

ARMY SBIR 10.1 PROPOSAL SUBMISSION INSTRUCTIONS

The US Army Research, Development, and Engineering Command (RDECOM) is responsible for execution of the Army SBIR Program. Information on the Army SBIR Program can be found at the following Web site: <https://www.armysbir.com/>.

Solicitation, topic, and general questions regarding the SBIR Program should be addressed according to the DoD portion of this solicitation. For technical questions about the topic during the pre-Solicitation period, contact the Topic Authors listed for each topic in the Solicitation. To obtain answers to technical questions during the formal Solicitation period, visit <http://www.dodsbir.net/sitis>. For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (8:00 am to 5:00 pm ET). Specific questions pertaining to the Army SBIR Program should be submitted to:

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The Army participates in three DoD SBIR Solicitations each year. Proposals not conforming to the terms of this Solicitation will not be considered. The Army 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.

SUBMISSION OF ARMY SBIR PROPOSALS

Army Phase I proposals have a 20-page limit; including the Cover Sheets and Technical Proposal, but excluding the Cost Proposal and the Company Commercialization Report. Proposals submitted over 20-pages will be deemed NON-RESPONSIVE and will not be evaluated. This statement takes precedence over section 3.4 of the general DoD solicitation instructions. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of those submitting the proposal to ensure any PDF conversion is accurate and does not cause the proposal to exceed the 20-page limit.

The entire proposal (which includes Cover Sheets, Technical Proposal, Cost Proposal, and Company Commercialization Report) must be submitted electronically via the DoD SBIR/STTR Proposal Submission Site (<http://www.dodsbir.net/submission>). When submitting the mandatory Cost Proposal, the Army prefers that small businesses complete the Cost Proposal form on the DoD Submission site, versus submitting within the body of the uploaded proposal. The Army WILL NOT accept any proposals which are not submitted via this site. Do not send a hardcopy of the proposal. Hand or electronic signature on the proposal is also NOT required. If the proposal is selected for award, the DoD Component program will contact you for signatures. If you experience problems uploading a proposal,

call the DoD Help Desk 1-866-724-7457 (8:00 am to 5:00 pm ET). Selection and non-selection letters will be sent electronically via e-mail.

Any proposal involving the use of Bio Hazard Materials must identify in the Technical Proposal whether the contractor has been certified by the Government to perform Bio Level - I, II or III work.

Companies should plan carefully for research involving animal or human subjects, or requiring access to government resources of any kind. Animal or human research must be based on formal protocols that are reviewed and approved both locally and through the Army's committee process. Resources such as equipment, reagents, samples, data, facilities, troops or recruits, and so forth, must all be arranged carefully. The few months available for a Phase I effort may preclude plans including these elements, unless coordinated before a contract is awarded.

If the offeror proposes to use a foreign national(s) [any person who is NOT a citizen or national of the United States, a lawful permanent resident, or a protected individual as defined by 8 U.S.C. 1324b(a)(3) – refer to Section 2.15 at the front of this solicitation for definitions of “lawful permanent resident” and “protected individual”] as key personnel, they must be clearly identified. **For foreign nationals, you must provide resumes, country of origin and an explanation of the individual’s involvement.**

No Class 1 Ozone Depleting Chemicals/Ozone Depleting Substances will be allowed for use in this procurement without prior Government approval.

Phase I Proposals must describe the "vision" or "end-state" of the research and the most likely strategy or path for transition of the SBIR project from research to an operational capability that satisfies one or more Army operational or technical requirements in a new or existing system, larger research program, or as a stand-alone product or service.

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

The Army implemented the use of a Phase I Option that may be exercised to fund interim Phase I activities while a Phase II contract is being negotiated. Only Phase I efforts selected for Phase II awards through the Army’s competitive process will be eligible to exercise the Phase I Option. The Phase I Option, which **must** be included as part of the Phase I proposal, covers activities over a period of up to four months 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 or cost-plus-fixed-fee Phase I Cost Proposal (\$120,000 maximum) 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 \$70,000 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.

Phase I Key Dates

10.1 Solicitation Pre-release	November 12 – December 9, 2009
10.1 Solicitation Opens	December 10, 2009 – January 13, 2010
10.1 Solicitation Closes	January 13, 2010; 6:00 a.m. ET
Phase I Evaluations	January – March 2010
Phase I Selections	March 2010
Phase I Awards	May 2010*

**Subject to the Congressional Budget process*

PHASE II PROPOSAL SUBMISSION

Army Phase II proposals have a 40-page limit; including the Cover Sheets and Technical Proposal, but excluding the Cost Proposal and the Company Commercialization Report. Proposals submitted over 40-pages will be deemed NON-RESPONSIVE and will not be evaluated. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of those submitting the proposal to ensure any PDF conversion is accurate and does not cause the proposal to exceed the 40-page limit.

Note! Phase II Proposal Submission is by Army Invitation only.

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 are successfully executing their Phase I efforts, will be invited to submit a Phase II proposal. Invitations to submit Phase II proposals will be released at or before the end of the Phase I period of performance. The decision to invite a Phase II proposal will be made based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in section 4.3. DoD is not obligated to make any awards under Phase I, II, or III. DoD is not responsible for any money expended by the proposer before award of any contract. For specifics regarding the evaluation and award of Phase I or II contracts, please read the front section of this solicitation very carefully. Every Phase II proposal will be reviewed for overall merit based upon the criteria in section 4.3 of this solicitation, repeated below:

- a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
- b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.
- c. The potential for commercial (defense and private sector) application and the benefits expected to accrue from this commercialization. The Army exercises discretion on whether a Phase I award recipient is invited to propose for Phase II. Invitations are issued no earlier than completion of the fourth month of the Phase I contract award, with the Phase II proposals generally due one month later. In accordance with SBA policy, the Army 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.

Invited small businesses are required to develop and submit a technology transition and commercialization plan describing feasible approaches for transitioning and/or commercializing the developed technology in their Phase II proposal. Army Phase II cost proposals must contain a budget for the entire 24 month Phase II period not to exceed the maximum dollar amount of \$730,000. During contract negotiation, the contracting officer may require a cost proposal for a base year and an option year. These costs must be submitted using the Cost Proposal format (accessible electronically on the DoD submission site), and may be presented side-by-side on a single Cost Proposal Sheet. The total proposed amount should be indicated on the Proposal Cover Sheet as the Proposed Cost. Phase II projects will be evaluated after the base year prior to extending funding for the option year.

Fast Track (see section 4.5 at the front of the Program Solicitation). Small businesses that participate in the Fast Track program do not require an invitation. Small businesses must submit (1) the Fast Track

application within 150 days after the effective date of the SBIR phase I contract and (2) the Phase II proposal within 180 days after the effective date of its Phase I contract.

CONTRACTOR MANPOWER REPORTING APPLICATION (CMRA)

Accounting for Contract Services, otherwise known as Contractor Manpower Reporting Application (CMRA), is a Department of Defense Business Initiative Council (BIC) sponsored program to obtain better visibility of the contractor service workforce. This reporting requirement applies to all Army SBIR contracts.

Beginning in the DoD 2006.2 SBIR solicitation, offerors are instructed to include an estimate for the cost of complying with CMRA as part of the cost proposal for Phase I (\$70,000 maximum), Phase I Option (\$50,000 max), and Phase II (\$730,000 max), under “CMRA Compliance” in Other Direct Costs. This is an estimated total cost (if any) that would be incurred to comply with the CMRA requirement. Only proposals that receive an award will be required to deliver CMRA reporting, i.e. if the proposal is selected and an award is made, the contract will include a deliverable for CMRA.

To date, there has been a wide range of estimated costs for CMRA. While most final negotiated costs have been minimal, there appears to be some higher cost estimates that can often be attributed to misunderstanding the requirement. The SBIR Program desires for the Government to pay a fair and reasonable price. This technical analysis is intended to help determine this fair and reasonable price for CMRA as it applies to SBIR contracts.

- The Office of the Assistant Secretary of the Army (Manpower & Reserve Affairs) operates and maintains the secure CMRA System. The CMRA Web site is located here: <https://cmra.army.mil/>.
- The CMRA requirement consists of the following items, which are located within the contract document, the contractor's existing cost accounting system (i.e. estimated direct labor hours, estimated direct labor dollars), or obtained from the contracting officer representative:
 - (1) Contract number, including task and delivery order number;
 - (2) Contractor name, address, phone number, e-mail address, identity of contractor employee entering data;
 - (3) Estimated direct labor hours (including sub-contractors);
 - (4) Estimated direct labor dollars paid this reporting period (including sub-contractors);
 - (5) Predominant Federal Service Code (FSC) reflecting services provided by contractor (and separate predominant FSC for each sub-contractor if different);
 - (6) Organizational title associated with the Unit Identification Code (UIC) for the Army Requiring Activity (The Army Requiring Activity is responsible for providing the contractor with its UIC for the purposes of reporting this information);
 - (7) Locations where contractor and sub-contractors perform the work (specified by zip code in the United States and nearest city, country, when in an overseas location, using standardized nomenclature provided on Web site);
- The reporting period will be the period of performance not to exceed 12 months ending September 30 of each government fiscal year and must be reported by 31 October of each calendar year.
- According to the required CMRA contract language, the contractor may use a direct XML data transfer to the Contractor Manpower Reporting System database server or fill in the fields on the Government Web site. The CMRA Web site also has a no-cost CMRA XML Converter Tool.

Given the small size of our SBIR contracts and companies, it is our opinion that the modification of contractor payroll systems for automatic XML data transfer is not in the best interest of the Government. CMRA is an annual reporting requirement that can be achieved through multiple means to include manual entry, MS Excel spreadsheet development, or use of the free Government XML converter tool. The annual reporting should take less than a few hours annually by an administrative level employee. Depending on labor rates, we would expect the total annual cost for SBIR companies to not exceed \$500.00 annually, or to be included in overhead rates.

DISCRETIONARY TECHNICAL ASSISTANCE

In accordance with section 9(q) of the Small Business Act (15 U.S.C. 638(q)), the Army will provide technical assistance services to small businesses engaged in SBIR projects through a network of scientists and engineers engaged in a wide range of technologies. The objective of this effort is to increase Army SBIR technology transition and commercialization success thereby accelerating the fielding of capabilities to Soldiers and to benefit the nation through stimulated technological innovation, improved manufacturing capability, and increased competition, productivity, and economic growth.

The Army has stationed Technical Assistance Advocates (TAAs) in five regions across the Army to provide technical assistance to small businesses that have Phase I and Phase II projects with the participating organizations within their regions.

For more information go to http://www.armysbir.com/sbir/taa_desc.htm.

COMMERCIALIZATION PILOT PROGRAM (CPP)

In FY07, the Army initiated a CPP with a focused set of SBIR projects. The objective of the effort was to increase Army SBIR technology transition and commercialization success and accelerate the fielding of capabilities to Soldiers. The ultimate measure of success for the CPP is the Return on Investment (ROI), i.e. the further investment and sales of SBIR Technology as compared to the Army investment in the SBIR Technology. The CPP will: 1) assess and identify SBIR projects and companies with high transition potential that meet high priority requirements; 2) provide market research and business plan development; 3) match SBIR companies to customers and facilitate collaboration; 4) prepare detailed technology transition plans and agreements; 5) make recommendations and facilitate additional funding for select SBIR projects that meet the criteria identified above; and 6) track metrics and measure results for the SBIR projects within the CPP.

Based on its assessment of the SBIR project's potential for transition as described above, the Army will utilize a CPP investment fund of SBIR dollars targeted to enhance ongoing Phase II activities with expanded research, development, test and evaluation to accelerate transition and commercialization. The CPP investment fund must be expended according to all applicable SBIR policy on existing Phase II contracts. The size and timing of these enhancements will be dictated by the specific research requirements, availability of matching funds, proposed transition strategies, and individual contracting arrangements.

NON-PROPRIETARY SUMMARY REPORTS

All award winners must submit a non-proprietary summary report at the end of their Phase I project and any subsequent Phase II project. The summary report is unclassified, non-sensitive, and non-proprietary and should include:

- A summation of Phase I results
- A description of the technology being developed

- The anticipated DoD and/or non-DoD customer
- The plan to transition the SBIR developed technology to the customer
- The anticipated applications/benefits for government and/or private sector use
- An image depicting the developed technology

The non-proprietary summary report should not exceed 700 words, and is intended for public viewing on the Army SBIR/STTR Small Business area. This summary report is in addition to the required final technical report and should require minimal work because most of this information is required in the final technical report. The summary report shall be submitted in accordance with the format and instructions posted within the Army SBIR Small Business Portal at <http://www.armysbir.com/smallbusinessportal/Firm/Login.aspx> and is due within 30 days of the contract end date.

