velocity intercepts of HE submunition warheads that leverages first-principle physics modeling techniques. Conduct sample calculations using representative (simplified) geometries. Develop a plan for a low cost and innovative HE testing approach. Research existing test data that can be utilized for benchmarking of the simulation methodology and begin to identify innovative tests and data collection to fill gaps in the existing data set.

PHASE II: Further develop techniques within the first-principle codes to enable modeling of the required phenomenology. Anchor the code predictions to existing test data and refine the model as needed. Begin extension of the modeling capability to threat-representative geometries for both unitary submunition warheads and full payload geometries. Plan and execute new tests to define HE reactions and submunition warhead geometries as needed to fill gaps.

PHASE III: Transition the first-principle physics-based modeling capability developed under this program to MDA lethality and debris prediction tools (e.g. PEELS and KIDD, respectively). Simplification of the techniques developed here is necessary to support fast-running engineering codes.

COMMERCIALIZATION: This technology would benefit Insensitive Munitions testing of reactive materials (HE and propellants) and other DoD weapon program modeling and simulation. EOD and safety transport and disposal of munitions and other explosives could leverage this information to better perform these missions.

REFERENCES:
1. Missile Defense Data Center Program Brochure, Approved for Public Release 09-MDA-4371 (17 MAR 09)

2. Tarver, C. M. and Chidester, S. K., "On the Violence of High Explosive Reactions", 2004 ASME Pressure Vessels and Piping Conference, San Diego, CA, July 2004.

3. Asay, B. W., Non-Shock Initiation of Explosives, Springer-Verlag, New York, 2009.

KEYWORDS: sympathetic, submunition, missile, lethality, testing, warhead, high explosive

MDA12-009 TITLE: <u>Fast-Running Physics-Based Models for Intercept Debris Aero-heating and Aero-thermal Demise</u>

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors, Weapons

ACQUISITION PROGRAM: MDA-DEFL

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OBJECTIVE: Develop an approach for assessing the aero-thermal demise of the debris generated following a ballistic missile defense intercept

DESCRIPTION: The intercept of a ballistic missile at high altitudes generates thousands of debris fragments, ranging in size from less than a millimeter to tens of centimeters. These pieces typically re-enter the atmosphere, and may or may not burn up before they strike the Earth. Assessment of this aero-thermal demise phenomenon can thus have a significant effect on sensor performance (discrimination, tracking, sensor loading, etc), particularly for lower-tier elements, consequences of intercept, as well as range safety issues for flight tests.

Whether or not a particular fragment survives re-entry depends on a variety of factors, including the fragment (linear and angular) velocity just after intercept, the aerodynamic characteristics of the fragment, and the fragment material. The aerodynamic characteristics, in turn, are strongly coupled to the trajectory described by the fragment after the intercept. Most of these fragments are highly irregular in shape; therefore, simple analytical models are likely insufficient to predict the aerodynamic heating they experience. First-principles numerical techniques, such as computational fluid dynamics (CFD), could in theory be used to predict the aero-thermodynamic environment around each fragment. However, the time required per fragment for CFD grid generation and trajectory-coupled flow solution, combined with the large number of fragments associated with a single intercept, makes a “full-blown” CFD approach an impractical choice for supporting consequence management, scenario planning, and other high-level assessment functions.

In light of the above observations, an approach is desired that incorporates a physics-based aerodynamic heating methodology into an aerodynamic trajectory framework capable of producing rapid predictions for large debris sets. The desired methodology must meet a number of requirements: (1) it must utilize realistic debris geometry, and not be restricted to simple geometric constructions; (2) it must be compatible with existing tools for debris generation and debris propagation; (3) it must be capable of extension to coupled phenomena such as surface recession; (4) it must be applicable to the full range of altitude and velocity regimes experienced during debris fly-down, from rarefied hypersonic to continuum supersonic/subsonic; (5) it must benchmarked using existing test data.

PHASE I: Formulate an approach for predicting intercept debris aerodynamic heating and break-up that meets the requirements listed above. Perform proof-of-principle calculations using this approach for simple shapes, such as spheres and flat plates. Compare these predictions to high-fidelity results, theory, and/or test data.

PHASE II: Perform further demonstration of the methodology proposed in Phase I through application to arbitrary fragment geometries. These results may be validated through comparison to test data (if available) or body-fitted CFD results. Integrate the validated aero-thermal analysis approach into an existing tool for intercept debris propagation, and apply it to a representative set of realistic debris. This debris set will be supplied from a high-fidelity finite-element calculation of a BMD engagement or flight test event.

PHASE III: Extend and enhance the combined algorithm so that it can be used to provide more accurate debris footprints for a variety of BMDS functions. These would include debris mitigation measures for lower-tier elements, general consequence management and flight test range safety.

COMMERCIALIZATION: Benefits to DoD, NASA, the commercial launch industry to understand if failed launches, or range safety launches, or re-entering orbital platforms will be a threat to air and ground based assets.

REFERENCES:
1. BMDS Development mission and Plan Website

2. Missile Defense Data Center Program Brochure, Approved for Public Release 09-MDA-4371 (17 MAR 09)

3. Amar, A. J., Blackwell, B. F., and Edwards, J. R., “One-dimensional ablation using a full Newton’s method and finite control volume procedure”, Journal of Thermophysics and Heat Transfer, Vol. 22, No. 1, 2008, pp. 71-82.

4. Kuntz, D. W., Hassan, B., and Potter, D. L., “Predictions of Ablating Hypersonic Vehicles Using an Iterative Coupled Fluid/Thermal Approach”, Journal of Thermophysics and Heat Transfer, Vol. 15, No. 2, 2001, pp. 129-139.

KEYWORDS: demise debris orbitaI suborbital intercept destruct simulation modeling

MDA12-010 TITLE: <u>Antenna design in the Plasma Environment</u>

TECHNOLOGY AREAS: Sensors, Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a tool to enable modeling and simulation and, in turn, design of antennas in a re-entry environment. Specifically, the goal is for a tool that provides the coupled prediction of the antenna performance in a plasma sheath.

DESCRIPTION: The Missile Defense Agency flies a variety of ballistic missile targets for all elements of the Ballistic Missile Defense System. Depending on the individual test objectives, it may be necessary to fly a missile into the endo-atmosphere where plasma environments can impede TM & GPS communication. Plasma sheaths envelop portions or the entirety of the vehicle and effectively shield the antennas from proper operation. A variety of solution techniques exist for the development of antennas which perform in the plasma environment. These techniques vary from antenna placement to matching scenarios, etc. In the BMDS target development arena, expensive testing to characterize plasma environments and subsequent design loops for antennas is not possible. It is instead desirable to develop an antenna design tool that can predict the plasma environment and the antennas operation in it. The goal is a coupled Computational Electro-Magnetic / Computational Fluid Dynamics (CEM/CFD) tool that predicts the plasma environment and the antenna (including the impact of the antenna and associated transmit power on the plasma environment). The tool must provide detailed antenna modeling for generic antenna designs on the re-entry body.

The end result tool could then be coupled with traditional or advanced antenna techniques to design antennas which would then be able to support maintaining data link throughout re-entry. Alternatively, it could enable the selection of ground telemetry asset locations as to minimize impact of the plasma sheath of telemetry coverage.

PHASE I: Demonstrate in simulation the ability to develop a coupled CEM/CFD tool that can provide CEM predictions of both antenna performance in a plasma sheath for a simple scenario of the proposer’s choosing.

PHASE II: Expand the tool to be able to model re-entry bodies along general trajectories with general antennas. Anchor the tool against known test data.

PHASE III: Apply the tool to support MDA or other agencies in predicting re-entry antenna performance or designing antennas.

COMMERCIALIZATION: A variety of commercial space projects are now under way. These systems would provide enhanced safety and/or failure analysis should this tool enable antennas that operate all the way through the re-entry environment with fewer to no drop-outs.

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KEYWORDS: antennas, plasma, re-entry

MDA12-011 TITLE: <u>RF Material Property Characterization</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors, Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a system capable of providing non-destructive evaluation (NDE) of composite, non-conductive materials in multi-layer stacks while simultaneously providing feedback on material thicknesses and RF material properties.

DESCRIPTION: The Missile Defense Agency produces many composite materials in applications spanning the breadth of the agency. Composite structures and layups play an important role in a variety of sensor and weapon system platforms. Composite structures and layups are also an important part of Missile Defense targets. These composite layups include thermal protection systems, motor casings, etc. Flaws in target composites may either be structural (disbonds, inclusions, or voids) as well as RF (unexpected complex permittivity or permeability).

Current methods of non-destructive evaluation for composites vary. Some, such as "tap" tests, rely on human training to identify issues. Other tests such as X-ray or ultrasonic testing can produce good data with respect to structural issues but cannot identify issues in material make-up resulting in unexpected RF performance characteristics.

The goal is the development of an inexpensive and effective means of assessing for most structural issues while simultaneously checking material layer thickness and RF material properties. The RF material property measurement requirement is complicated by the need for RF material properties on each individual layer in contract to a composite "effective permittivity" for a material stack to enable high-fidelity modeling. Wavelengths of interest for RF material property extraction include S-X Bands. Structural voids and inclusions are of interest for sizes roughly larger than a nickel.

The final NDE system should be fundamentally man-portable. By this, it is meant that the system should not require special equipment or multiple people to move. The system should not require any special protective gear to operate.

PHASE I: Develop a concept system to perform NDE and material property characterization data collection of composite, non-conductive material stacks. The concept system should be able to identify inclusions and voids as a threshold and disbands as a goal. Further, the system should be able to identify RF material properties (permittivity and permeability) for individual layers in a multi-layer material stack. The system should also be able to identify material layer thicknesses for manufacturing verification. Demonstrate the performance of the system to perform all of these functions through modeling and simulation.

PHASE II: Develop a prototype of the concept system. Perform bench testing of the system and proceed to development tests in the field. Re-package the design into a portable unit and perform field testing.

PHASE III: Perform NDE on various composites as part of manufacturing processes.

COMMERCIALIZATION: Composite materials are common in a wide variety of commercial applications including commercial aircraft.

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KEYWORDS: NDE, non-destructure, RF material property extraction

MDA12-012 TITLE: <u>Advanced Techniques for Lossless Compression of Target Vehicle Telemetry</u>

TECHNOLOGY AREAS: Information Systems, Electronics, Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Help offset the limited bandwidth for vehicle telemetry against the increasing requests for addition telemetered truth information by using new mathematical techniques developed for video and audio or related applications and applying to telemetry encoding. A generalized methodology which can be adapted to imagery, health and status information, inertial measurement or global positioning system (GPS) position and orientation data is highly desirable but targeted approaches which are optimal for specific heterogeneous data streams but have low computational overhead and rigorous error-rejection are also sought.

DESCRIPTION: As target flight tests become increasingly complex to fully exercise BMDS functionality and anchor performance, the amount of information being downlinked from target and interceptor vehicles creates significant logistical challenges simply due to bandwidth needs. Currently while some limited compression is in use, there is no broadly employed standard which can address the reduction of TM bandwidth across a full suite of MDA Target test vehicles. Generally data is PCM encoded and often the data has to be encrypted for security reasons. This solicitation is intended to provide the Missile Defense Agency (MDA) with techniques based on both traditional methods and latest art designed for applications in streaming on-line content and cyber data security.

There are several factors which complicate the implementation of data compression in the MDA flight test environment. There are multiple target providers, multiple target vehicles and significant flight to flight variance in terms of available bandwidth and desired data. Possibly the primary challenges is the diversity of potential information and the increasingly demanding rates which must be supported. In addition, due to the costs of doing even a single flight test it is critical that all information be collected with the highest reliability and the lowest potential for loss of information upon correction. In the case of off-nominal flight conditions or anomalous events in flight, it is impossible to know a priori which channels of data will be most critical post-flight. As a result there is a high priority on maintaining the integrity of the data and assuring accurate transmission of all data streams. Typical types of data include:

1) Health and Status information on the motor, electronics, internal systems, payloads, etc. typically collected at 100Hz rates.

2) Imagery, visible, IR which may or may not be calibrated, typically collected at 10-50Hz rates.

3) Thermal sensor data including reference junction temperatures, as many as 100 sensors typically collected at 100Hz.

4) Body kinematic information in various forms at 100Hz rates.

5) Furthermore any or all of the data may be encrypted due to classification or information protection requirements.

The data is typically assembled on the ground as post-processed files with IRIG time information and various data channels. Calibration factors are applied on the ground.

A successful approach must meet certain criteria.

1) Low Computational Overhead: on-board processing is typically limited.

2) Readily transportable to different processors. The concept must be able to be adaptable to different flight vehicles and flight computers

3) Lossless compression. While the standards of this will vary depending on the data stream in question for some values, including imagery, it may be critical to completely and rigorously reconstruct the precise radiometric scene. This would be on an item by item basis but lossless compression must be available as an option for any stream.

4) Low latency. While some computational delay is expected the telemetry data in the moments in advance of a failure, intercept, anomaly or other instantaneous event are often of the highest interest. As a result, latencies on the order .01 seconds are desired.

5) Overall telemetered data footprint reduction on the order of 5x or greater but smaller compression amounts are to be expected for different data types and techniques which meet all criteria but achieve lower overall compression are still of interest.

6) Robustness under compression. Typically data is compressed before encryption but this can reduce the security level of the telemetered data due to predicable patterns put into the compressed data which can make cryptanalysis easier. Since it may be possible to protect any specific details of implemented algorithms as classified, high consideration will be given for specialized models which can maintain performance and security of national security information.

7) Simplicity is a goal. Since algorithms are generally tailored for specific types of data, a multi-algorithm approach is useful but a successful solution will cover all types of expected data and will contain the simplest implementation as possible.

For the tasks in all Phases of development, telemetry streams at the appropriate classification level and reflecting the program needs and requirements will be provided to all awardees as Government Furnished Information (GFI). Performance will be judged based on compression amounts, data loss/degradation and computational efficiency as criteria for progress from Phase I to Phase II, or Phase II to follow-on work.

PHASE I: Demonstrate the feasibility of the proposed approach on the GFI data sets. Provide statistics on compress ratio, computation time/latency, processor compatibility, and applicability to the different data streams and types. Imagery data in particular can be extremely challenging for downlinking, successful proposals will include some treatment of this type of data. While classified data will not be supplied, Phase 1 work should also address the potential for dealing with encrypted data and a projection of expected performance.

PHASE II: In Phase II representative encrypted data will be provided GFI along with a complete data stream for processing and scoring. Once demonstrated for these classes of data the contractor will provide a post-flight a postiori data compression using hardware in the government Tech Team laboratory which will be reduced by the government as would flight TM and compared to the results obtained on mission day.

After this a fully or partially encrypted data will be tested in the same facility and used for final evaluation.

Additional interchanges with prime target providers will be held. Phase II software interfaces for integration into target provider launch vehicles will be identified and fully documented in the Phase II final report.

PHASE III: Phase III will involve the successful integration and implementation of the compression software (or hardware/software solution) in live flight (real time) conditions in a piggy-back mode. Results will be compared to ground test results and to official truth data products. This will require a teaming arrangement and a path for tech transfer into industry directly at the end of Phase III. Either a follow-on test will run on board in real time for a flight test using fully or partially encrypted data or depending on logistics the initial real time test will be conducted for encrypted data streams

COMMERCIALIZATION: The contractor will pursue commercialization of the various technologies developed in Phase II for potential commercial uses in such diverse fields as methodology and tool development for DoD. The commercialization for MDA Targets may come from teaming arrangements reached between the algorithm provider and target prime contractors. In addition, it is expected that if successful for encrypted data there will be substantial other applications within the DoD in MDA, Space Surveillance and other organizations.

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KEYWORDS: telemetry, compression, encryption, data reduction, bandwidth

MDA12-013 TITLE: Modular Hypergolic Leak Detector

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

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The Missile Defense Agency (MDA) is seeking innovative concepts and products to improve the safety and logistics challenges of hypergolic propellant based propulsion systems. This includes sensor technology and leak mitigation technologies. The overall goal of projects selected under this topic will be to develop and demonstrate innovative technologies to enable safe storage and deployment of liquid hypergolic propulsion (LHP) systems for ballistic missile defense interceptors. Specifically this research and development goal is to develop a modular Hypergolic leak detector that has the capability to be reconfigured depending upon the detections requirement at hand. This year’s effort is a focused development of high reliability, low power and low cost transducer element that would be able to detect rapid changes in concentration of hypergolic fuels and oxidizers for use within a tactical Leak Detection Subsystem.

DESCRIPTION: A number of fielded missile systems use hypergolic fuels and oxidizers as a means of propulsion. A significant shortfall in this area is the inability to accurately verify any leaks of the hypergolic fuels or oxidizers. The key to the utility of this detector is not only a low threshold for detection, but reliable and accurate detection of the target contaminant in all required environments. A true "leak" of significance should result in a fairly rapid change in the concentration of the target chemical inside the canister. Once a threshold for a target contaminant has been reached, the transducer would change states to activate a separate alarm device. The chemicals the unit should be sensitive to include any of the common Hypergolic rocket fuels and oxidizers which include but are not limited to Monomethyl Hydrazine, MON-25, and others. The maximum threshold for a target contaminant shall be less than 100 ppm at all required environments.