ARMY SUBMISSION OF FINAL TECHNICAL REPORTS

A final technical report is required for each project. Per DFARS clause 252.235-7011 (<http://www.acq.osd.mil/dpap/dars/dfars/html/current/252235.htm#252.235-7011>), each contractor shall (a) submit two copies of the approved scientific or technical report delivered under the contract to the Defense Technical Information Center, Attn: DTIC-O, 8725 John J. Kingman Road, Fort Belvoir, VA 22060-6218; (b) Include a completed Standard Form 298, Report Documentation Page, with each copy of the report; and (c) For submission of reports in other than paper copy, contact the Defense Technical Information Center or follow the instructions at <http://www.dtic.mil>.

ARMY SBIR PROGRAM COORDINATORS (PC) and Army SBIR 10.1 Topic Index

Participating Organizations	PC	Phone
<u>Aviation and Missile RD&E Center (Missile)</u>	Otho Thomas	(256) 842-9227
A10-001	Innovative Method to Correlate Sub-Scale to Full-Scale Insensitive Munition Tests	
A10-002	Correlated Radar Clutter Map Creation for Multi-spectral Scene Generation	
A10-003	Controllable Spectrum Infrared Source	
A10-004	Modular, Rapid, Common Hardware-in-the-loop Framework Development	
A10-005	Novel Propellant Formulations Containing Nano-particulates	
A10-006	Missile Delivered UAV	
A10-007	Coupled Jet-Interaction Base Flow Simulation	
A10-008	Synthesis of Sulfide Nanopowders for Durable Optical Ceramics	
<u>U.S. Army Test & Evaluation Command</u>	Nancy Weinbrenner	(703) 681-0573
	Michael Orlowicz	(410) 278-1494
A10-009	Automation of the Operational Test Data Process	
<u>Communication Electronics Command</u>	Suzanne Weeks	(732) 427-3275
A10-010	Real-time Visualization Tool for Distributed Intrusion Detection System Data	
A10-011	Intelligent Agents for Improved Sensor Deployment and Surveillance	
A10-012	Coordinated Responses through Knowledge Sharing in Mobile Agent-Based Intrusion Detection Systems	
A10-013	Intrusion Detection System (IDS) With Automatic Signature Generation for Self Healing Networks	
A10-014	Spoofing Network Architectures in Response to Hostile Reconnaissance	
A10-015	Linearity Improvement of MMIC Power Amplifiers at Reduced Output Power Backoff	
A10-016	Wideband Multi-Carrier Digital Up-Converter	
A10-017	Indium Surface Preparation for Improved Flip-Chip Hybridization	

A10-018 In-Vacuo Passivation of High Aspect Ratio HgCdTe Surfaces
A10-019 Electronically Switchable infrared Beam Splitter Technology
A10-020 Advanced Molded Glass Lenses
A10-021 Lightweight, Wide Field-Of-View Wave-guided Head-mounted Display
A10-022 Innovative Annealing Apparatus for Mercury-Based, Compound Semiconductors
A10-023 Untethered Real Time Low Cost Head Tracking
A10-024 Real-Time Vis-SWIR Multispectral Sensor for Day/Night Operations
A10-025 Large Format Dual Band FPA ROIC for Low Flux Environments

Edgewood Chemical Biological Center

Ron Hinkle

(410) 436-2031

A10-026 A Viable Method for Metal Nano-Coating of Graphite Microfibers
A10-027 Improved Methods of Explosively Disseminating Bi-Spectral Obscurant Materials

Space and Missiles Defense Command

Denise Jones

(256) 955-0580

A10-028 Innovative and Novel Concepts for Eye-Safe Wavelength High Power Fiber Lasers for Increased Performance
A10-029 Flux Compression Generators
A10-030 Electromagnetic Attack Detector
A10-031 Lightweight Nanosatellite Propulsion System to Enhance Battlespace Awareness and Battle Command Capabilities
A10-032 Information Security and Trust in a Space Communications Network

DEPARTMENT OF THE ARMY PROPOSAL CHECKLIST

This is a Checklist of Army Requirements for your proposal. Please review the checklist carefully to ensure that your proposal meets the Army SBIR requirements. You must also meet the general DoD requirements specified in the solicitation. **Failure to meet these requirements will result in your proposal not being evaluated or considered for award.** Do not include this checklist with your proposal.

___ 1. The proposal addresses a Phase I effort (up to **\$70,000** with up to a six-month duration) AND (if applicable) an optional effort (up to **\$50,000** for an up to four-month period to provide interim Phase II funding).

___ 2. The proposal is limited to only **ONE** Army Solicitation topic.

___ 3. The technical content of the proposal, including the Option, includes the items identified in Section **3.5** of the Solicitation.

___ 4. **Army Phase I proposals have a 20-page limit**; including the Cover Sheets and Technical Proposal, but **excluding the Cost Proposal and the Company Commercialization Report**. Proposals submitted over 20-pages will be deemed **NON-RESPONSIVE** and **will not** be evaluated. This statement takes precedence over section 3.4 of the general DoD solicitation instructions. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of those submitting the proposal to ensure any PDF conversion is accurate and does not cause the proposal to exceed the 20-page limit.

___ 5. The Cost Proposal has been completed and submitted for both **the Phase I and Phase I Option** (if applicable) and the costs are shown separately. The Army prefers that small businesses complete the Cost Proposal form on the DoD Submission site, versus submitting within the body of the uploaded proposal. The total cost should match the amount on the cover pages.

___ 6. Requirement for Army Accounting for Contract Services, otherwise known as CMRA reporting is included in the Cost Proposal.

___ 7. If applicable, the Bio Hazard Material level has been identified in the technical proposal.

___ 8. If applicable, plan for research involving animal or human subjects, or requiring access to government resources of any kind.

___ 9. The Phase I Proposal describes the "vision" or "end-state" of the research and the most likely strategy or path for transition of the SBIR project from research to an operational capability that satisfies one or more Army operational or technical requirements in a new or existing system, larger research program, or as a stand-alone product or service.

___ 10. If applicable, Foreign Nationals are identified in the proposal. An employee must have an H-1B Visa to work on a DoD contract.

Army SBIR 10.1 Topic Index

A10-001	Innovative Method to Correlate Sub-Scale to Full-Scale Insensitive Munition Tests
A10-002	Correlated Radar Clutter Map Creation for Multi-spectral Scene Generation
A10-003	Controllable Spectrum Infrared Source
A10-004	Modular, Rapid, Common Hardware-in-the-loop Framework Development
A10-005	Novel Propellant Formulations Containing Nano-particulates
A10-006	Missile Delivered UAV
A10-007	Coupled Jet-Interaction Base Flow Simulation
A10-008	Synthesis of Sulfide Nanopowders for Durable Optical Ceramics
A10-009	Automation of the Operational Test Data Process
A10-010	Real-time Visualization Tool for Distributed Intrusion Detection System Data
A10-011	Intelligent Agents for Improved Sensor Deployment and Surveillance
A10-012	Coordinated Responses through Knowledge Sharing in Mobile Agent-Based Intrusion Detection Systems
A10-013	Intrusion Detection System (IDS) With Automatic Signature Generation for Self Healing Networks
A10-014	Spoofing Network Architectures in Response to Hostile Reconnaissance
A10-015	Linearity Improvement of MMIC Power Amplifiers at Reduced Output Power Backoff
A10-016	Wideband Multi-Carrier Digital Up-Converter
A10-017	Indium Surface Preparation for Improved Flip-Chip Hybridization
A10-018	In-Vacuo Passivation of High Aspect Ratio HgCdTe Surfaces
A10-019	Electronically Switchable infrared Beam Splitter Technology
A10-020	Advanced Molded Glass Lenses
A10-021	Lightweight, Wide Field-Of-View Wave-guided Head-mounted Display
A10-022	Innovative Annealing Apparatus for Mercury-Based, Compound Semiconductors
A10-023	Untethered Real Time Low Cost Head Tracking
A10-024	Real-Time Vis-SWIR Multispectral Sensor for Day/Night Operations
A10-025	Large Format Dual Band FPA ROIC for Low Flux Environments
A10-026	A Viable Method for Metal Nano-Coating of Graphite Microfibers
A10-027	Improved Methods of Explosively Disseminating Bi-Spectral Obscurant Materials
A10-028	Innovative and Novel Concepts for Eye-Safe Wavelength High Power Fiber Lasers for Increased Performance
A10-029	Flux Compression Generators
A10-030	Electromagnetic Attack Detector
A10-031	Lightweight Nanosatellite Propulsion System to Enhance Battlespace Awareness and Battle Command Capabilities
A10-032	Information Security and Trust in a Space Communications Network

Army SBIR 10.1 Topic Descriptions

A10-001 TITLE: Innovative Method to Correlate Sub-Scale to Full-Scale Insensitive Munition Tests

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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 an innovative method (modeling and experiment) to successfully correlate subscale propellant, warhead, and explosive sensitivity testing to full-scale Insensitive Munition Testing.

DESCRIPTION: All munitions that contain energetic materials, such as propellants and warheads, are required to pass relevant Insensitive Munitions tests or obtain waivers from the Department of Defense Insensitive Munitions Board. These tests require full-up systems and are very expensive. A number of subscale tests, such as critical diameter, card gap, and burn-to-violent reaction tests, have been developed to screen energetic material that are being considered for application into a new system or as an upgrade to an existing munition. These tests are sometimes required to obtain an interim hazard classification and, eventually, a full Department of Transportation approval. There has been little effort to correlate the results of these subscale tests, either using modeling or experiments, to full-scale tests. Often, tests like critical diameter tests are required for safety or transportation purposes in a government publication without explaining how the results are used to approve or deny the request. This is a high risk program because the subscale tests do not simulate large scale testing. The small scale tests only address one of a number of parameters that control sensitivity and safety. For instance, the Burn-to-Violent Reaction test is performed by shooting a bullet or fragment at a test device composed of two square samples with a propellant bonded to a missile's case material and the propellant sides facing each other. This determines the sensitivity to impact and shock, but does not represent a full-up missile motor that is circular, with a complex center perforation shape, and can allow pressure to increase. A method to correlate the subscale and full-scale test results is needed to reduce cost and schedule for meeting Insensitive Munition requirements. Similarly, the other subscale tests only address one specific parameter and not the motor as a whole. In addition, there has not been a large number of full-scale tests because of the huge expense; therefore, an empirical correlation is not practical. Teaming with a solid propellant motor manufacturer is recommended because of their experience and capabilities with subscale and full-scale tests. Such teaming, however, is not required.

PHASE I: The physics that control IM test response will be studied and a set the key parameters that affect these tests will be proposed. The subscale tests be analyzed to determine which of these parameters they address, and then to determine if there is a fatal flaw in these subscale tests that prevent a correlation or a modification to a test that will eliminate or minimize that flaw. Data from the full-scale and subscale tests will be compared using the identified key parameters. Phase I will require significant innovative and creative thinking. A number of key issues will be identified that cannot be determined by standard tests and will be identified as technology gaps. Phase I should be focused on minimum signature, Class 1.1 propellants. The Phase I deliverable will be a report that describes the physics that controls the IM tests, which parameters are being adequately addressed by the current subscale tests, and which need to have new tests developed.

PHASE II: New subscale tests will be developed to address the technology gaps identified in Phase I. The small business has the flexibility to delete a current test if it does not adequately address a parameter and will need creative thinking to develop these innovative new tests. Current and newly developed subscale tests will be performed on currently deployed tactical missile systems and the resulting data will be used to assure that all of the critical parameters are fully characterized. The final task is to determine correlations between the subscale test results and those from full-scale tests. Phase II should address both Class 1.1 and 1.3 solid propellants.

PHASE III: All Department of Defense Services should be very interested in this capability once it is demonstrated to be reliable, as would solid propellant manufacturers. This method will apply to propulsion, warhead, and other explosive applications. Other potential marketing targets would be the mine and road construction industries. To commercialize the results of this program, the method could be sold or leased to interested organizations (DOD, Industry, mining/construction industries) or the small business could sell their services as a consultant to the same organization to aid in the development of new energetic systems.

REFERENCES:

1. TB 700-2 Department of Defense Ammunition and Explosives Hazard Classification (newest revision)
2. MIL-STD-1751A (or newest revision) Department of Defense Test Method Standard Safety and Performance Tests of the Qualification of Explosives (High Explosives, Propellants, and Pyrotechnics)
3. 49 CFR Title 49 Hazardous Material Regulations (newest revision)
4. MIL-STD-2105C (or newest revision) Department of Defense Test Method Standard Hazard Assessment Tests for Non-Nuclear Munitions (Insensitive Munitions Standard)

KEYWORDS: solid propellants; minimum signature propellants; propellant development; solid propellant motor testing; sub-scale propellant testing; full-scale Insensitive munitions testing.