The Hypergolic Chemical Transducer (HCT) shall be a small compact device less than one inch in diameter and two inches in length including all external interfaces for both wired and wireless connection. The HCT shall be a very low power device capable of being battery powered and using less than 0.3 milli-watts average (< 5 milli-watts peak). The mean time between false alarms for the HCT shall be greater than 12500 hrs. Reliability shall be greater than 8000 hrs MTBF. The HCT shall be able to be deployed and operate for six continuous months of operation or one year of storage without a change of its battery.

The Hypergolic Chemical Transducer shall operate through temperatures from -46 to +71 deg C in an Air and/or dry nitrogen environment consisting of less than 65 ppmv water. The HCT shall have a shelf life of no less than four years including one year of continuance use within specified environments.

The selected provider will be expected to work closely with the THAAD Product Office Logistics Division and the prime contractor to accurately define interfaces and tolerances in order to facilitate infusion of the HTC into the fielded weapons system.

PHASE I: Conduct experimental and or modeling efforts to demonstrate proof-of-principle of the proposed technology to detect and characterize leaks in the required environments. Demonstration of transducer's technology's ability to meet the require accuracy, reliability, power and supportability requirements.

PHASE II: Build and demonstrate the functionality of a prototype HTC and its ability to be integrated in a reference Hypergolic leak detection system. Demonstrate applicability to both selected military and commercial applications.

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

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

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KEYWORDS: hypergolic sensors

MDA12-014 TITLE: Acquisition, Tracking and Pointing Technologies for High Energy Laser Applications

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate advanced and innovative components, algorithms and electronics supporting next generation acquisition, tracking and pointing (ATP) sensor and jitter control technologies to provide support to future missile defense missions using significantly less components than traditional applications. Even though ATP is a broad topic, the MDA focus areas for this year are listed by priority below.

Offerors MUST direct their proposal to one of the three topic areas otherwise, the proposal will be non-compliant. If the offeror has a question or clarification, they are highly encouraged to contact the topic authors to discuss the subject before submitting a proposal.

The three (3) focus areas corresponding to this topic arranged by priority are:

Focus Area I: Low noise, high sensitivity and high bandwidth detector arrays used to collect and count electrons with mission applicable quantum efficiency. Low noise, high sensitivity, high bandwidth detector arrays are of absolute importance for future ATP missions. The ability to accurately capture and count electrons from a source is critical for more effective tracking capabilities in high altitude environments. The predicted area of performance will be in the 1 micrometer wavelength realm.

Focus Area II: Airborne hyper-spectral sensors for ballistic and airborne target applications able to detect short, mid and long wavelengths. The hyper-spectral sensor's algorithm should be able to integrate the different wavelengths and output a combined image. Airborne hyper-spectral sensor for ballistic and airborne targets is another important ATP technology which will provide future programs with exceptional capabilities such as target identification. The hyper-spectral sensor should be able to integrate the sensed wavelengths into one coherent image for this purpose.

Focus Area III: Jitter suppression algorithms and their requisite supporting control electronics to utilize and control jitter through the optical train. These technologies include but are not limited to fast steering mirrors, optical inertial reference units, inertial sensors for precision pointing and inertial stabilization, optical sensors for jitter and/or image stabilization, algorithms and control electronics/processors. Jitter suppression is required on several Missile Defense Agency (MDA) systems including future interceptor concepts. The ability to accurately track an object of interest from a platform undergoing base motion disturbances due to system operations is critical. The interest remains in ATP technologies that will allow higher performance tracking and pointing in realistic environments. Sub-microradian performance is required for many missions.

DESCRIPTION: All focus area proposed hardware MUST address packaging for high altitude airborne applications at a minimum and supporting interceptor applications will be considered a plus. This requires specific emphasis on size, weight and power (SWaP) for proposed electronics.

The environmental parameters that should be addressed for any hardware proposed include: High altitude airborne operations in near vacuum conditions (optional traceability to space operations in vacuum a plus); components should have a shelf life of at least 5 years to accommodate payload integration and a service life of a minimum of 5 years. The components have to operate in a radiation environment. For high altitude airborne applications, the offerors should address proton and gamma radiation with a minimum total dose of 10 kRad with special emphasis placed on single event upset (SEU) and single event latch-up (SEL). Demonstrating a path to 100-300 kRad hardness is a plus. The operating temperature range drives concept and capabilities with -54 degrees C to 40 degrees C desired to cover several requirements. For long term survival temperature range -60 to 71 degrees C is desired.

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

PHASE II: Complete critical design of prototype component including all supporting MS&A. Fabricate a prototype or engineering demonstration unit (EDU) and perform characterization testing within the financial and schedule constraints of the program to show level of performance achieved compared to stated government goals. In addition, environmental testing, especially radiation testing (if required), is highly encouraged in this phase if selected components do not have radiation performance data. The final report shall include comparisons between MS&A and test results, including identification of performance differences or anomalies and reasons for the deviation from MS&A predictions. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system, spacecraft, and/or payload contractors.

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

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

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KEYWORDS: Directed Energy, Laser, High Energy Laser, Diagnostic, Laser Power Measurement, Detectors, Hyper-Spectral, Jitter, Algorithms

MDA12-015 TITLE: Development of Line-narrowed Diode Pump Sources for DPAL systems

TECHNOLOGY AREAS: Electronics, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop line-narrowed, frequency stabilized diode pump sources to allow efficient resonant optical pumping of alkali laser systems.

DESCRIPTION: This topic addresses diode technologies focused on enabling advanced closed cycle flowing media laser systems that offer compact directed energy system solutions for future ballistic missile defense applications.

A promising example is the Diode Pumped Alkali Laser (DPAL). DPALs offer the potential for high power and efficient operation by leveraging the advantages of solid state and gas laser systems. These lasers are produced by direct optical pumping of alkali atoms in the vapor phase. The extremely low quantum defect of the alkali system minimizes thermal loading and, like other gas lasers, the gain medium can be flowed to reduce thermal management requirements. One key to producing efficient systems is matching the absorption linewidth of the gain media to the emission bandwidth of the diodes.

Absorption linewidths are typically on the order of 0.01 nm to 0.1 nm while the diode emission is typically on the order of a few nanometers. Previously, in order to obtain sufficient overlap, a combination of pressure-broadening of the gain medium and diode linewidth narrowing using external cavities was used. The pressure-broadening can lead to detrimental effects in laser performance, such as beam quality degradation. Additionally, the diode-narrowing techniques are expensive and difficult to implement, thus limiting their practical use.

A particular area of interest includes enabling technologies and support systems for the high-power optical pumping of alkali vapor atoms. Semiconductor diode laser technology presents the most cost-effective and scalable method to obtain the high powers and narrow spectroscopic linewidths required for these applications. Research and development is needed to realize scalable narrow-linewidth wavelength-stabilized laser diode pump sources for DPAL applications. The availability of these high-power spectroscopic pump sources would also find use in industrial and medical applications such as spin-exchange optical pumping (SEOP). With an efficient optical pump source, diode-pumped alkali vapor lasers have the potential for scaling to extremely high-power levels for industrial and military applications. The main impediment to achieving these power levels has been the availability of high-power narrow spectral line-width laser diode pump sources. Traditional efforts to produce narrow-line high-power diode laser pump sources typically rely on one of three methods, each with inherent tradeoffs and limitations. Technologies that are presented should meet or exceed the following requirements:

1) Diode emission bandwidth less than or equal to 0.05nm.

2) Center frequency locked to the D2 transition of one of the alkalis of interest. Rubidium is of highest interest to MDA, Cesium is the second highest, and Potassium is the third.

3) The long-term frequency drift cannot exceed 3GHz. The offeror should also consider the time it takes for the system to turn on and stabilize, as ultimately this will be required to be on the order of a few seconds.

Technical approaches focused on or including 2D surface emitting diode laser architectures are of specific interest.

PHASE I: Demonstrate in Phase I through modeling, analysis, and proof-of-principle experiments of critical elements of the proposed technology that the proposed approach is viable for further investigation in Phase II. Phase I work should clearly validate the viability of the technology proposed to meet the operational environment for directed energy applications in a component critical performance demonstration. Phase I should also result in a clear technology development plan, schedule, transition risk assessment, and requirements document.

PHASE II: The Phase II objective is to validate a scalable and producible technology approach that MDA users and prime contractors can transition in Phase III to their unique laser application. Validate the feasibility of the proposed concept developed in Phase I by development and demonstration of a key components brassboard and the execution of supporting laboratory/field experiments to demonstrate technology viability. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration subsystem. The goal of the Phase II effort is to demonstrate technology viability and the offeror should have working relationships with system and payload contractors.

PHASE III: In this phase, the contractor will apply the innovations demonstrated in the first two phases to one or more MDA element systems, subsystems, or components. The objective of Phase III is to demonstrate the scalability of the developed technology, transition the component technology to the MDA system integrator or payload contractor, mature it for operational insertion, and demonstrate the technology in an operational level environment. A partnership with a current or potential supplier of MDA element systems, subsystems or components is highly desirable as is interaction with OSD High Energy Laser Joint Technology Office programs.

COMMERCIALIZATION: High power laser components have numerous commercial and other government agency applications in metal cutting, material processing, welding, remote sensing (both terrestrial and space), satellite communications, power beaming, and weather sensing. Outside of MDA, numerous other DoD applications of the technology include tracking, designation, directed energy, demilitarization of munitions, and IED destruction.

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KEYWORDS: directed energy, high energy laser, alkali lasers, pectroscopic laser diode pumps

MDA12-016 TITLE: <u>Optics and Coatings for High Energy Laser Applications</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: High-performance optical substrates and coatings and the industrial base and expertise required to develop and produce same are essential ubiquitous elements for continued successful development of high-energy lasers, sensors, countermeasures, and other optical systems for military purposes.

Proposed here is the development of processes and method for production of coatings and substrates for high-energy lasers in particular and specifically for Diode Pumped Alkali Laser Systems (DPALS) which are of near-term interest.

DESCRIPTION: MDA interest in compact, high-performance lasers will be advanced by availability of durable, affordable, and readily available optical coatings and substrates; to the end the following focus areas are delineated.

Focus Areas:
1) Optical coatings and substrates resistant to the effects of contamination and the presence of 100μm-class particles at temperatures on the order of 500 C and intensities of greater than or equal to 40 kW/cm2.

2) Candidate optical coatings and substrates must be resistant to saturated Rb(v)-He(g) mixtures at temperatures on the order of 500 C and intensities of greater than or equal to 40 kW/cm2.
a) Coatings must be capable of being applied to high quality substrates such as sapphire.
b) The coating must transmit maximum and reflect minimum amount of light at D1 and D2 wavelengths of Rb.
c) Coatings must be capable of being subjected to saturated Rb(v)-He(g) mixtures at temperatures on the order of 500 C and intensities of greater than or equal to 40 kW/cm2 without damage or failure.
d) The coating should be resistant not only to Rubidium vapor but also its oxides and hydroxides.

3) Development of new processes for production of high-quality sapphire windows with extremely low impurity levels.

4) Development of processes for control of bonding and thicknesses coatings on substrates such as sapphire.

PHASE I: Demonstrate in Phase I through modeling, analysis, and/or proof-of-principle experiments of critical elements for the proposed technology for further investigation in Phase II. Phase I work should clearly validate the viability of the proposed technology. Phase I will culminate in a CDR-level design. Phase I should also result in a clear technology development plan, schedule, transition risk assessment, and requirements document. Offerors are highly encouraged to work with High Energy Laser (HEL) system integrators and/or their respective sub-system contractors to help ensure applicability of the proposed effort and the viability of the technology for transition.

PHASE II: The Phase II objective is to validate a scalable and producible technology approach that MDA users and prime contractors can transition in phase III to their unique laser application. Validate the feasibility of the Phase I concept by development and demonstration of witness samples that will be tested to ensure compliance with requirements. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration subsystem. The goal of the Phase II effort is to demonstrate technology viability. A partnership with a current or potential supplier of MDA systems, subsystems or components is highly desirable and should include testing of samples. The final report should include but is not limited to the methods, results, and shortcomings of claims in support of success of the candidate systems for the corresponding focus areas.

PHASE III: In this phase, the contractor will apply the innovations demonstrated in the first two phases to one or more MDA systems, subsystems, or components. The objective of Phase III is to demonstrate the scalability of the developed technology, transition the component technology to the MDA system integrator or payload contractor, mature it for operational insertion, and demonstrate the technology in an operational level environment.

COMMERCIALIZATION: The contractor will pursue commercialization of the various technologies developed in Phase II for potential commercial uses in other DOD high energy laser systems, missile windows; and other systems requiring high quality sapphire windows/ optical coatings.

REFERENCES:

1. S. Appelt, A. Ben-Amar Baranga, C. J. Erickson, M. V. Romalis, A. R. Young, and W. Happer, "Theory of spin-exchange optical pumping of 3He and 129Xe", Phys. Rev. A., 58, p. 1412-1439 (1998).

2. DPALS symposium at the SPIE High Power and Laser Ablation (HPLA) conference, Santa Fe, 2008 (Proc SPIE, 7005).

3. W.F. Krupke, Diode pumped alkali lasers (DPALs) an overview, Proc. SPIE High-Power Laser Ablation, Vol. 7005, pp. 700521-13, (2008).

4. B. Zhdanov, T. Ehrereich, and R.J. Knize, Narrowband external cavity laser diode array, Elec. Letters, Vol. 43, No. 4, pp. 221-222, (2007).

5. Aleksey M. Komashko; Jason Zweiback, Modeling laser performance of scalable side pumped alkali laser (Proceedings Paper) SPIE Proceedings Vol. 7581, High Energy/Average Power Lasers and Intense Beam Applications IV, 17 February 2010.

6. Boris Zhdanov, Thomas Ehrenreich, and Randall Knize, Optically pumped alkali-vapor lasers http://spie.org/documents/Newsroom/Imported/412/2006090412.pdf

7. Zhdanov, B.V. Stooke, A. Boyadjian, G. Voci, A. Knize, R.J., 17 Watts continuous wave Rubidium laser, IEEE Lasers and Electro-Optics, 2008 and 2008 Conference on Quantum Electronics and Laser Science. CLEO/QELS 2008. 4-9 May 2008.

8. "Ballistic Missile Defense Review," Office of the U. S. Secretary of Defense, February 2010. http://www.defense.gov/bmdr/

KEYWORDS: directed energy, high energy laser, alkali lasers, thin film coatings

MDA12-017 TITLE: Atmospheric Characterization for Directed Energy Applications

TECHNOLOGY AREAS: Space Platforms, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: There is a need to reliably measure, analyze and forecast with adequate accuracy and precision the high altitude (upper troposphere and stratosphere to 100 kft and beyond) atmospheric conditions relevant to high energy laser propagation. Existing ground-based atmospheric profilers and scintillometers capable of measuring at high altitudes are subject to cloud impacts, and/or they are not transportable and often lack the required spatial resolution for detailed analyses. In-situ measurements systems (i.e. airborne platforms) typically do not operate at altitudes above 45,000 feet.

DESCRIPTION: Develop instrumentation hardware along with appropriate deployment system to effectively and efficiently measure (remote or in-situ) the high altitude atmospheric conditions related to directed energy propagation. Existing balloon-borne instrumentation (i.e. thermosonde instruments) are not robust enough for frequent use in the field, and are subject to their own weather sensitivities (e.g. icing in clouds). The atmospheric conditions should include temperature, moisture, winds, density, electromagnetic refraction, and optical turbulence.

The technology will likely include a combination of atmospheric measurement (in-situ or remote sensing) and numerical weather prediction (modeling and simulation) to adequately characterize the spatial and temporal aspects of the problem. The focus of previous measurement and modeling-simulation efforts has been near the ground or near the tropopause (~30 kft), or yielded capabilities lacking adequate reliability, accuracy, and precision to effectively advance high energy laser applications. This new topic should advance the legacy research that focused on the lower altitude environment, and provide a user-friendly interface to the new technology and real-time data.

PHASE I: Detailed analysis of the high altitude atmospheric conditions related to directed energy applications, and how the "Proof of Concept" instruments will quantitatively measure (with appropriate accuracy and precision) this environment. Survey of current/future numerical weather prediction (NWP) analysis/forecast models, and how the innovative atmospheric data could be assimilated into the NWP process and improve the analysis/forecast capability. Plan (or prototype) for atmospheric decision assistance tool that incorporates the measured data along with the NWP into a user-friendly application/system.

PHASE II: Develop prototype instrumentation (remote and/or in-situ) and atmospheric modeling, analysis, and forecast capability with requisite accuracy and precision to capture the optical turbulence impacts. Develop a user-friendly, prototype atmospheric decision assistance toolkit to assimilate the measurements from the instrumentation (to include unique space-based information that exists) along with the atmospheric model data to enhance and graphically display the atmospheric conditions for operational testing.

PHASE III: In this phase, the contractor will apply the innovations demonstrated in the first two phases to one or more MDA systems, subsystems, or components. The objective of Phase III is to demonstrate the Efficient and effective instrumentation and software (MS&A) to characterize and forecast the directed energy atmospheric conditions in the troposphere and stratosphere for MDA systems; then transition the component technology to the MDA system integrator or payload contractor, mature it for operational insertion, and demonstrate the technology in an operational level environment.

COMMERCIALIZATION: The contractor will pursue commercialization of the various technologies developed in Phase II for potential commercial uses in other DOD high energy laser systems, astronomy, NASA, and space based long-range secure communications.