A10-002 TITLE: Correlated Radar Clutter Map Creation for Multi-spectral Scene Generation

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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 computational techniques for creation of spatially correlated MMW clutter maps for use in computer scene generation applications

DESCRIPTION: Correlated computer-generated imagery stimulates advanced multi-spectral seeker models used in the development of data fusion algorithms. Current methods for generating spatially correlated millimeter wave (MMW) clutter for site-specific terrains require time-intensive off-line mathematical operations (convolution) to produce inputs for scene generators. These terrains are used in integrated flight simulations (IFS) of tactical missiles using scene-based sensors. The requirement is to generate spatially correlated MMW clutter maps that are registered to infrared (IR) and semi-active (SAL) terrain databases through terrain height and class maps of test sites. It is desired that a method be found in which the requisite terrain MMW map is either computed rapidly at the beginning of the simulation or during the actual simulated flight. Possible approaches include Fast Fourier Transforms (FFT) or fractal-based generators. The method should allow for the statistical variation of clutter radar cross sections (σ_0) based on the class type, while retaining the texture or spatial correlation found in the terrain. It is also desired that the method incorporate the correct relationships among linear and circular polarization components, with the ability to generate either linear or circular polarization as needed.

Contract Security Classification Specification, DD Form 254, is not required.

PHASE I: The goal of the Phase I effort is to identify promising approaches for creation of spatially correlated MMW clutter maps from empirical terrains used in integrated flight simulations (IFS) at the Aviation and Missile Research, Development and Engineering Center (AMRDEC). Various techniques will be examined for their suitability to generate spatially correlated radar returns from empirical MMW terrain databases. Metrics for

computational efficiency and fidelity will be developed to compare radar return estimates from the new MMW clutter generation algorithms and MMW empirical databases. Phase I will demonstrate the feasibility of promising techniques for generating spatially correlated MMW clutter and will outline demonstration success criteria for Phase II.

PHASE II: The Phase II effort consists of performing modeling and simulation of advanced computation techniques for spatially correlated MMW clutter generation and demonstrating metrics for each technique's results versus empirical terrain databases. The empirical terrains are used in the Aviation and Missile Research, Development and Engineering Center's (AMRDEC) Common Scene Generator (CSG) to support integrated flight simulations (IFS) of tactical missile seekers. This phase will produce a final set of algorithms for generation of spatially correlated MMW clutter suitable for military and commercial applications. The Phase II data package will include algorithms descriptions, source code, results from algorithm metric tests, and verification that the algorithm's outputs support fidelity requirements for multi-spectral seekers used on contemporary tactical missile systems.

PHASE III: The Phase III effort is a continuation of the Phase II effort to productize the methods for generating correlated MMW terrain databases for military and commercial scene generation applications. A software library with these algorithms will be produced that provides support for military terrain databases and commercially available terrain databases. This software library will be integrable into the AMRDEC's Common Scene Generator, which is used in scene-based flight simulations of tactical missile systems. The software library will be compatible with commercial terrain database standards to support terrain visualization and situation awareness applications. Documentation of the algorithms, source code and validation results will be provided to support transfer of simulation technologies to scene generation applications.

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KEYWORDS: clutter, spatial correlation, millimeter-wave, texture, simulation, radar, scene generation

A10-003 TITLE: Controllable Spectrum Infrared Source

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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: Development of efficient, controllable infrared (IR) sources to support the testing of NIR to LWIR sensors within a Hardware-in-the-Loop (HWIL) simulation environment. A realistic NIR to LWIR simulator capable of producing correct in-band spectrum irradiance levels would provide a repeatable, more realistic, and cost-effective means of validating missile performance in critical, stressing environments.

DESCRIPTION: Many of today's most sophisticated missile sensors operate in environments with complex irradiance contributions. These contributions manifest themselves as either direct source illumination or diffuse background illumination. Missile systems are often required to handle all aspects of these optical effects, including stray light rejection, raised background levels and additional background noise contributions. Select sensor systems

even require nominal operation while the solar disk is within the operational field-of-view. State-of-the-art scene projector systems have historically addressed only the target/objects infrared thermal emissions. Direct and indirect irradiance of the unit-under-test (UUT) have not been addressed outside of optical modeling codes. Efficient controllable infrared sources are needed to cover all IR contributions in a realistic spectral environment. The desired IR source should be efficient IR emitter that can cover many gaps that exist in IR emitter sources. The emitter intensity should be controllable with the minimum dynamic range of 8 bits, and center wavelength should be stable to less than 0.01 microns and the spectral width of less than 0.1 microns. The desired power output is greater than 200mW per 0.1 micron spectral width.

PHASE I: Explore the feasibility of developing a set of efficient NIR to LWIR sources that can be controlled in amplitude. Evaluate innovative approaches which may be used to build an integrated solution and perform trade-off analysis to determine the best approach. Develop a preliminary design for the NIR to LWIR simulator test set. Perform modeling and analysis to establish the proof-of-principle and predict the performance specifications for the final system. Phase I report shall detail theoretical performance limits and possible methods to achieve desired performances.

PHASE II: Perform detailed design of the concept selected in Phase I, and fabricate one of more prototype NIR to LWIR IR sources for the simulator test set. Demonstrate an integrated solution and characterize its performance in an actual HWIL environment. Government furnished equipment items, such as stand-alone NIR pulsed laser projectors, can be used in the evaluation and testing of the proposed test set. Prototype emitters shall be developed under this effort which are compatible with HWIL facility use in size, energy consumption and safety.

PHASE III: Commercial applications for this technology are found in the medical, law enforcement, fire, automobile, security, and air craft industries. The select frequency, controllable IR sources developed under this topic would provide excellent sources for selectable frequency heating lamps, health and status monitor for medical imaging, and more efficient telecommunications transmitters. Military applications for this technology include IR seeker testing, virtual training environment, and stealth IR illumination system.

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KEYWORDS: near-infrared (NIR), longwave infrared (LWIR), hardware in the loop (HWIL), simulations, solar radiation, glint, internal reflection

A10-004 TITLE: Modular, rapid, common hardware-in-the-loop framework development

TECHNOLOGY AREAS: Air Platform, Information Systems, Electronics, Battlespace, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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OBJECTIVE: The goal of this topic is to research and develop key technology areas that will reduce latency in a multi-node communication architecture and lead to a modular and re-usable communications architecture for the hardware-in-the-loop (HWIL) test environment.

DESCRIPTION: Two key technology areas need to be improved to perform real-time HWIL simulations. One area is wideband multi-node data switching capability with ultra low latency capable of adapting to a flexible simulation architecture. The system must exhibit fault tolerance, high resolution data time tagging, and deterministic data transfer. Another critical area that has to be developed is the capability to run parts of simulations in a firmware environment whenever possible to reduce the simulation latency. This requires an innovative method to convert complex high level codes to firmware codes such as Very High Speed Integrated Circuits Hardware Description Language (VHDL).

PHASE I: Establish feasibility of the proposed concept by defining a multi-node switch architecture and latency reduction concepts to meet or exceed design goals.

PHASE II: Develop and demonstrate a prototype system of at least three nodes. Demonstrate that design goals are met and illustrate expandability to at least 24 nodes without loss of capability. Demonstrate reliable communications without message loss and data time-tagging ability. Demonstrate the capability to convert traditionally SW intensive process in a firmware environment.

PHASE III: Demonstrate viability in commercial application by integrating the system into an Army laboratory. The system will be used for missile HWIL testing and aviation survivability equipment development environment. The concept can be applied to reduce the latency in a multi-node battlefield communication systems. Potential commercial applications include high performance cluster computing environments in which a diverse array of data types and formats are utilized, such as digital content distribution, digital video surveillance with processing such as facial recognition, signal processing, and scientific research. This system could permit the development of massively parallel computing environments in which the compute units operate asynchronously and share no common communications protocol.

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KEYWORDS: communications, switches, network architecture, HWIL, modular, high bandwidth, low latency

A10-005 TITLE: Novel Propellant Formulations Containing Nano-particulates

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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 minimum signature solid propellant using nano-particles to improve its physical and ballistic properties.

DESCRIPTION: There has been little recent success in formulating new propellants that have higher burning rates, and better physical and Insensitive Munition properties. One reason is that most of this work has been to vary the currently accepted propellant ingredients. Novel oxidizer, fuel, or binders are necessary to break out of this constraint. Nano-technology has been receiving significant attention in the last few years in all DOD components as well as other agencies because of their unique properties. In past years, nano-sized ammonium perchlorate demonstrated a faster burning rate, but it also increased its sensitivity. Nano-particulates have unique properties, such as huge surface area and potential attraction on a molecular level; therefore, they have the potential to increase burning rate, specific impulse, and/or physical properties. Ammonium perchlorate and ammonium nitrate are not of interest for this topic. No other restrictions are given on nano-particulate candidates. This topic relates to nitrocellulose/nitramine minimum signature propellants; therefore, high concentrations of a metal would not be of interest because the resulting propellant would not meet minimum signature requirements. There have been problems with nano-particulates agglomerating and increasing viscosity during mixing processes in many applications; therefore, attention must be paid to how easily the nano-particulates are dispersed. Also, nano-particulates can be health hazards, therefore, safe working practices are required to assure that personnel are not exposed to these materials. Creative approaches, both candidate nano-materials and/or their purpose) is desired, therefore, examples of nano-particulates and how they are used are not given. Due to the requirement to work with energetic materials, partnering with an established propulsion manufacturer is strongly suggested, but not required.

PHASE I: The list of potential candidate nano-particles identified in the proposal will be evaluated at a small scale to determine their compatibility with minimum signature propellant components. The cost of these materials is not an issue at this time because if a nano-particulate has promise, the price will decrease significantly when it is needed in large quantities. These nano-materials could be purchased commercially or synthesized by the proposer or their subcontractor. These compatibility tests will be required as additional candidate materials are identified. Those candidates that are demonstrated to be compatible with the other propellant ingredients will be formulated on a small scale and characterized by Differential Scanning Calorimetry, Thermal Gravimetric Analysis, and burning rate. The results of these small scale tests will be evaluated and the burning rate exponent, n , obtained. Thermal chemical calculations will be performed to determine if the new formulations have the same or increased specific impulse. At least four nano-materials will be identified for further development and characterization in Phase II.

PHASE II: The candidate formulations will be scaled up to sufficient size to determine stress, strain, and modulus of the propellants at temperatures between -40°C and $+65^{\circ}\text{C}$. The temperature coefficient of burning rate at constant pressure, sp , and the temperature sensitivity of chamber pressure at constant area ratio, pk will be determined. Small motors, such as the Army standard 2" x 4" motors, that contain about a third of a pound of propellant, will be produced and tested to determine the pressure vs. time relationship. Larger motors, which contain about 10 pounds of propellant will be produced and tested at temperatures between -40°C and $+65^{\circ}\text{C}$ to determine standard ballistic properties at larger size. The data from the candidate propellant formulation tests will be evaluated and one formulation will be selected to obtain thorough ballistic, mechanical, and physical property characterization.

PHASE III: A novel formulation with improved physical, mechanical, ballistic and safety properties will be of interest to all Department of Defense Services, the Missile Defense Agency, NASA, the Coast Guard, and private companies that provide satellite insertion and/or manned space flights. The commercialization of the product of this program will be greatly enhanced by partnering with a major solid propulsion company. Communication with missile prime contractors during Phase I and/or Phase II would also promote the insertion of this propellant into existing missile systems.

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KEYWORDS: minimum signature solid propellant, propellant physical properties, propellant ballistic properties, nano-particulates, burning rate, stress, strain, modulus

A10-006 TITLE: Missile Delivered UAV

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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OBJECTIVE

To develop innovative concepts to provide near real-time situational awareness on the battlefield with the possibility of providing a quick response attack.

DESCRIPTION

ISR (Intelligence, Surveillance, and Reconnaissance) platforms delivered from missiles can potentially provide battlefield information that is only seconds old when transmitted from long ranges. This information is particularly valuable since it is so current. It provides the potential for striking a very mobile enemy before he has time to alter his position. In addition, it also offers the possibility of a deep strike by the platform itself.

Among the potential ISR platforms that have recently been proposed/developed/built are a large number of UAV (Unmanned Aerial Vehicle) and LAM (loiter-attack missile) concepts. Some of these concepts have the potential of being packaged in a missile and carried for long distances from their launch point. Obviously, the quicker the missile arrives in the vicinity of the targets, the more valuable the information being transmitted to the war fighter for use in targeting the enemy and/or providing situational awareness and/or providing battle damage information. The use of any existing components for this system obviously is important since the cost of the system is directly affected.