REFERENCES:
1. Smith, Fred G. editor,1993. Infrared & Electro-Optical Systems Handbook, Volume 2, Atmospheric Propagation of Radiation. SPIE Optical Engineering Press.

KEYWORDS: directed energy, laser, atmospheric characterization, weather, electromagnetic energy, optical turbulence, refractive index, Cn2, extinction, attenuation, infrared, troposphere, stratosphere, scintillation.

MDA12-018 TITLE: Light weight Rubidium-Metal Vapor Circulating System

TECHNOLOGY AREAS: Air Platform, Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate an innovative, lightweight, and contamination resistant Rubidium Helium circulation system suitable for supplying the gain medium of a Diode Pumped Alkali Laser System (DPALS)

DESCRIPTION: This topic addresses material technologies focused on enabling advanced closed cycle flowing media laser systems that offer compact directed energy system solutions for future ballistic missile defense applications. Specifically technologies enabling (or the creation of) a lightweight, contamination resistant Rubidium

Helium circulation system. A fundamental component of Diode-Pumped Alkali Laser Systems (DPALS) is a closed-cycle circulating system capable of delivering of a mixture of helium (He) gas and rubidium-metal (Rb) vapor to a test cell at a specified temperature, pressure, flow rate, and rubidium concentration. Consideration will be given only to those proposals in which:

1. contamination of the mixture by water and oxygen are considered (a repeat of the Fort St Vrain generating station experience is not desired),

2. alkali-metal vapor corrosion-resistant materials of construction are featured,

3. commercially-available industrial hardware are used, and

4. minimization of the total weight of the system is considered. DPALS performance data or information is not required for this topic.

PHASE I: Prepare and deliver a technical data package or design package, for MDA review, for a closed-cycle circulating system for the Phase II effort. Emphasis will be placed on unique and innovative ways to make the system out of materials that are contamination resistant and light-weight.

PHASE II: Design, procure, install, and test a demonstration system capable of circulating one (1) gram per second of the mixture in the pressure and temperature ranges of 10 – 20 atm and 150 – 225 C.

The rubidium concentration should be delivered at 90% of saturation concentration. The test cell pressure drop is on the order of 5% of the total pressure.

Deliver a report on the as-built system in a technical data package which includes but is not limited to system drawings, performance, material and energy balances, and observations relative to required changes for Phase III.

PHASE III: Design, procure, install, and test a demonstration system capable of circulating ten (10) grams per second of the mixture in the pressure and temperature ranges of 10 – 20 atm and 150 – 225 C.

The rubidium concentration should be delivered at 90% of saturation concentration. The test cell pressure drop is on the order of 5% of the total pressure.

Deliver a report of the as-built system in a technical data package which includes but is not limited to system drawings, performance, material and energy balances, and observations relative to required changes for commercialization.

COMMERCIALIZATION: Exact commercial applications other than Rb-He and other alkali-metal laser systems are unknown; however, the contractor is highly encouraged to identify possible uses in the scientific community such as Rubidium vapor system have applications to atomic clocks and medical devices.

REFERENCES:
1. C. F. McDonald and M.K. Nichols, "HELIUM CIRCULATOR DESIGNCONSIDERATIONS FOR MODULAR HIGH TEMPERATURE GAS-COOLED REACTOR PLANT" GA Technologies, GA project 6300 Dec 1986

2. H.G. Olson and H.L. Brey, "THE FORT ST. VRAIN HIGH TEMPERATURE GAS-COOLED REACTOR," Nuclear Engineering and Design 53 (1979) 133-140

KEYWORDS: DPAL, DPALS, diode pumped alkali laser, directed energy, contamination, light weight materials

MDA12-019 TITLE: Solid State High Energy Laser Batteries and Power Sources

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

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop an innovative, lightweight, and robust power system that is scalable from 100kw to a system capable of powering the diodes array of a diode pumped MW class high energy laser system. Such a power system would include the batteries, hardware and electronics necessary to power high energy laser diodes.

DESCRIPTION: The next generation of technology for laser weapons, i.e. diode pumped or fiber, requires significant electrical power for driving the laser and supporting systems. Compact and lightweight power generation, storage, and conditioning are necessary for transitioning the laser technology to an airborne platform for missile defense. On-demand power of 1MW to 10MW is required for continuous laser operations for 10's of seconds at a time with minimal down time between shots (<1 min). Realistic available on-board power is limited to 5KVA to 10KVA and is typically 3-phase, 115/200 VAC, line-to-neutral, up to 400 Hz variable (Ref 1); on-board power is usually very noisy. Technology considered under this topic must be able to operate in a closed environment and withstand the effects of a high altitude environment.

This topic seeks to produce a robust lightweight power source to operate on an airborne platform. The architecture must include batteries and other hardware sufficient for conditioning the power out of the batteries to power laser diodes and heat exchangers. The architecture must also be scalable to MW of power.

PHASE I: Develop a preliminary design for the proposed power system or subsystem. Proof of concept hardware development and test is highly desirable. Proof of concept demonstration may be subscale or specific risk reduction activities associated with critical components or technologies. Test results (if performed) should be used in conjunction with Modeling and Simulation results to verify scaling laws and feasibility. Phase I will include the development of plans to further develop/exploit this technology in Phase II. Offerors are strongly encouraged to work with system and/or payload contractors to help ensure applicability of their efforts and begin work towards technology transition.

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

PHASE III: Develop and execute a plan to market and manufacture the product developed in Phase II. Assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing. The contractor will pursue commercialization of the various technologies developed in Phase II for potential commercial uses such as emergency power generators, photovoltaic power inverter, or electric vehicles.

COMMERCIALIZATION: The contractor will pursue commercialization of the various technologies developed in Phase II for potential commercial uses in other DOD high energy laser systems and airborne/ space applications with similar power requirements.

REFERENCES:
1. Luiz Andrade and Carl Tenning, "Design of the Boeing 777 Electric System," IEEE AES Magazine, pp. 4-11, July 1992, http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=220573

2. Paul N. Barnes, George A. Levin, and Edward B. Durkin, "Superconducting Generators for Airborne Applications and YBCO Coated Conductors," 2008 IEEE Power and Energy Society General Meeting - Conversion

and Delivery of Electrical Energy in the 21st Century, pp. 1-4, 20-24 July 2008, http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4596946

3. LaMarcus Hampton, Paul N. Barnes, Timothy J. Haugan, George A. Levin, and Edward B. Durkin, “Compact Superconducting Power Systems for Airborne Applications,” AFRL-RZ-WP-TP-2010-2061, Air Force Research laboratory, Power Generation Branch, Power Division, Wright-Patterson Air Force Base, OH, January 2009, http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA515601

4. “A320 Simulator Flight Crew Operating Manual,” STD 1.3.1, Section 1.24 Electrical, pp. 1.24.00 – 1.24.20, http://www.smartcockpit.com/data/pdfs/plane/airbus/A320/systems/A320-Electrical.pdf

5. MIL-STD-704F Aircraft Electric Power Characteristics, the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094, 12 March 2004, http://www.wbdg.org/ccb/FEDMIL/std704f.pdf

6. “Aviation Electricity and Electronics—Power Generation and Distribution,” NAVEDTRA 14323, Naval Education and Training Professional Development and Technology Center, NAVSUP Logistics Tracking Number 0504-LP-100-9601, February 2002, http://www.hnsa.org/doc/pdf/aviationpower.pdf

7. MERCURY 50 Recuperated Gas Turbine Generator Set, Solar Turbines, http://mysolar.cat.com/cda/files/126873/7/dsm50pg.pdf

8. PureCell® Model 400, UTC Power, http://www.utcpower.com/files/PRMAN69600D.pdf

9. “The Ballistic Missile Defense System (BMDS),” Missile Defense Agency, U.S. Department of Defense, http://www.mda.mil/system/system.html

KEYWORDS: Power, laser, compact, lightweight, generation, storage, conditioning, batteries, supply, inverter

MDA12-020 TITLE: Methodologies for Realtime Correction of Water Vapor Effects on an Infrared Scene

TECHNOLOGY AREAS: Sensors, Battlespace

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop software tools to remove, in real time, the effects of atmospheric water vapor of an infrared scene.

DESCRIPTION: The ability to accurately determine characteristics of an infrared scene depends on compensation for the effects of water vapor in the medium between the sensor and the scene. This SBIR deals specifically with the effects due to water vapor between an observation platform and its area of interest. Infrared sensors must look through the atmosphere where dynamic climate conditions directly affect the target signature and apparent position as seen by the sensor, through water vapor. Specifically: Model the effects of water vapor on an infrared scene. Leverage available weather databases for humidity data. Develop tools that can mitigate these effects for a simulated scene.