PHASE I: This solicitation seeks innovative concepts to deliver an ISR (Intelligence, Surveillance, and Reconnaissance) platform that reports back in near real-time and provides the possibility of a long-range strike mission at the end of the ISR mission. Technical approaches formulated in Phase-I shall place emphasis on minimization of the delay in providing battle field information and attacking the enemy target complex. Phase-I concept development shall include simulated fly-outs of the system to determine flight parameters of interest (area-

time coverage, maximum and minimum range, dispense altitude, operational altitude, etc.) and, thus, establish the potential for Phase-II success.

PHASE II: The technical approach formulated in Phase-I will be developed and refined for full-scale flight simulation. The contractor shall pay particular attention to the dispense of the ISR platform from the missile accounting for any aero-propulsion interference between the platform and missile. The contractor will also pay particular attention to the missile proposed for delivery of the ISR system to insure there are no incompatibilities between the delivery mission and the original operational requirements of the missile (center-of-gravity, angle-of-attack, flight velocity, etc.). The critical flight phase of the concept shall be refined and the dispense of the ISR platform planned for a test in a full scale, Government owned ground test facility using instrumented tunnel models at a fidelity level deemed appropriate at that time. Tunnel time will be provided as GFE; tunnel models will be developed under Phase-II.

PHASE III: If successful, the end result of this Phase-I/Phase-II research effort will be a validated concept and set of validated research tools for the dispense, by AMRDEC, of a ISR platform from a tactical missile. The transition of this product will require additional upgrades of the software tool set for a user-friendly environment along with the concurrent development of application specific data bases to include the required input parameters such as vehicle geometries, aerodynamic and aero-propulsion properties, and performance parameters.

For military applications, this technology is directly applicable to the battle field awareness provided from UAVs and other ISR platforms. Currently, this information is near real-time and is not provided for any long range battle field situations. There are no known commercial applications for this technology at this time; however, it is conceivable that search/rescue and wild fire control operations that have a very short time line could benefit directly from this technology product.

The most likely customer and source of Government funding for Phase-III will be those service project offices responsible for the development of battle field situational awareness specifically using UAV ISR platforms. Indeed, the expansion of UAV capabilities and missions throughout the armed services continues as one of the most promising areas of research as evident in Reference 1 which forecasts a combined service and industry near term investment of over \$20 billion.

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KEYWORDS: UAV, LAM, missile, delivery, ISR, performance

A10-007 TITLE: Coupled Jet-Interaction Base Flow Simulation

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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 an advanced physics based model capable of capturing the flowfield physics for a low altitude missile in flight during a guidance event in which a lateral jet-interaction thruster flowfield located near the missile base couples with the missile base flowfield.

DESCRIPTION: Positioning jet-interaction control thrusters near the aft end of a missile for pitch control offers an inviting configuration for missile designs; however, experience has shown that the performance of such configurations may be disappointing in that the resultant pitching moment during flight may be considerably less than the moment calculated using static jet-interaction thrust. Intuition would suggest coupling of the jet-interaction and base flowfields in these situations but the flowfield physics of the phenomena are unknown along with those parameters -- flight Mach number, jet-interaction thrust, base diameter, dynamic pressure, missile thrust to name but a few -- which could limit the effect.

Both missile base flows and jet-interaction flowfields have proven difficult areas for computational fluid dynamic (CFD) techniques. The flow region, in each case, contains most of the complications of aero-thermo-chemical problems including flow separation, two-phase gas/particle non-equilibrium, chemical kinetics, turbulent flow, and complex geometry. Often enough the state-of-the-art hybrid Reynolds-averaged Navier Stokes/Large eddy simulation (RANS/LES) computational fluid dynamic (CFD) formulations have proven inadequate to the task as a predictive tool for these flows without the added complications of coupled jet-interaction and base flowfields.

PHASE I: Innovative solutions techniques are sought which can advance the state-of-the-art for the prediction of the flowfield of a missile flying at low altitude (turbulent flow) during a guidance event in which a lateral jet-interaction thruster flowfield located near the missile base couples with the missile base flowfield while accounting for the effects of incoming boundary layer, asymmetric body flows, arbitrary particle size/number densities at the combustor exit, and three-dimensional arbitrary geometry. The model shall be able to predict the flow separation environment, particle distribution fields, and resultant body forces/moments.

One meaningful demonstration will then be executed and a flow field solution produced with this advanced computational model during Phase-I. This demonstration shall model the simple case of a Mach 1.05, sea level, air flow over an axisymmetric cylindrical body-base with jet-interaction thruster as follows:

Missile length = 1.55 m

Missile diameter = 0.17778 m

Hemispherical nose

Jet centered at 0.0508 m from the aft end

With jet-interaction thruster properties as follows:

H₂ gas

Constant specific heat ratio exhaust = 1.41

Constant molecular weight exhaust = 2.016

Stagnation temperature = 300 K

Stagnation pressure = 17.0 MPa

Exit radius = 7.985 mm

Throat radius = 3.665 mm

Conical nozzle with a 15 degree half-angle

The outcome of this test case will serve as a gauge to assess the potential for Phase-II success.

PHASE II: The physical model formulated in Phase I will be developed and refined using computational fluid dynamics to evaluate jet-interaction base flow coupling over a broad range of missile and thruster parameters of interest. Additionally, this advanced computational fluid dynamics model will be run blind for a supersonic jet-interaction test case for which detailed flowfield data will be available to demonstrate the advanced capabilities for analyzing and modeling coupled jet-interaction base flow regions.

PHASE III: If successful, the end result of this Phase-I/Phase-II research effort will be a validated predictive model for the analysis of missile designs which employ jet-interaction control thrusters near the aft end for pitch control. The transition of this product, a validated research tool, to an operational capability will require additional upgrades

of the software tool set for a user-friendly environment along with the concurrent development of application specific data bases to include the required input parameters such as missile geometries, solid rocket motor properties, jet-interaction thruster properties, and performance parameters.

For military applications, this technology is directly applicable to all rocket propulsion missile systems. The most likely customer and source of Government funding for Phase-III will be those service project offices responsible for the development of advanced missile concepts such as the KEAPS, KEI, and PAC-3 programs.

For commercial applications, this technology is directly applicable to all commercial launch systems such as the NASA Aries, and the Delta and Atlas families.

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KEYWORDS: base flow, jet-interaction, computational fluid dynamics, aerodynamics, missile

A10-008 TITLE: Synthesis of Sulfide Nanopowders for Durable Optical Ceramics

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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 processes to produce multi-kilogram quantities of high purity nanometer sized sulfide powders suitable for producing fully dense bulk nanocrystalline optical ceramics.

DESCRIPTION: Multimode sensors are being employed on missiles to maximize their modes of operation and target engagement. The dome or window used to protect the internal components must be transparent to all sensed wavelengths of the internal sensors. Very few materials are sufficiently transparent at both the semi-active laser wavelengths and long-wave infrared wavelengths (8-12 microns). The current benchmark material is multispectral ZnS, but it lacks the physical durability to survive in severe rain, sand, or shock environments. It has been demonstrated that reducing the grain size in oxide ceramic materials can improve mechanical properties. Long-wave infrared transmitting materials also should greatly benefit from reduced grain size.

Optical nanomaterials enable a new way of optimizing the mechanical properties without sacrificing optical properties. For long-wave infrared applications, sulfide based nanomaterials are required. The wavelengths of interest in these materials are visible through LWIR. In order to fabricate nanocrystalline sulfide optical ceramics

using suitable powder consolidation techniques, extremely fine, pure sulfide powders with narrow powder size distribution are required. The powders must be minimally agglomerated, have an average particle diameter of 35 nm to 50 nm with no more than 10% less than 10 nm and no more than 10% greater than 70nm, and a maximum particle diameter of 100 nm. Spherical powders are more desirable than powders having higher aspect ratios. The sintering characteristics and optical properties of ceramic powders are highly influenced by residual impurity levels. It is desirable to synthesize nanosized sulfide powders with minimum impurity content. The target sulfide purity is 99.99%. Impurities must be less than 10 ppm oxygen, less than 10 ppm carbon, and impurity transition metals less than detectable levels by GDMS. It is also desirable that the powders remains free flowing, resistant to agglomeration, and have good sintering kinetics.

The Army is seeking the following: (1) inexpensive, robust, and scalable method(s) for synthesizing nanosized (i.e., 10 – 100 nm) high purity sulfide powder with the characteristics described above; and (2) an inexpensive, robust, and scalable method to mass produce the nanosized sulfide powders. The process must produce repeatable powder characteristics such as particle size, chemical properties, and physical characteristics. The cost goal for this effort is less than \$500/kg. Additionally, suitable doping and/or anti-agglomeration agent(s) that may be used to suppress excessive grain growth during powder consolidation processing and/or to prevent inter particle agglomeration prior to powder compacting process may be needed. It is highly desirable that these agent(s) do not negatively affect the material properties of the densified ceramics.

PHASE I: Develop and/or demonstrate method(s) for synthesizing nanometer sized pure sulfide powders to include zinc sulfide and one other metal sulfide. Powders must meet the specifications described above. Develop an overall process design specification with particular attention to cost and scalability. The supplier must demonstrate the production of at least 1 kg of each material in a single batch and must show a path for reducing costs to the <\$500/kg goal.

PHASE II: Build and demonstrate a prototype process to synthesize the nanometer sized pure sulfide powders developed in Phase I. Demonstrate synthesis rates between 2-10 kilograms per day at the prototype scale while meeting purity, particle size, and uniform size distribution goals described above. Refine the method(s) if required. Extend the synthesis process capability to other sulfide powder compositions.

PHASE III: Refine and scale the powder synthesis process developed in Phase II for use in a commercial ceramics processing environment while maintaining the desired purity, particle size, and size distribution. The ability to produce pure nanoparticle sulfide powders will lead to more durable materials for long-wave infrared dome and window applications. Commercial applications may include security and surveillance, rugged infrared imagers for police, firefighters and first responders, industrial inspection systems, and biomedical imaging including endoscopy. The Army, along with other branches of service, is interested in using these materials for missile and sensor window applications. These materials could potentially be used by the military in surveillance, robotic vision, and medical applications as well.

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KEYWORDS: Zinc sulfide nanopowder, synthesis, mass production, low cost, scalable method

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop the capability to automate the operational test data process through design, demonstration, and implementation of a unified automated process related to system-of-systems test data with the objective of providing a draft product to the analyst within one week after the test to enable production of a final System Evaluation Report (SER) within 90 days after completion of an operational system-of-systems test event.

DESCRIPTION: Several acquisition programs present the test and evaluation community with significant challenges related to the timely reporting of system effectiveness based on information developed from massive amounts of data which are being collected from complex system-of-systems. Collection of this data may result in several hundred Terabytes per week to be processed, stored, correlated and used to produce a final test report. The collection and reduction of test and evaluation resources requires a new approach to these challenges.

The test data process consists of many time-related steps, most of which are conducted separately with significant intervening delays. The following steps are generally recognized, but may be varied in order or selected as needed, to be part of the test data process:

- a) Collection of data from the system(s) under test
- b) Transfer of selected data from the units(s) to a central or distributed collection point(s)
- c) On-line monitoring of selected data during the test
- d) Real-time test control
- e) Conversion of data to a common format
- f) Transfer and storage of the raw (unprocessed) data in a central or distributed database
- g) Processing
- h) Authentication
- i) Warehousing of processed data in a central or distributed database
- j) Restricting access
- k) Retrieval of the processed data
- l) Mining of the processed data for trends, relationships, and statistics
- m) Generation of the Test Report

The end product of the test and evaluation process is a Test Report on the battlefield effectiveness and suitability of the system(s) or system-of-systems under test. This report must be definitive and timely to support major acquisition decisions. In particular, evaluators and analysts must be able to have draft test results shortly after the conclusion of a test to allow sufficient time for analysis and final editing of the report. The criticality of acquisition decision timelines and the reduced resources to support analysis and evaluation require an increased emphasis on use of automation to augment and accelerate the operational test data process. During post-event analysis, the evaluator and analyst will want to assess performance from a wide range of aspects – from purely technical (speed and quality of service, throughput, timeliness of system responses) to purely operational (what were the impacts on command and control decisions, were fire missions executed in a timely manner if fire support messages were re-routed due to network turbulence, was situational awareness adversely impacted). In either case, the information required is exponentially more complex than that normally provided or assessed during traditional acquisition efforts.

It is envisioned that tools from many large-scale operations may provide some of the potential solutions, for example, the Versatile Information Systems Integrated On-Line Nationwide (VISION) technology, will make unified collection possible. Software tools such as VeriFIDES can be used to restrict access of data to authorized users. Other potential sources of solutions may come from the rapidly evolving fields of visual analysis and data mining and from previous government efforts towards an automated process. Applications for monitoring and analysis must be integrated with a variety of data types in real-time, application interfaces and data collection instrumentation to perform these functions.

PHASE I: The goal of Phase I is to perform a study to identify various automation technologies to meet the objectives outlined above and provide a general approach to their integration into a unified process. This study will include identification of technology alternatives for each test data process step listed above which may be suitable for process integration and sources of these technologies. Reuse of existing technology with appropriate tailoring is

encouraged as is identification of technologies needed which do not exist and possible avenues of development. The report should compare the technology alternatives and recommend a course of action.

PHASE II: The goal of Phase II is to design, develop and demonstrate a prototype of the integrated process recommended in Phase I. This plan should include a phased spiral development plan and identify specific technology developments, entry/exit criteria for each phase, task assignments and projected costs.

PHASE III: The capability developed under this SBIR has the potential to meet a wide variety of Government and commercial needs. Potential applications will include the ability to evaluate the performance of large scale systems or system-of-systems prior to deployment and fielding, and the ability to train users and evaluate systems under a variety of realistic conditions. The initial customer for this capability will be the Army Operational Test Command (OTC). OTC will utilize the capability to test and evaluate various Army systems. In Phase III, other customers would be across the government and industry. Customers in addition to OTC will include other Service test agencies and Federal and Service intelligence agencies, which must make sense and generate draft reports from streams of incoming test and intelligence information, respectively. Gathering, sorting, and reporting on intelligence information for both international strategic purposes and for homeland security can be accelerated and otherwise improved with this capability. In the commercial world, the need for data gathering and reporting automation is present in the test and evaluation and in the power and natural resource management arenas. For instance, industry conducts early developmental testing for DoD systems and for other customers, and this testing is increasingly involving complex, data-rich systems-of-systems environments. In the power monitoring and natural resources monitoring areas, power generation, water supply monitoring, and other environmental resource monitoring tasks are producing country-wide data that will need to be gathered, analyzed, and reported quickly. New breakthroughs in computational power will also increase the need for data sorting and reporting automation. A good example of the challenges being faced in the commercial world is the large scale testing of "cloud computing" solutions. The large scale, multiple system or system-of-system test problem is similar to the data stream from a cloud computing system, so the result of this research has the potential to offer significant commercial payoffs.

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1. AR 73-1 Test and Evaluation Policy, 1 August 2006.
2. DA Pam 73-1 Test and Evaluation in Support of System Acquisition, 30 May 2003.
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4. Concept Paper, Automating the Test Data Process in the Army Test and Evaluation Command, Henry Merhoff, 5 Oct 2004.

KEYWORDS: Operation Test data, Data Management, Data Processing, Automated Data Process, Data Warehouse, Data Mining

A10-010 TITLE: Real-time Visualization Tool for Distributed Intrusion Detection System Data

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: Develop a real-time visualization engine for distributed tactical intrusion detection systems (IDS).

DESCRIPTION: GhostNet was a cyber espionage network of over 1,295 infected computers in 103 countries that was reported about in March 2009. GhostNet was discovered following a 10-month investigation that was greatly aided by using advanced data visualization and analysis tools. Even with the current capabilities provided by

today's tools there is a need for further advancement of real-time visualization techniques. Furthermore, the tactical environment brings added complexities to distributed intrusion detection systems (IDS) that may also be wireless.

A main objective is to design a framework that facilitates real-time, visual data reduction techniques that help alleviate the information overload experienced by the Warfighter. Distributed intrusion detection systems have the potential to produce vast amounts of data that can easily overwhelm the administrators and nodes of a network and in the worst case desensitize them due to the constant flood of textual information. In a tactical environment, there is often not enough time to check every log entry from network nodes so there is a huge advantage for a system that can present the most important information in an easy to understand, visual format that allows the user to drill down further into the data if needed.

Moreover, recent trends show coordinated, stealthy behavior coming from multiple sources is on the rise. Another objective is to make the discovery of such events possible and better understood with novel visual representations and filtering. Having such a system in place will greatly aid in the detection and notification of network probing, distributed denial of service attacks, replay attacks, data exfiltration and other malicious behavior coming from coordinated efforts. It is also foreseeable that such tools could aid in the attribution of such attacks that are coming internally, externally, or both.

Designing and deploying these visualization techniques will help aid the real-time detection of coordinated attacks such as GhostNet and other network security intrusions. These visual systems will reduce detection time and false alarms by providing intuitive and timely information related to the overall security posture of the network. Filtering and clustering capabilities should be incorporated as ways to reduce the dataset and still maintain the essential information. One last challenge is ensuring that the software-based solution can operate in the tactical world where bandwidth and processing capabilities are limited and the number of nodes may range from a few to thousands. For this reason, the Army is seeking innovative ideas from the small business community in order to better visually present the data generated by a distributed IDS and the security posture of the network.

PHASE I:

- 1) Perform a study to determine what approaches can be taken toward attacking the problem. The end solution may run on both Windows and Linux.
- 2) Provide design and architectural documents for a prototype tool.
- 3) Develop a simple prototype that demonstrates the feasibility of the concept.
- 4) Towards the end of the study, a presentation will be given to the government detailing the Phase I effort and Phase II options. The government will decide whether to pursue a Phase II effort and the best options for it.

PHASE II:

- 1) Based on the results from Phase I, refine and extend the design of the real-time visualization tool for distributed intrusion detection system data prototype to a fully functioning solution.
- 2) Conduct a test and provide evaluation results that demonstrate the ability of the proposed solution to visually represent intrusion detection system data against a simulated attack.
- 3) Conduct a test and provide evaluation results that demonstrate the ability of the proposed solution to visually represent the identification of compromised hosts, data exfiltration and anomalous network flows.
- 4) Provide updated design and architectural documents regarding the Phase II effort.
- 5) A presentation will be given to the government detailing the Phase II effort.

PHASE III: In Phase III, the actual commercialization of the contractor product will take place. The technology being researched and developed under this topic will allow for quicker response time to network attacks, provide a real-time visual representation of the intrusion detection system data and the network security posture, and reduce the number of false alarms associated to IDS. These capabilities would benefit both the DoD strategic and tactical communities but also commercial organizations who need to optimize the speed at which network attacks are detected and responded to.

REFERENCES:

1. Tracking GhostNet: Investigating a Cyber Espionage Network <http://www.scribd.com/doc/13731776/Tracking-GhostNet-Investigating-a-Cyber-Espionage-Network>

2. A. Wood, "Intrusion detection: Visualizing Attacks in IDS Data", SANS Institute, February 2003.
3. Goodall, J. R. "User Requirements and Design of a Visualization for Intrusion Detection Analysis" Proceedings of the 2005 IEEE Workshop on Information Assurance and Security West Point, NY United States Military Academy, pp. 394-401, 2005.
4. G. Conti, K. Abdullah, J. Grizzard, J. Stasko, J. Copeland, M. Ahamad, H. Owen and C. Lee, "Countering Security Analyst and Network Administrator Overload Through Alert and Packet Visualization" IEEE Computer Graphics and Applications (CG&A), March 2006.
5. F. Fischer, F. Mansmann, D. Keim, S. Pietzko, and M. Waldvogel, "Large-scale Network Monitoring for Visual Analysis of Attacks" VizSec 2008, September 2008.
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KEYWORDS: Intrusion detection systems, visualization, network attacks, graphical display, real-time, distributed, tactical, cyber defense, cyber security

A10-011 TITLE: Intelligent Agents for Improved Sensor Deployment and Surveillance

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop intelligent agents that can be employed to work in coordination with multiple sensor networks to facilitate the deployment of the sensors to optimize situational awareness. These agents will interact with environmental and status monitoring devices to direct redeployment of the sensors in response to changing environmental conditions, degradation in sensor performance, or sensor failure. The intelligent agents will reconfigure the sensors so that mission priorities are addressed in real-time. Expected benefits to the warfighter include reduced operator workload and improved mission effectiveness. For example, when changing weather conditions (fog, heavy precipitation, sand storm, etc.), result in degraded sensor range and impaired field of view, the intelligent agent function will be to recognize deteriorating conditions, interact with the sensor model to derive effect on performance, evaluate impact to mission effectiveness, and reallocate unused sensors, or, direct reconfiguration of remaining sensors, to maximize overall mission performance. These innovative functional capabilities shall be applied to the Distributed Common Ground System-Army (DCGS-A) and Joint Unified Maritime Protection System (JUMPS).

DESCRIPTION: Increasingly complex operating areas such as fielded systems, and, the maritime domain, require an ever growing number and variety of sensors to provide adequate situational awareness in support of the detection of conventional and asymmetric threats. Intelligent agents have the potential to be applied to this mission, providing both analysis to optimize initial deployment, and, real-time monitoring to recommend changes in the sensors as a function of operational status, changing environmental conditions, or, updated mission priorities. Innovative approaches are sought for the design, development, and, employment, of intelligent agents in support of broad spectrum, multiple sensor systems that optimize sensor deployment and provide real-time recommendations for reconfiguration in response to changing conditions.

PHASE I: Perform design study to formulate innovative technical approaches to apply intelligent agents to a multiple sensor system suitable for use to support sensor deployment and reconfiguration in response to changing conditions. Complete an intelligent agent design concept and demonstrate through modeling analysis that it meets the requirements of improved situational awareness.

PHASE II: Use the results of the design concept generated in Phase I to develop a detailed software model of a multiple sensor system. The model should include sensor performance, sensor status, environmental, and geographical detail. Implement the intelligent agents as part of the model and perform a demonstration to validate

that the approach improves situational awareness in response to changing environmental, sensor, or mission conditions.

PHASE III: Implement the intelligent agents as part of the DCGS-A/JUMPS sensor suite and deploy the system for test and evaluation. Potential applications include Harbormaster Command and Control Center (HCCC) where intelligent agents for sensor deployment can be used to improve surveillance contributing to enhanced situational awareness in support of port security operations and the Army Corps of Engineers where intelligent agents can be employed to secure critical national waterways with key infrastructure including locks and dams.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Technologies developed are directly applicable to law enforcement and key infrastructure security applications such as nuclear power facilities and oil/natural gas terminals where enhanced surveillance adaptable to changing conditions using multiple sensors is critical.

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2. Situation Awareness in Intelligent Agents: Foundations for a Theory of Proactive Agent Behavior, Raymond So and Liz Sonenberg, 2004
3. Intelligent battlespace awareness and information dissemination through the application of BDI intelligent agent technologies, Andrew Lucas, Ralph Ronnquist, Nick Howden, Paul S. Gaertner, John Haub, 2003

KEYWORDS: intelligent agents, sensors, sensor networks, situational awareness, status monitoring, operator workload, Distributed Common Ground System-Army (DCGS-A), Joint Unified Maritime Protection System (JUMPS)

A10-012 TITLE: Coordinated Responses through Knowledge Sharing in Mobile Agent-Based Intrusion Detection Systems

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: To develop a mechanism by which Mobile Agents can formulate a coordinated response to a threat.

DESCRIPTION: A Mobile Agent-Based Intrusion Detection system is one that uses autonomous software that is capable of moving from one host to another in an attempt to detect and respond to suspicious activity. Typically, this suspicious activity is detected based solely on locally collected data. Thus, the agent only has a limited picture when attempting to formulate a response. This response may not be appropriate if the activity is part of a larger coordinated attack.

Coordinated attacks are an ever increasing threat to networks world wide, such attacks include but are not limited to distributed scanning (use of multiple hosts to scan a network) and distributed denial of service attacks. Due to the distributed nature of such attacks, detecting and responding to them is a very complex problem.

The focus of this research is to develop a framework in which mobile agents can be dispatched in a random or as needed basis to network nodes. This research should investigate the use of multiple agents with different intrusion detection mechanisms running. If each agent detects intrusions in the same manner then an attacker only needs to circumvent that detection mechanism. When different detection mechanisms are used they will overlap in some

areas, such as one would see if a Venn diagram was drawn showing what each mechanism can detect, but will provide a more robust defense-in-depth architecture.

The random distribution of these agents amongst the network must ensure the protection of the network while not being predictable by an attacker. Agents on the network should be replaceable by other agents to dynamically modify the network security. In doing so it will need to be researched how to maintain a command and control architecture of the agents, allowing them to join, leave, find, and communicate with other agents. The work may look into leveraging distributed hash tables to accomplish this.

Additionally, the framework should allow the agents to securely communicate with each other and be invisible to attackers looking to gain information regarding which agents are active on the network and where. Beyond finding and communicating with each other, the agents will need to be able to form trust relationships of their neighboring agents and develop a jointly formulated view of the network, whether and intrusion is occurring, and how to respond. Determining how to and when to trust other agents is important as the agents themselves may be compromised to act in a malicious manner.