PHASE I: Demonstrate the feasibility of modeling atmospheric effects such as various water vapor types on apparent position with high accuracy including all physics typically neglected by physical optics techniques. Also, demonstrate the feasibility of modeling star backgrounds for use in star calibration functions with atmospheric conditions. For example, demonstrate the feasibility of modeling the relationship between accuracy of these models, and the error or uncertainty of a star calibration. Develop a plan to mature the selected technique(s) in Phase II.

PHASE II: Implement the plan developed in Phase I and demonstrate the performance of the tool on models of interest to MDA. Characterize performance on modern hardware and assess the accuracy of the code on realistic models.

PHASE III: Refine methodology and tool development and transition to interested platforms. COMMERCIALIZATION: Commercialization: The contractor will pursue commercialization of the various technologies developed in Phase II for potential commercial uses in such diverse fields as pilot training simulations, computer graphics hw/sw applications, remote sensing, meteorology, and weather prediction.

REFERENCES:
1. D. Crow, C Coker, W. Keen, “Fast Line-of-sight Imagery for Target and Exhaust-plume Signatures (FLITES) scene generation program”, Technologies for Synthetic Environments, Hardware-in-the-loop Testing XI, Proc. of SPIE Vol 6208.

2. "Ballistic Missile Defense Review," Office of the U. S. Secretary of Defense, February 2010. Available via internet at http://www.defense.gov/bmdr/

3. The Composite Characteristics of Cirrus Clouds: Bulk Properties Revealed by One Year of Continuous Cloud Radar Data, Journal of climate, Gerald G. Mace, Eugene E. Clothiaux

4. SAMM2: http://www.kirtland.af.mil/library/factsheets/factsheet.asp?id=7924.

KEYWORDS: water vapor, atmospheric effects, Infrared, weather, remote sensing, IR modeling, star backgrounds

MDA12-021 TITLE: <u>Lightweight Communication Equipment for Interceptor Communications</u>

TECHNOLOGY AREAS: Electronics, Space Platforms

ACQUISITION PROGRAM: SM3IIB

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a light weight and low power communication system to enable small kill vehicle communications in flight.

DESCRIPTION: Current light weight kill vehicles have limited data communication abilities once separated from the interceptor missile. To enable longer range intercepts with smaller kill vehicles, communication equipment needs to be made smaller, lighter, and more power efficient.

A significant need exists for enhanced, highly reliable, high speed, in-flight communications between the Ballistic Missile Defense System (BMDS) Fire Control and Interceptor/Kill Vehicles in an operational fading channel environment potentially perturbed by nuclear weapons effects. Any proposed communications schemes must have the lowest possible weight impact on the kill vehicle. Communication links between Communication Ground Terminal relayed through the Interceptor third stage should be considered. Advanced secure interceptor communication systems (<200 grams and 3”x2”x0.5” in size) will be required for future systems. The system must establish link(s) between the kill vehicle and ground control with an estimated transmission range for the kill vehicle of 50 km with peak transmission power of <5 Watts. They must also be able to receive updates at ranges up to 1000 km. Significant reduction in the area and geometric shape of antennas for the kill vehicle is also requested including fractal antenna designs that are capable of receiving signals from a large range of orientations.

PHASE I: During the Phase I contract, the proposer will conduct an initial design evaluation of their proposed system and perform any laboratory/breadboard experimentation or numerical modeling needed to verify the proposed method. The deliverable will be an initial design for a prototype system with accompanying theoretical/numerical performance estimates.

PHASE II: If selected for a Phase II, the proposer will complete a detailed prototype design to government performance requirements. The prototype will then be fabricated and tested in a simulated environment to verify theoretical/design assumptions. The final deliverable will be a detailed performance analysis of the experiment and an initial design of an engineering development model of the resulting system.

PHASE III: Phase III selections will have adequate support from a MDA contractor. The proposer shall continue testing and development with a MDA contractor to refine performance and reliability characteristics.

COMMERCIALIZATION: Long range line of sight communications systems for satellites or aircraft.

REFERENCES:
1. Galindez, Richard, et. al., “A Common Data Link (CDL) for Space-Based Communications: Migration of Airborne Hardware to Space," Small Satellite Conference, Aug. 2005.

2. J. Colebank, B. Stewart, N. Tracey, J. Staines, and H. Smith, “Survival in the Orbital Battlefield: Improving the Odds,” AIAA 2010-1765.

KEYWORDS: Communications, Datalink, Radio

MDA12-022 TITLE: Miniature Extendable Nozzles or actuating nozzles for improved ISP of DACS thrusters

TECHNOLOGY AREAS: Air Platform, Space Platforms, Weapons

ACQUISITION PROGRAM: SM3IIB

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The Missile Defense Agency (MDA) is seeking innovative solutions for improving the specific impulse (ISP) of kill vehicle Divert and Attitude Control Thrusters (DACS) Thrusters. This topic should focus on low-weight methods of extending or actuating DACS size nozzles to increase expansion ratio with high reliability. Discussions of alternative solutions are welcome.

DESCRIPTION: Future Missile Defense Weapon Systems will need to increase divert capability (acceleration) to perform mission requirements. Increased mass flow out the nozzle by higher temperature propellant is limited by the thermal limits of advanced materials. ISP may also be increased by increasing the velocity of the propellant exiting the nozzle.

DACS systems typically are carried in the nosecone of a missile interceptor and the volume available to store the DACS thrusters is limited. The typical thruster will have a minimum length bell nozzle with the expansion ratio limited by the length available to store the nozzle. Considerable work has been completed in the past on mechanical nozzle extensions to increase the expansion area and several expandable nozzle designs are currently in use but they are typically heavy and used for small increases in exit velocity. DACS thrusters are used in an exo-atmosphere near vacuum environment and can potentially be expanded much further than expandable nozzles designed for use in the atmosphere.

Weight is critical for DACS thrusters and any nozzle extension system must be low weight. The extension system must also be highly reliable. If the nozzle extension fails to actuate correctly, the effective thrust from the thruster will be greatly reduced and the DACS will become severely imbalanced.

The MDA is seeking thrust levels that range between 100 – 350 lbf with nozzle expansion ratios greater than 24 that can operate at a minimum of 1 minute while operating on a gas generator at 5500F.

Solutions utilizing divert change control systems other than DACS thrusters are welcome.

PHASE I: During the Phase I contract, The proposer shall conduct a design study that shows the feasibility of the concept including numerical simulation of the proposed approach. They proposer shall trade the additional mass added to the system against the system performance and compare to traditional nozzles of equivalent properties. The proposer shall provide estimated performance and reliability characteristics.

PHASE II: If selected for a Phase II, the proposer shall fabricate the nozzle concept for testing. Testing should include multiple initial tests that demonstrate the deployment of the concept. Phase II should conclude with hot fire testing of the concept in a vacuum. The proposer shall provide performance and reliability estimates.

PHASE III: Phase III selections will have adequate support from a MDA Prime or Propulsion vendor. The proposer shall continue testing and development with a MDA Prime or Propulsion vendor to refine performance and reliability characteristics.

COMMERCIALIZATION: Commercial Satellite Control

REFERENCES:
1. Mattingly, J. D., Elements of Propulsion, AIAA Educational Series 2006

2. Carey, L, Dueringer, J, Nixon, G. "Convoluted Nozzle Extension", Journal of Spacecraft, Vol. 9, July 1972

3. Lacombe, A., Pichon, T., Lacoste, M., "High temperature composite nozzle extensions, a mature and efficient technology to improve upper stage Liquid Rocket Engine performance", AIAA 2007-5470

KEYWORDS: Divert and Attitude Control System, Nozzles, Nozzle Extension, Extendable Nozzles, Thrusters

MDA12-023 TITLE: <u>Powdered Propellant Rocket Motor</u>

TECHNOLOGY AREAS: Air Platform, Space Platforms, Weapons

ACQUISITION PROGRAM: SM3IIB

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop an innovative method of delivering, injecting, and igniting a powdered solid propellant to a combustion chamber in a controlled manner under an accelerating reference frame or in microgravity.

DESCRIPTION: Multiple concepts have been proposed to create a system that has the safety and storage capabilities of a solid rocket motor (SRM) system while having the thrust control and flexibility of a liquid system.

Material handling of a fine powder from a storage tank to one of several combustion chambers under acceleration, rotation, and microgravity conditions is proposed as one method of combining the best of both types of motors.

The Divert and Attitude Control System (DACS) is a combination of multiple nozzles and valves to either deliver liquid fuel or hot gasses from a central SRM to provide thrust on the kill vehicle to maneuver in space. By powdering the SRM fuel, it may be possible to enable the SRM system to closely mirror the benefits of the liquid system.

The system may use a compressed gas such as O2 or liquid to carry the fuel particles and aid in combustion or a mechanical system to force feed the particles into combustion chamber. The system must be extremely light weight and accurately control the rate at which the fuel is injected. A method of igniting the fuel particles once inside the combustion chamber for pulsed operation will also be required.