The agents would be operating in both a tactical mobile ad hoc network, which has constraints such as low bandwidth, and a sustaining base network which does not have the constraints of a tactical network. Further, this research would evaluate the benefits of mobile agents over static agents in both tactical and sustaining base networks

Research areas of interest include but are not limited to: (1) communication protocols used by the agents, (2) securing the communication between the agents—(integrity, availability and confidentiality), (3) formulating coordinated responses among agents, (4) communicating across resource constrained networks, (5) communicating across heterogeneous networks, (6) detecting coordinated attacks, (7) determining trust of other agents, (8) command and control architecture for agent distribution, join/leave network, and finding neighbor nodes, (9) varied intrusion detection mechanisms for agents to use, (10) communications that are not detectable by an attacker.

PHASE I: The contractor shall perform a study to develop a concept for a framework and knowledge-sharing mechanism between mobile agents. Towards the end of the study the contractor shall present to the government a design and architecture document for the proposed framework and communication protocols. In addition, the contractor will provide a minimal prototype solution that demonstrates the feasibility of the concept.

PHASE II: Based on the results of Phase I, the contractor will refine and extend the design of the mobile agent communication and response formulation mechanism to a fully functionally solution capable of detecting and responding to coordinated attacks. At the end of Phase 2, the contractor will provide test and evaluation results demonstrating the aforementioned ability. Additionally, the contractor will provide an updated design and architecture document for the proposed framework and communication protocols.

PHASE III: Formulating coordinated responses to distributed attacks would be marketable to both DoD and commercial sectors. Applicable DoD deployment domains include tactical and sustaining base networks. Commercial domains that are likely to benefit from this technology due to being potentially high value targets include banking and finance, defense contractors, communication centers, and SCADA systems.

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2. Power Aware Agent-based Intrusion Detection Systems, <http://infolab.stanford.edu/~jonsid/spaid.pdf>
3. Network and Agent Based Intrusion Detection Systems, <http://www.model.in.tum.de/um/courses/seminar/worm/WS0405/albag.pdf>
4. A New Flexible Multi-Agent Approach to Intrusion Detection for Grid, Pei-You Zhu, Ji Gao
5. Applying Mobile Agents to Intrusion Detection and Response, <http://csrc.nist.gov/publications/nistir/ir6416.pdf>

KEYWORDS: Mobile Agents, Intrusion Detection, Coordinated Attacks, Distributed Attacks, Cyber Security, Cyber Defense

A10-013 TITLE: Intrusion Detection System (IDS) With Automatic Signature Generation for Self Healing Networks

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: To develop an intrusion detection system (IDS) that can be leveraged to create a self-healing, self-monitoring, self-diagnosing, self-hardening, and self-recovering network architecture after corruption an attack through the automatic generation of signatures for malicious code.

DESCRIPTION: In today's world, computer systems have become so complex and interdependent that the original model of system defense, based around a signature-based intrusion detection system (IDS) that requires updating by the software developer for new malicious code signatures is becoming infeasible. Additionally, these signatures are created manually through long hours of disassembling a worm or virus which creates a critical lag time before protection mechanisms can reach the field. The Army needs effective mechanisms to protect vulnerable hosts from being compromised while allowing them to continue providing critical services under aggressively spreading attacks for unknown vulnerabilities. A failure to respond correctly and rapidly can have disastrous consequences. Army systems should automatically detect and respond to threats of all kinds, including but not limited to automated attacks.

Therefore, the goal of this research is to develop a host intrusion detection system (IDS) that can support a self-healing, self-monitoring, self-diagnosing, self-hardening, and self-recovering network architecture after corruption an attack by automatically creating malicious code signatures to protect against variants of known threats as well as possible zero day attacks. The research under this effort would focus on host-based IDS that can monitor software execution at the instruction level to track what data was derived from untrusted sources, and detect when untrusted data is used in ways that signify that an attack has taken place. Research will have to be conducted for determining trusted versus untrusted resources, but for the initial effort under this topic all processes and data from locally executed programs on the host would be treated as trusted, with all information coming from external sources as untrusted, and tracked regarding where the external data propagates throughout the system (e.g., system calls, assembly code, format strings, etc). This technique should be able to reliably detect a large class of exploit attacks and should not require access to source code of programs running on the host, allowing it to be used on commercial-of-the-shelf software.

Once the IDS on the host detects an attack, it should generate a signature which is then distributed to IDS software on other vulnerable hosts over a secure connection. The generation of the new signatures should take into account information such as: what data can be extracted from the system at the point of the attack, what data can be traced back through the system using the point of the attack as a starting point, what data flows through the system were captured at the time of the attack, what information is on the stack or heap currently, what information is in memory, and how closely does this information match to previously known signatures. This will allow for tightly, well-crafted signatures with a low likelihood of false positives or false negatives. The more tightly these signatures can match the exploit the higher the probability of detecting polymorphic worms and viruses becomes. The signature creation algorithm should be able to deal with an adversarial environment where malicious parties may try to mislead the system in the creation of new signatures.

The other hosts' IDS authenticate the source of the new signature, verify the integrity of the signature, verify the correctness of the signature, and use it to self-harden against attacks. Malicious code signatures are created from the

exploit itself similar to the way a vaccine is created from a virus and should therefore have a lower chance of triggering false positives.

PHASE I:

- 1) Develop a concept for a self healing intrusion detection system technology.
- 2) Provide design and architecture documents of a prototype tool that demonstrates the feasibility of the concept.
- 3) Develop prototype that demonstrates the feasibility of the concept

PHASE II:

- 1) Based on the results from Phase I, refine and extend the design of the intrusion detection system prototype to a fully functioning solution.
- 2) Provide test and evaluation results demonstrating the ability of the proposed solution to detect, react, and recover from a simulated attack.

PHASE III: Applicable DoD deployment domains include tactical and sustaining base networks. The DoD will utilize the technology developed under this effort to remain operational during an attack. The automation provided by this technology also allows for a decrease in human management of the network and which allows for that soldier/employee to focus on another critical area of the mission. As a result, the technology will find use in both the DoD and commercial sector.

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KEYWORDS: Self healing, Intrusion detection systems (IDS), automatic signature generation, cyber security, cyber protection

A10-014 **TITLE:** Spoofting Network Architectures in Response to Hostile Reconnaissance

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Missiles and Space

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 limit the effectiveness of a cyber attack and to increase the resources required to perform hostile reconnaissance of the network resulting in additional time for the defenders to mount an appropriate response.

DESCRIPTION: The first stage in a cyber attack is to perform reconnaissance on the target network. The attacker's goal is to identify targets that either contain the desired information or are critical to network traffic. Following that step, the attacker will determine what is exploitable on the targeted network devices. If the information gathered above is incorrect, the attackers will waste time and resources attempting to exploit systems and services that may or may not exist, which will result in more time for the defenders to take the appropriate response.

The focus of this research is to develop a mechanism to detect network based reconnaissance efforts and to deny the attacker access to real network data while providing them with false information regarding the number and types of systems connected to the network. Secondly, the research would develop methods to deceive attackers so that they cannot determine what cyber security protection technologies are being used. This includes but is not limited to: what the protection technologies monitor, where they are, and how they communicate. These mechanisms will need to be able to operate in tactical and strategic environment and be able to work within the respective restraints associated within these environments. Finally, these mechanisms should minimize the release of false information for legitimate requests.

Research areas of interest include but are not limited to (1) detecting scanning attempts, (2) spoofing valid network information, (3) network confidentiality, and (4) cyber security protection technology confidentiality.

PHASE I:

- 1) Research and develop a concept for detecting a reconnaissance effort on the network and supply false information for the attacker instead of the real network information.
- 2) Provide design and architecture documents of a prototype tool that demonstrates the feasibility of the concept.
- 3) Provide a minimal software prototype demonstrating the feasibility of the concept.

PHASE II:

- 1) Based on the results from Phase I, refine and extend the design of the prototype system to a fully functioning system addressing multiple recon vectors.
- 2) Provide system design specifications.
- 3) Provide an analysis demonstrating the robustness of the product to a set of un-prepared-for attacks and the systems ability to detect and react to these attacks.
- 4) Provide risk/impact analysis of false positives resulting in legitimate requests receiving misleading information.

PHASE III: The government and commercial sectors are both under constant cyber attack by domestic and foreign interests who seek to steal their sensitive information. Therefore, a means to provide false information to attackers which would limit their ability to attack the network would be marketable to both organizations.

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2. Worm and attack early warning: piercing stealthy reconnaissance,
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3. Detecting randomly scanning worms based on heavy-tailed property,
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KEYWORDS: Network reconnaissance, deception, spoofing, intrusion detection, cyber defense, cyber security

A10-015 TITLE: Linearity Improvement of MMIC Power Amplifiers at Reduced Output Power Backoff

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: Develop innovative methods and techniques for the design and fabrication of solid state power amplifiers (SSPAs) that exhibit high linearity when operated at low power output backoff from saturated output power.

DESCRIPTION: Modern microwave and millimeter-wave communications applications in on-the-move, manpack, and UAV environments are placing increasing demands on power amplifier efficiency because of both limited prime power and limited capacity for exhausting waste heat. While amplifier efficiency ratings are often reported as peak power-added efficiency, typically achieved at conditions of high RF drive where the amplifier is operated near saturation, this is not a good figure of merit for understanding the efficiency of communications system amplifiers. Instead, one should consider the power-added efficiency of the amplifier when operated with an output power backoff from saturation that enables the amplifier to achieve some desired spectral regrowth or intermodulation distortion performance (i.e., PAE at maximum linear output power).

SSPA efficiency generally declines with increasing output power backoff from the peak efficiency condition near saturated operation. If one can reduce the output power backoff (OPBO) required to achieve a specified distortion performance, the efficiency at maximum linear output power will be improved. The distortion behavior of SSPAs is influenced by AM-AM distortion (amplitude compression or expansion) and AM-PM conversion. AM-PM conversion is often the dominant contribution to the distortion behavior of SSPAs. It is known that in multi-stage solid state amplifiers, different choices of bias line-ups for the various stages can significantly improve or degrade AM-PM conversion, intermodulation distortion and spectral regrowth. This is most likely the result of the AM-PM conversion of one stage partially cancelling or reinforcing the AM-PM conversion of a subsequent stage.

PHASE I: Develop innovative methods and techniques for the design and fabrication of solid state power amplifiers (SSPAs) that exhibit high linearity when operated at low power output backoff from saturated output power.

The effort will focus primarily on amplifiers for use in 29.5-31 GHz power amplifiers for tactical mobile satellite communications systems with an objective linear power added efficiency of 30 percent. The objective spectral regrowth level is -30dBC at one SR offset for offset quadrature phase shift keying (OQPSK) modulation for linear output powers up to 10 watts.

PHASE II: Develop and demonstrate solid state power amplifiers (SSPAs) that exhibit high linearity when operated at low power output backoff from saturated output power based on the methods and techniques developed under Phase I.

PHASE III DUAL USE APPLICATIONS: The amplifier design methodology developed under this effort could be used in a broad range of military and commercial communications applications, including satellite, line of sight, point to point and point to multipoint communications systems where power consumption and cooling capacity are of maximum importance.

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2. Crespo-Cadenas, C.; Reina-Tosina, J.; Madero-Ayora, M.J., "Phase characterization of two-tone intermodulation distortion," IEEE MTT-S, 2005.

KEYWORDS: distortion, linearity, spectral regrowth, power added efficiency, solid state power amplifiers

A10-016 TITLE: Wideband Multi-Carrier Digital Up-Converter

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: Design, develop, and fabricate a multi-carrier wide band digital In phase and Quadrature (I-Q) phase to composite analog converter. Accept and synthesize composite digital Intermediate Frequency (IF) ranging from 950-1950 MHz, having an instantaneous bandwidth of 1 GHz.

DESCRIPTION: Currently some variants of medium/large satellite communications terminals are required to support 48/96 (threshold/objective) uplink communications carriers for a single terminal. The number of supportable links dictates aggregate capacity and connectivity, while driving the Size, Weight, and Power (SWAP) requirements of the supporting baseband equipment in the Digital Communications Satellite System (DCSS). The DCSS performs all the modem, multiplexing, switching, routing, patching, and link adaptation functions. The Army is currently investigating the application of a digital based architecture, where the DCSS would provide the RF subsystem a composite digital IF to synthesize. Synthesizing a composite digital IF presents a challenge with using a single Digital to Analog Converter (DAC), because additional back-off and scaling is required to support multi carrier operation. The additional back-off reduces the signal-to-noise ratio (SNR) that is available from the DAC. The reduction in SNR, on an individual carrier basis, creates difficulties in achieving the spectral mask requirements of MIL-STD-188-165A. Another artifact of synthesizing multiple carriers is the Spurious Free Dynamic Range (SFDR) of the DAC. As the number of carriers is increased the SFDR is significantly decreased, resulting in the relative level of the carriers to the spurs generated by the DAC to decrease. The spurs generated can eventually create further difficulty achieving spectral purity requirements. The Army is seeking an innovative solution capable of synthesizing an instantaneous bandwidth of up to 1 GHz, supporting multi-carriers (48 objective, 96 desired), in the range of 950 – 1950 MHz, where the carrier data bandwidth will range from 64 Ksps – 26 Msps (threshold), (should account for carrier spacing factor of modulated carrier, typically 1.2 not exceeding 1.4). The individual carriers shall comply with spectral mask and purity requirements per MIL-STD-188-165 A. Synthesizer will be required to interface to a terminal baseband processor, whose interface control documentation will be provided.

PHASE I: Design a concept for a Wideband Multi-Carrier Digital Up-converter. Perform an analysis on projected DAC(s) used in concept, demonstrating feasibility of current device(s) synthesizing objective or desired number of carriers. Individual carrier bandwidths can be a mixture from 64 Ksps to 26 Msps, with the aggregate not to exceed ~900 Msps. Detailed analyses should show resulting spectral mask/purity of carriers, resulting spurious free dynamic range, and trades between maximum output power per carrier.

PHASE II: Design, test, and demonstrate a prototype Wideband Multi-Carrier Digital Up-converter. Prototype shall operate over 950 – 1950 MHz, and synthesize 48 carriers (objective) or 96 carriers (desired) up to 1 GHz instantaneous bandwidth, consisting of mixed carrier bandwidths. Prototype shall interface to a baseband processor, with a defined ICD (will be provided). Prototype shall be tested and demonstrated showing; interoperability with baseband processor interface; objective or desired multi-carrier synthesis within 1 GHz ; mixture of carriers from 64 Ksps to 26 Msps, with the aggregate not to exceed ~900 Msps; compliance with MIL-STD-188-165 A spectral mask/purity requirements and all applicable requirements for transmissions.

PHASE III: Wideband Multi-Carrier Digital Up-converter is an integral component to achieving an all digital terminal architecture. An all digital terminal architecture has the potential for current and future use on WIN-Ts Wideband SATCOM Terminal Systems (WSTS). Successful commercialization/productization of a Wideband Multi-Carrier Digital Up-converter, could offer enhanced performance and reduction of life cycle cost for PM WIN-T programs, including WIN-T Regional Hub Nodes being procured under the WIN-T program. The resulting technology will provide a method to obtain increased resolution for either narrow band or wideband applications. A Wideband Multi-Carrier Digital Up-converter can greatly enhance and enable military and commercial sector applications such as adaptive digital array radar, electronic warfare applications, and wideband modems.

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2. MIL-STD-188-165 A, "Interoperability of SHF Satellite Communications PSK Modems (FDMA Operation)", 1 November 2005.

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4. X. Cui, D. Yu, S. Sheng; X. Cui; "Design and Implementation of Digital Up Converter for Homenet", Electron Devices and Solid-State Circuits, 2005 IEEE Conference on 19-21 Dec. 2005 Page(s):739 - 742.
5. Y. Chen; "Computationally efficient multichannel digital up converter", Signal Processing Proceedings, 2000. WCCC-ICSP 2000. 5th International Conference on 21-25 Aug 2000 Page(s):2058 - 2061 vol. 3.
6. Definition of Interface between the Configurable Basestation Processor (CBP) and the Direct L-Band Converter (DLBC), Appendix A, Preliminary Draft.

KEYWORDS: DAC, satellite, communications, digital, converter, multi-carriers

A10-017 TITLE: Indium Surface Preparation for Improved Flip-Chip Hybridization

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: This solicitation seeks a surface preparation technique for indium bumps that is able to remove the indium oxide surface layer and replaces it with a passivation layer. The passivation layer must be stable on the order of at least several hours to allow for focal plane array hybridization. Additionally, unlike indium oxide which is very robust, it must easily crack. This would allow indium to break through and bond to either another passivated indium bump or a contact metallization pad with little compressive force. Process temperatures to form the surface preparation must be held below 160°C, though a maximum process temperature under 100°C is preferred. The technique must not damage, corrode, or leave residue on the focal plane array or readout integrated circuit. Finally, the solution should be one that limits changes to current industry equipment. Simpler solutions will therefore be preferred.

DESCRIPTION: Infrared focal plane arrays composed of epitaxial HgCdTe grown on lattice-matched CdZnTe substrates require readout circuitry that processes the light sensed by the focal plane array and turns it into an image. Because processing of II-VI materials is difficult and expensive compared to silicon, this circuitry is not fabricated monolithically. Instead, the readout integrated circuit is fabricated separately on a silicon substrate and bonded, or hybridized, to the focal plane array. Bump bonds form the one-to-one interconnection between pixels on the focal plane array and corresponding circuitry on the readout integrated circuit. Due to several mechanical requirements of the bump bonds, indium is almost universally used in the infrared industry to form them. Indium is a soft and flexible material that is able to conform to strain caused by expansion differences between the focal plane array and readout integrated circuit upon cooling. While indium has ability to bond well to a variety of materials, a robust thermal oxide forms on it that hinders this. This thermal oxide forms quickly at room temperature and has a high melting point of 1900°C, compared to 156°C for indium. When attempting to hybridize two wafers, this oxide forms a shell around the bumps which the indium must break through for successful hybridization. As pixels on focal plane arrays have become smaller and will continue to do so in the future, bump sizes have decreased likewise. As bumps shrink, breaking through the oxide layer becomes more difficult since its thickness remains constant upon scaling down. Eventually, hybridization of the focal plane array to the readout integrated circuit becomes nearly impossible. Because of this, a passivating surface becomes necessary.

PHASE I: Develop a passivation process for that considers all items listed in the objective. Show evidence that this process does not damage, corrode, or leave residue on HgCdTe or Si and that the passivation layer is indeed fragile enough for indium to break through with little force. In this phase, dummy parts may be used due to the high cost of focal plane arrays and readout integrated circuits.

PHASE II: Refine process for high repeatability and high yield on indium bumps with a pitch at the current state-of-the-art. Fabricate any machinery necessary to perform the passivation process. By the end of this phase, this process must be capable of being inserted into a focal plane array fab line. Perform passivation process and hybridize a true HgCdTe focal plane array and Si readout integrated circuit. Deliver hybridized focal plane array to the Army for characterization.

PHASE III: Potential applications include all types of infrared cameras, especially those whose resolution is increased by the use of focal planar arrays with smaller pixels. These high resolution cameras play a critical role in long range target identification for Army ground systems and persistent surveillance for Army air systems. Consumer applications that could benefit from this technology include any consumer electronics chip that requires a large number of input/output connections on a physically small chip. An example would be in the portable electronics industry, where great effort is put into miniaturizing all aspects of the final product.

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1. Kim, J., Schoeller, H., Cho, J., Park, S., Effect of Oxidation on Indium Solderability, Journal of Electronic Materials, vol. 37, 2008, pp. 483-489.
2. Lozano, M., Cabruja, E., Collado, A., Santander, J., Ullan, M., Bump bonding of pixel systems, Nuclear Instruments and Methods in Physics Research A, vol. 473, 2001, pp 95-101.

KEYWORDS: Night Vision, Infrared, Indium, Bump Bond, Flip Chip, Hybridization, Focal Planar Array, CdZnTe, HgCdTe

A10-018 TITLE: In-Vacuo Passivation of High Aspect Ratio HgCdTe Surfaces

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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 conformal in-vacuo passivation techniques for HgCdTe based infrared devices. The ideal passivation would be deposited in-vacuo. It would allow conformal coverage on highly reticulated surfaces. The passivation would perform as an excellent electrical passivation; ie allow no shunt currents, surface inversion, charge trapping, etc. And It would act as a chemical passivation; not allow oxide or hydrocarbon formation in the surface, etc.

DESCRIPTION: HgCdTe narrow band gap devices are used to produce many infrared detectors. Many of these advanced devices require complex structures to be processed into them. These structures can include but not limited to delineation structures, vias, micro-lenses, anti-reflective structures, diffraction gratings, and type converting etches. Many result in high aspect ratio surfaces. Often plasma processing is used to produce these structures. The use of these plasmas processes result in clean carbon and oxygen free surfaces with little Hg depletion. However, the moment they are removed from vacuum oxygen and hydrocarbon contamination start to build on the surface. In this study we would like an in-situ or minimally in-vacuo process to be developed that will chemically and electrically passivate high aspect ratio HgCdTe surfaces. This passivation must be able to be vacuum compatible and not dope the HgCdTe it is passivating.

PHASE I: Theoretically identify and determine technical feasibility of different passivation materials and appropriate deposition methodology for the passivation of high reticulated HgCdTe surfaces. Develop initial test passivation methods for the identified passivation methods. Test passivation on HgCdTe test devices.

PHASE II: Produce prototype hardware that allow this passivation to be deposited on high aspect ratio HgCdTe surfaces. The quality of this passivation should be evaluated with electrical characterization, examples: current-voltage measurements, lifetime measurements, and Hall measurements. The passivation should also be evaluated chemical structurally, examples: Auger Electron Spectroscopy, X-ray photoelectron spectroscopy, Scanning Electron Microscopy, and Secondary Ion Mass Spectrometry. The final test of the passivation integrated the developed passivation into the production of infrared focal plane arrays.

PHASE III: The Goal of this phase is to transfer this technology to the the Infrared Focal Plane Array (IRFPA) manufacturing houses. This will allow the IR-FPA industry to passivate more complex surfaces than the current state-of-the-art allows. This advancement would enable industry more process flexibility to produce less-expensive more complex focal plane arrays for the DOD and Army. In-turn this technology would enable more advanced infrared sensors for the solder at a lower cost to the Army.

This conformal passivation could lead to less-expensive, better performing FLIRs for platforms like Apache and Abrams. It would enable less expensive third generation infrared detectors for RSTA and airborne operations. And it would allow sensors with better sensitivity for BMDS.

Commercial applications include smog detectors, temperature arrays for weather satellites, and sensors the examination of real time manufacturing yield.

Other commercial applications, allow the production of larger more sensitive infrared focal plane arrays for astronomy applications like examining red shift, performing real time IR spectroscopy of objects, and enabling more sensitive very large base line infrared interferometry .

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2. A. J. Stoltz, J.D. Benson and P.J. Smith, "Morphology of Inductively Coupled Plasma Processed HgCdTe Surfaces," J. Elec. Mater. 37(9), 1225-1230 (2008).
3. M. Carmody, J.G. Pasko, D. Edwall, E. Piquette, M. Kangas, S. Freeman, J. Arias, R. Jacobs, W. Mason, A. Stoltz, Y. Chen and N.K. Dhar, "Status of LWIR HgCdTe-on-Silicon FPA Technology," J. Elec. Mater. 37(9), 1184-1188 (2008).
4. A. J. Stoltz, P. R. Norton, "Dry Etch Development for a Dual, Front and Backside, processing of II-VI Compound Semiconductors," Compound Semiconductor Mantech Digest of Papers 6.6 (2008).

KEYWORDS: HgCdTe, passivation, electrical, devices, infrared, IRFPA, FPA, focal plane array, sensors.

A10-019 TITLE: Electronically Switchable infrared Beam Splitter Technology

TECHNOLOGY AREAS: 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: The goal of this topic is to develop a switchable infrared beam splitter and the associated enabling technology that allow the beam splitter to be electronically controlled to change from transmissive to reflective in multiple infrared spectral bands.

DESCRIPTION: Recent advances in detector technology have enabled the imaging of multiple spectral bands onto the same image plane. These dual band optical systems provide the capability to image both spectral bands independently and viewed simultaneously. The capability of these 3rd Gen FLIR Systems can be expanded by the development of optical systems that take advantage of each spectral band independently. Being able to change the optical path of each spectral band provides an enhanced capability over the current state of the art. However, current state of the art would require the use of movable components to achieve such a task. This requires extra volume and contributes to potential boresight and alignment errors that are unacceptable.

Electro-chromic technology has been demonstrated in the infrared regions to provide the capability switch from transmissive to reflective over certain bands. Application of this or similar electronic switching technologies to dual band systems can provide a significant advance in the state of the art.

The fundamental goals of this topic are to develop a beamsplitter that will change from reflective to transmissive in both the MWIR and LWIR, independently of each other.

- Transmission change from less than 5% to greater than 90%
- Reflection change from less than 5% to greater than 90%
- Change time less than 2.0 seconds for entire range
- Substrate sizes of up to 3" in diameter
- Wavelengths for MWIR region 3.5 – 5.0 microns (or broader)
- Wavelengths for LWIR region 7.5 – 12.0 microns (or broader)
- Nominal angle of incidence 45 degree for beamsplitter (+/- 20 degree range from nominal)
- Nominal angle of incidence 0 degree for filter (+/- 20 degree range from nominal)
- Electronically induced change
- Operation in -30C to +70C environment (use of TEC or other mechanism acceptable)

Other desirable but not required attributes include wavelength selectivity within spectral bands, application to other spectral bands such as SWIR, and application to curved surfaces. Similar technology can be used for applications such as a non-moving filter "wheel."