PHASE I: During the Phase I contract, the proposer will conduct an initial design evaluation of their proposed system and perform any laboratory/breadboard experimentation or numerical modeling needed to verify the proposed method. The deliverable will be an initial design for a prototype system with accompanying theoretical/numerical performance estimates.

PHASE II: If selected for a Phase II, the proposer will complete a detailed prototype design to government performance requirements. The prototype will then be fabricated and tested in a simulated environment to verify theoretical/design assumptions. The final deliverable will be a detailed performance analysis of the experiment and an initial design of an engineering development model of the resulting system.

PHASE III: Phase III selections will have adequate support from a MDA contractor. The proposer shall continue testing and development with a MDA contractor to refine performance and reliability characteristics.

COMMERCIALIZATION: Commercial Space Launch and Sattelite Control

REFERENCES:
1. Saito, T., Koizumi, H, Kuninaka, H., “Powdered Propellant PPT with Automatic Feed System”, AIAA 2009-1381

2. Shorr, M., Reinhardt, T., “Feasibility of a Fluidized Powder Demand-Mode Gas Generator”, Journal of Spacecraft, vol. 11, No. 1, 1974.

KEYWORDS: Rocket Motor, Powder Flow

MDA12-024 TITLE: Waste Heat Recovery of Rocket Motors for Reduction of Battery Weight

TECHNOLOGY AREAS: Air Platform, Electronics, Space Platforms

ACQUISITION PROGRAM: SM3IIB

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The Missile Defense Agency (MDA) is seeking innovative solutions for recovering waste heat left in the insulation surrounding a solid rocket motor (SRM) or liquid rocket motor combustion chamber and converting it into electricity to recharge batteries for long flight missions resulting in a reduction in the total battery weight needed. This may result in a net reduction in mass of the overall missile system.

DESCRIPTION: The third stage generally follows a ballistic trajectory after burnout and remains relatively close to the kill vehicle that performs the intercept of the target warhead. It may be possible to place communications relay equipment or target tracking equipment on this third stage to reduce the weight of the kill vehicle. Based upon initial estimates, there may be as much as 11-30 MJ of waste heat left over in an average third stage rocket motor after burnout. If a small fraction of this waste heat were to be converted to electricity to recharge a battery, it may be possible to reduce 4-10 kg of battery weight in the overall missile by converting from thermal batteries to rechargeable batteries with this recovery system.

The method of heat recovery and conversion should be very light weight (<5kg) and capable of supplying approximately 300W of electricity to the power management system while removing heat from the insulation around a rocket motor case of approximately 0.6 meters in diameter and 1 meters long for at least 5 minutes. At burnout, it is estimated that the average temperature of the fist centimeter of insulation around the motor lining is approximately 2000 K. The system must be capable of operating in a micro-gravity environment and survive the high-g environment of launch.

Thermoelectric, thermocouple, and fluid/vapor based systems are all potential candidates but will require extensive modification to operate under the desired conditions and performance requirements.

PHASE I: During the Phase I contract, the proposer will conduct an initial design evaluation of their proposed method of recovering the waste heat and perform any laboratory/breadboard experimentation or numerical modeling needed to verify the proposed method. The deliverable will be an initial design for a prototype system with accompanying theoretical/numerical performance estimates.

PHASE II: If selected for a Phase II, the proposer will complete a detailed prototype design to government performance requirements. The prototype will then be fabricated and tested in a simulated environment to verify theoretical/design assumptions. The final deliverable will be a detailed performance analysis of the experiment and an initial design of an engineering development model of the resulting system.

PHASE III: Phase III selections will have adequate support from a MDA Prime or Propulsion vendor. The proposer shall continue testing and development with a MDA Prime or Propulsion vendor to refine performance and reliability characteristics.

COMMERCIALIZATION: Satellite launch systems or small commercial power generation systems.

REFERENCES:
1. Cengel, Y.A, Boles, M. A., Thermodynamics, McGraw-Hill, 1998

2. McCarty, R., et al, "Experimental Verification of Thermal Switch Effectiveness in Thermoelectric Energy Harvesting", Journal of Thermophysics and Heat Transfer, Vol. 21, No. 3.

KEYWORDS: Power Management System, Power Systems

MDA12-025 TITLE: Affordable Reinforced Polymer Composite Structures with embedded electrical interfaces

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Weapons

ACQUISITION PROGRAM: QS and AB are beneficiaries of this technology

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OBJECTIVE: Develop and demonstrate carbon fiber reinforced polymer (CFRP) composite missile structures with incorporated power and signal transporting capability throughout a weapon system and to system subcomponents. These technologies should be affordable and yield increased volumetric efficiency, reduced maintenance requirements, improved reliability, and reduced system weight. Additionally, the technologies should function in operational conditions to include extreme temperatures, humid and corrosive environments, and maneuvering loads. Carbon based conductor technologies are preferred.

DESCRIPTION: Modern weapons systems contain power cables, signal wiring, and power buses .These necessary components account for a considerable amount of the total system weight and are vulnerable to damage during production and in service. By incorporating power and signal transporting capability into composite structures, critical volume within the missile airframe will be made available for other functions that will lead to extended range and enhanced lethality. This technology will improve reliability and quality by minimizing connector failure points, decreasing manufacturing cycle times, and reducing part count.

Recent advances in electronic materials and nanostructures, allow the possibility of conductor and connector embedment in the CFRPs without degradation of structural performance. The use of carbon based conductors is of particular interest due to their high specific strength and electromotive compatibility with carbon fiber composites. Technical areas like electromagnetic interference shielding, cross-talk susceptibility, interconnects at structural joints, damage tolerance, coefficient of thermal expansion mismatch, and conductor ingress and egress must be addressed for successful transition

PHASE I: Demonstrate feasibility of an integrated conductor through fabrication of a cylindrical CFRP composite. Demonstrate conductor capability and structural performance. Estimate weight and cost savings.

PHASE II: Develop and fabricate a prototype CFRP composite intermediate ballistic missile representative airframe with newly demonstrated power and signal carrying capability, conductor ingress and egress, and component interconnects. Perform appropriate characterization and testing to validate system functionality.

PHASE III: Develop and execute a plan to manufacture, test, and evaluate the prototype developed in Phase II. Additionally, assist in transitioning this technology to the prime(s) contractor.

COMMERCIALIZATION: Improved composite manufacturing techniques and electrical interface methods will serve as enabling technologies for automotive, commercial aerospace, infrastructure, other Department of Defense Agencies, etc.

REFERENCES:

1. B. Z. Jang, "Advanced Polymer Composites: Principles and Applications," 387 pages, ASM International, Dec. 1994

2. Military Handbook - MIL-HDBK-17-4A: Composite Materials Handbook, Volume 1 through 3 - Polymer Matrix Composites

3. Carbon nanotube wires and cables: Near-term applications and future perspectives , Paul Jarosz, Christopher Schauerman, Jack Alvarenga, Brian Moses, Thomas Mastrangelo, Ryne Raffaelle, Richard Ridgley and Brian Landi Nanoscale, 2011, 3, 4542-4553

4. Hyonny Kim, Myounggu Park, Kelli Hsieh, Fatigue fracture of embedded copper conductors in multifunctional composite structures, Composites Science and Technology, Volume 66, Issues 7-8, June 2006, Pages 1010-1021, ISSN 0266-3538, 10.1016/j.compscitech.2005.08.007.

5. Ronald F. Gibson, A review of recent research on mechanics of multifunctional composite materials and structures, Composite Structures, Volume 92, Issue 12, November 2010, Pages 2793-2810, ISSN 0263-8223, 10.1016/j.compstruct.2010.05.003.

6. Ronald F. Gibson, A review of recent research on mechanics of multifunctional composite materials and structures, Composite Structures, Volume 92, Issue 12, November 2010, Pages 2793-2810, ISSN 0263-8223, 10.1016/j.compstruct.2010.05.003.

KEYWORDS: Carbon fiber reinforced polymer composites, electrical interconnects, embedded electronics, nano-materials

MDA12-026 TITLE: Marking of Components for Avoidance of Counterfeit Parts

TECHNOLOGY AREAS: Air Platform, Chemical/Bio Defense, Ground/Sea Vehicles, Sensors, Electronics, Battlespace, Space Platforms, Human Systems, Weapons, Nuclear Technology

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OBJECTIVE: Develop and demonstrate capability for guaranteeing authenticity of critical electronic components in MDA hardware. Ensure that physical marking techniques are sufficiently robust to withstand handling through supply chain intermediaries and program installation and maintenance processes. Demonstrate confidence in the marking process as a viable, affordable, reliable method of increasing confidence in the authenticity of DoD and MDA electronic components.

DESCRIPTION: MDA uses thousands of different electronic components in their mission and safety critical hardware. This includes systems such as missile guidance control, attitude control, radars, communications, systems abort, and telemetry systems. These systems rely on hundreds of defense contractors to design, purchase components for, and assemble the components into the BMDS's mission and safety critical systems. Reliable estimates indicate that more than 10% of the electronic components currently in these systems are obsolete. This means it is likely there are from 1,000 to 10,000 electronic components in MDA systems that are no longer available from the original manufacturer or an authorized supplier for the manufacturer. Virtually all other DoD agencies are facing a similar scenario. Counterfeiting is estimated to have increased from 13% to 22% annually in the past several years. A NAVAIR researcher estimated 15% of all spare and replacement integrated circuits purchased by DoD are counterfeit. In a 2.5 year span from 2007 to 2010, Customs and Border Protection (CBP) and Immigration and Customs Enforcement (ICE) seized over 5.6 million counterfeit semiconductor devices.

When electronic components are obsolete, they must usually be located from unauthorized suppliers. These suppliers search for parts from their own stock, contractor or government excess stock, and often from internet listing sites which list available components. Components from all locations, and in particular from internet listing sites, are at high risk for being counterfeited. Used, scrapped semiconductor electronic components are removed from circuit boards in a fashion that often subjects the parts to both thermal and electrostatic stresses beyond the manufacturer's recommended limits. In addition, generic components of this type (e.g., memory devices, amplifiers, voltage regulators) which have many versions from multiple manufacturers, may be remarked to falsely identify the parts as having greater than actual capability (e.g., capacity, speed, power dissipation, temperature range) for the part. This risk is present for all purchases from unauthorized suppliers, regardless of the obsolescence status. However, the risk for active parts is more easily mitigated through maximum use of authorized suppliers.

Most counterfeit electronic components are subjected to some level of remarking. This is done because new electronic components are generally packaged with all the parts in one shipment produced from a small number (two or less) of production batches. These batches are usually identified through a lot or date code designator on the top and/or bottom of the part which can be used to identify the approximate timeframe, and often facility, for the production of the component. Counterfeiters remark product, even if it is the correct part number, in order to make the entire shipment appear as if it was from one lot or date code.

There are currently three primary ways in which counterfeit parts are remarked. All of them involve some sort of abrasive method of removing the old ink markings. The most common method is to use sandpaper to remove the markings. The resultant directional scratches are then covered up by recoating with a liquid that cures to a color and texture similar to the original part. This method is usually fairly easy to detect with visual inspection and solvent application, but the remarking quality is improving. The second method is to use sandblasting equipment to gently remove the ink markings. The third method is to use mechanical lapping techniques to polish the surface. Since recoating the surface is not required, the last two methods are currently very difficult to detect, potentially requiring the use of a scanning electron microscope in order to detect leftover sanding particles or a different surface texture.

This topic solicits innovative methods of placing markings or coatings onto authentic parts at the time of manufacture, to enable customers at later stages in the supply chain to confirm that the component surfaces have not been tampered with. The four most critical requirements for this counterfeit component avoidance technique are:

1. The marking/coating must be virtually impossible for a counterfeiter to copy.

2. The marking/coating must withstand normal component handling and usage without significant deterioration.

3. The marking/coating process must not be cost-prohibitive.

4. The marking/coating verification process must not be cost or time prohibitive.

One method currently being investigated is the application of organic materials, specifically deoxyribonucleic acid (DNA), to component surfaces. Application of a unique mark to the component surface would provide a nearly guaranteed method of ensuring the component surfaces have not been tampered with. Components could still be refurbished and resold as new parts, but the markings, including lot and date code, would have to remain unchanged. While marking or coating components does not solve the current issue with obsolete parts, it would proactively address the counterfeiting of currently active parts which may become unavailable from authorized suppliers in the future. Development of a functional system may encourage widespread acceptance in DoD and commercial systems.

Development and test must be performed with the goal of meeting the four critical requirements above. Phase I development work should focus on meeting the first two critical requirements (difficult to copy, withstand normal use). Phase II should address the third critical requirement (cost-effective), plus investigate potential applications beyond electronic components. The third Phase should address the fourth critical component (simple fast detection).

PHASE I: Develop a method for placing a unique mark onto components. Ensure there are at least 10,000 different formulations available to identify different components, and potentially different manufacturing dates. Demonstrate the method for placing it onto a component in a manner that cannot be readily copied. Demonstrate the current detection methods are 100% accurate in differentiating legally coated/marked components from illegally (lower technology) coated/marked components, or uncoated/unmarked components. Demonstrate that the markings/coatings are compliant to MIL-STD-883H Test Method No. 2015 Resistance to Solvents after 1) physical handling, 2) temperature excursions from -65C to 300C for short periods (one minute), and -55C to 150C for extended periods (500 hours). Prove that modification of the surface by any of the three counterfeiting methods of remarking described above will guarantee detection as a remarked component. Acceptable detection methods at this level may include sending samples to the developer’s facility for analysis. Test plan must be submitted and approved by MDA.

PHASE II: Develop production-level methods that allow cost-effective placement of the unique marking onto components. Verify production capability to support marking formulation and supplies to multiple companies (100 minimum). Estimate minimum amount of unique marking material per component to achieve 100% confidence. Generate a cost model for the implementation. At this point the contractor or MDA would solicit DoD, contractor, and component manufacturer endorsement of the effort. The Phase II cost estimates would be assessed in order to determine feasibility.

PHASE III: Develop a plan to establish in-house detectability methods for electronic components that are 100% accurate in detecting remarked product. Determine implementation timeframe, and develop a cost estimate and time estimate for using equipment available for purchase to be used within the purchasing facility to determine whether components have been recoated. This in-house assessment capability must be stand-alone, but may include exchange of data with the developer in order to confirm encoded DNA information is accurate. MDA and developer present final information to DoD to develop plan forward for adoption (e.g., no adoption, adoption for only critical semiconductor components, full adoption).

COMMERCIALIZATION: The developer will pursue commercialization of the various technologies and processes developed in prior Phases potential commercial uses in electronic components, and assess potential for marking mechanical parts or materials, labels, and other items determined to be at high risk for counterfeiting.

REFERENCES:
1. "Intellectual Property Rights Violations: A Report on Threats to United States Interests as Home and Abroad", National Intellectual Property Rights Coordination Center, November 2011.

2. "DNA Marking and Authentication: A unique, secure anti-counterfeiting program for the electronics industry", James A. Hayward and Janice Meraglia.

KEYWORDS: Deoxyribonucleic acid (DNA), remarking, recoating, semiconductor, electronic components, obsolete, counterfeit.

MDA12-027 TITLE: <u>Thermal Isolation of Nozzle Exit Cone Insulators</u>

TECHNOLOGY AREAS: Air Platform, Battlespace, Weapons

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OBJECTIVE: Develop and demonstrate methods for thermally isolating a nozzle exit cone from its housing and the associated bondline joint.

DESCRIPTION: One of the limitations of a rocket motor nozzle is the heat transfer from the exit cone to the housing and bondline joint during firing and heat soak. This is especially true of a dual pulse rocket motor with an inter-pulse delay (IPD) that allows for additional heat soak between firings. Isolation of the exit cone retains the bondline joint integrity and reduces the temperature of adjacent components, such as, a flex bearing. For a dual pulse motor, this would allow for a longer IPD with greater flexibility in mission profiles due to added thermal protection and exit cone retention strength.

An innovation in applying thermal barrier coatings to phenolic nozzle components, such as, Carbon Cloth Phenolic (CCP) would reduce the heat transfer during and after operation of a rocket motor using a phenolic nozzle exit cone. The innovation should be both durable and lightweight while lowering the heat transfer into the bondline to maintain strength, and also reduce the heat transfer into the nozzle housing. The innovation should be compatible with traditional nozzle materials and adhesives while increasing performance over current state-of-the-art.

PHASE I: Develop a proof of concept, identify candidate materials for coatings, test capabilities, and conduct feasibility assessment for the proposed technology. Results from the design and assessment will be documented for Phase II.

PHASE II: Develop and demonstrate prototype designs incorporating Phase I technology in a relevant test environment. Develop and document design and/or test approaches. Perform appropriate characterization and testing, e.g. sub-scale motor tests.

PHASE III: The developed technology should have direct insertion potential into missile defense systems. Conduct engineering and manufacturing development, test and evaluation and hardware qualification. Demonstration would include, but not limited to, demonstration in a real system or operation in a system level test-bed with insertion planning for a missile defense interceptor.

COMMERCIALIZATION: The technologies developed under this SBIR topic should have applicability to automobile industry, aerospace industry unmanned vehicles, etc.

REFERENCES:
1. George P. Sutton, "Rocket propulsion Elements; Introduction to Engineering of Rockets", 7th edition, John Willey & Sons, 2001.

KEYWORDS: Adhesive, bondline, coating, insulator, nozzle, phenolic, solid propellant, thermal