PHASE I: At a minimum, the Phase I needs to demonstrate the design concept and the enabling technologies of switching in both the MWIR and LWIR spectral bands, and demonstrate a path forward to a phase II system. The fabrication, measurement, and delivery of a working prototype for at least one of the spectral bands meeting part of the goals is preferable, and will be heavily weighted in the evaluations.

PHASE II: Development and delivery of two or more beamsplitters capable of independently switching in both the MWIR and LWIR and meeting the goals as previously listed.

PHASE III: Developed components can be integrated into 3rd Gen Infrared systems and other multi-spectral systems to enable advanced operations. The technology is also applicable to single band uncooled infrared systems where electronic shutters may be desirable such as a thermal weapon sight. Commercial opportunities would include being a component supplier for 3rd Gen infrared systems, uncooled technologies such as thermal weapon sights and other military applications. Additional non-military applications may include use in paramilitary systems such as infrared systems employed by police and firefighters. Developed components could also be employed in laboratory test equipment where very precise alignment is requirement and thus moving components are non-desirable.

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1. Third generation infrared optics, Jay Vizgaitis, Proc. SPIE 6940, 69400S (2008), DOI:10.1117/12.779095.
2. Fabrication of electrochromically tunable photonic crystals, P. V. Ashrit and Su-Lan Kuai, Proc. SPIE 6322, 632202 (2006), DOI:10.1117/12.680628.

KEYWORDS: MWIR, LWIR, electro-chromics, electronic switching, dual band, 3rd Gen

A10-020

TITLE: Advanced Molded Glass Lenses

TECHNOLOGY AREAS: 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: Advance the state of the art in glass molding technology to include larger diameter optics, better surface finishes, improved yield, and advanced surface shapes (such as diffractives) in order to expand the use of molded optics to a larger number of components in military systems, thus significantly reducing cost and the number of optics that need to be manufactured overseas.

DESCRIPTION: The manufacture of refractive and diffractive optical surfaces in glass traditionally use widely different processes since the surface characteristics and specifications are so diverse. Refractive optical surfaces can be formed in glass by both traditional and CNC polishing methods, while diffractive surfaces have been produced by etching methods developed for the semiconductor industry. Therefore for glass optics, these surfaces have been created on separate components, increasing the cost and weight of the overall system. Yet by use of the glass molding process, both diffractive and refractive surfaces may be formed on a single optic, thereby reducing cost and increasing optical efficiency. Glass molding technology affords optics manufacturers the ability to accurately and consistently replicate an optical surface. Development of process understanding and the ability to replicate diffractive surfaces with glass molding methods are fundamental to the advancement of this technology and the delivery of lower cost optics of consistently high quality.

Improvements in the glass molding process are also possible in the areas expanded product size offerings. The greatest impediment to molding large optics (greater than 60mm diameter) is the management of thermal gradients that form in the glass during molding. Errors induced during the high temperature molding process are evidenced by deviations in actual surface figure from the designed surface (low frequency surface variations) and surface roughness (high frequency variations in the optical surface). Performance improvements such as reduced scatter and improved wave front will result in lower energy loss for the optical system and improved visual acuity for the soldier.

The goals of this effort are to advance the state of the art of molding glass optical elements by improved techniques, modeling, tooling, etc. that enable the fabrication of large element aspheric and diffractive and other complex surface of up to 100mm in diameter.

PHASE I: Determine the physical limitations of molding diffractive surfaces, determine glass types that support the creation of diffractive surfaces, and determine the availability of current modeling software to predict molded diffraction efficiency. Identify methods for creating larger diameter optical elements that will be able to meet the same quality control levels as ground and polished optics. Identify processes and tooling that will be required to fabricate components in Phase II.

PHASE II: Fabricate necessary tooling, machinery, and modeling software to create large diameter molded glass optics, diffractive optics, asphero-diffractive optics, and large diameter asphero-diffractive elements. Based on limitations from phase I, produce multiple optical elements to be evaluated and tested within to demonstrate the capabilities and limitations of the newly developed technologies.

PHASE III: Fabrication of molded elements for military systems to demonstrate ability to meet performance requirements of large element and diffractive elements that are traditionally fabricated by other means. Transition of this technology would be through optics fabricators that produce optics for military use as well as commercial use including camera lenses, binoculars, scopes, etc.

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1. Development of large-aperture aspherical lens with glass molding, Yasuhiro Aono, Mitsumasa Negishi, and Jun Takano, Proc. SPIE 4231, 16 (2000), DOI:10.1117/12.402759.

2. Precision compression molding process of low Tg glass aspheric lenses, Tao Ma and Jingchi Yu, Proc. SPIE 7282, 728205 (2009), DOI:10.1117/12.830783.

KEYWORDS: molded glass, optics, diffractives, tooling, molding

A10-021 TITLE: Lightweight, Wide Field-Of-View Wave-guided Head-mounted Display

TECHNOLOGY AREAS: 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: The development of a light weight, wave-guided head-mounted display with a minimum 60 degree FOV for use in military applications.

DESCRIPTION: Today's soldiers often find themselves in environments that require greater situational awareness than can be provided by current individual low-light level and thermal systems. In order to meet these needs, the United States Army is launching an aggressive effort to find innovative solutions that will provide soldiers with a wide field of view (WFOV) head mounted display that can provide the soldier with information from sensors on or near the soldier, as well as from a communication link with a larger network.

In order to optimize mobility, the soldier needs an unobtrusive system. The weight, profile and center of gravity must be minimal and compatible with the soldier's headgear, both current and future. In order to maintain situational awareness, the display must have a see-through capability. The soldier of the future will carry a large amount of equipment. Many of the systems will require power. Therefore, in order to make this concept feasible, the HMD needs to be both power and cost efficient.

Currently developed head-mounted display technologies based on optical waveguides have shown the capability to deliver information to the soldier in a package that meets many of their requirements. However, the available technologies have limited fields-of-view and have demonstrated difficulty in progressing to the Army's desired field of view specifications of 60 degrees threshold with an eventual target of 80 degrees. The Army is looking for innovative approaches to waveguide HMDs that can leverage the advantages of the technology while meeting these challenging FOV requirements. Also, as the field of view grows while the eye relief is maintained, the necessary size of the eyepiece will also increase. Therefore, in order to reduce the weight of the system, the technology needs to be effective on a plastic substrate as well as glass.

The army is seeking a waveguide eyepiece that will deliver an 80 degree circular field of view, or an 80 (H) x 64 (V) degree minimum rectangular field of view, with no less than SVGA resolution. The system shall utilize a plastic substrate with a see-through capability. In order to be compatible with the soldier's protective gear the system shall provide an eye relief of 25 mm and an eye motion box of at least 10mm. The system shall provide a dynamic grayscale of 100:1. The system shall provide a low profile of less than 1.5 inches to the soldiers' head. Stray light and light security is also a crucial issue, and the system should not allow light to "leak" from the waveguide in any unintended direction. The system can be either monocular or binocular.

PHASE I: Develop and present the design concept for a system that achieves a minimum of a 50 degree field of view. Develop and provide a physical demonstration for the enabling technologies characteristic to the system. A video card and/or device driver shall be included if necessary for the operation of the system. Projected paths that lead to meeting phase II requirements shall be provided.

PHASE II: Develop and deliver a hardware demonstrator for a wave-guided head-mounted display system that meets all requirements stated in the topic description. The system will have at a minimum a SXGA display with a 15-pin VGA connector and RS171 connection.

PHASE III: Development of a ruggedized system suitable for military head-mounted display applications such as use by aviators and dismounted infantry and establishing potential for the head-mounted display (HMD) technology in dual use applications in commercially available systems. This technology would be directly applicable to upgrading the performance of rotary wing vision systems (such as the Apache MPNVIS) as the HMD is currently the limiting component of the system. This technology would also be applicable to dismounted soldier vision systems such as ENVG-D. Potential commercial applications for HMDs include the medical and the entertainment/gaming industries as a commercial aviation.

REFERENCES:

1. Ichiro Fujieda, "Theoretical Considerations for Arrayed Waveguide Displays," Appl. Opt. 41, 1391-1399 (2002)
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KEYWORDS: Head-mounted display, wave-guide, optics, displays, imaging technology, HMD

A10-022 TITLE: Innovative Annealing Apparatus for Mercury-Based, Compound Semiconductors

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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 design and fabricate an apparatus which thermally anneals mercury-based, compound semiconductor wafers and maintains controlled mercury vapor pressure during such thermal treatments.

DESCRIPTION: The Army and DoD relies heavily upon mercury cadmium telluride (HgCdTe)-based photovoltaic technology for high-performance, thermal imaging systems. Next-generation systems are envisioned to entail large-format (>1M pixels), infrared focal plane arrays (IRFPA). As the IRFPA's format increases, so too must the area of epitaxial HgCdTe wafers, in order to contain costs through the economy of wafer-scale processing. Most device fabrication steps utilize existing, commercial, semiconductor processing apparatuses. However, the crucial, post-growth, processing step of mercury-saturated, thermal annealing of HgCdTe wafers has no commercially available apparatus.

Current techniques for thermal annealing of HgCdTe wafers typically involve encapsulation of HgCdTe wafers and liquid mercury in closed quartz ampoules. These techniques are costly and difficult to scale toward large-area HgCdTe wafers (6-inch diameter). Therefore, this solicitation seeks an innovative solution which enables isothermal annealing of large-area HgCdTe wafers and mercury vapor at temperatures up to 500°C. Ideally, the apparatus will control wafer temperature and mercury vapor pressure independently up to the isothermal vapor pressure. The apparatus should be (re)sealable and operational by technician-level personnel. The design priority of such apparatus must be safety of operation. Fail-safe and containment considerations are paramount. Additionally, contamination of the HgCdTe wafers by unwanted impurities during the annealing process must be avoided.

PHASE I: Engineering design of HgCdTe annealing apparatus. The contractor shall deliver sufficiently complete schematic design, such that the Government can determine probability of success. While complete machine

drawings/electrical schematics are not expected by the end of Phase I, the engineering design report should address, in detail, the following critical aspects:

1. Safety aspects of design, fail-safe mechanisms, approach to containment in event of failure/leak.
2. Design of re-sealable furnace, nature of sealing mechanism, choice of sealing materials.
3. Heating methods, temperature control methods.
4. Mitigation of contamination of HgCdTe wafers by unwanted impurities.

PHASE II: Complete engineering design, fabricate and deliver annealing apparatus prototype to the Government. The deliverable prototype shall be capable of annealing 3-inch HgCdTe wafers and mercury vapor at temperatures up to 500°C. Temperature monitoring and control will be automated. The deliverable prototype shall be accompanied by complete documentation, including complete machine drawings, electrical schematics and operator's manual.

PHASE III: Successful completion of Phase II, followed by validation of annealing apparatus functioning by Government experts, will likely, immediately lead to commercialization of the apparatus. It is conservatively anticipated that up to six apparatuses would be purchased by domestic IRFPA foundries, university and government laboratories upon completion of Phase II and validation by Government experts. Revenue from service agreements would maintain the small business. Further commercial or Government investment is anticipated to fund the scale-up to larger area HgCdTe wafers (~ 6-inch). Additionally, the technology developed under Phases I and II, could potentially be applied to other, commercial semiconductor processes, in which high vapor pressure, corrosive constituents may be present. Examples of such applications include: annealing of metal-semiconductor contacts; processing of polycrystalline silicon for solar cell applications; annealing of gallium nitride and similar materials.

REFERENCES:

1. Fundamentals of Infrared Detector Materials, Michael A. Kinch, SPIE Press (2007) pp. 65-66.

KEYWORDS: thermal annealing, HgCdTe, mercury, semiconductor, infrared detectors, photovoltaic, infrared focal plane arrays, IRFPA

A10-023 TITLE: Untethered Real Time Low Cost Head Tracking

TECHNOLOGY AREAS: 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 a low cost technology for head tracking that will enable multiple users to move around within an extended volume and maintain individual five dimensional coordinates with low latency that is insensitive to changes in the user's environment.

DESCRIPTION: Recent efforts to provide enhanced situational awareness via Distributed Aperture Systems (DAS) have enabled a new capability for users to have individual views of the outside world as opposed to a single view provided from a gimbal sensor. This capability requires that each user provide unique five dimensional coordinate inputs to the system in order to view the correct sensor imagery. Furthermore, the DAS systems are providing imagery to vehicle crew members that are required move around within the vehicle to achieve their mission. It is also expected that the environment that the crew is operating in will change frequently as a part of their mission which may be to carrying supplies to a location for dropoff or pickup cargo from a location. This frequently changing environment requires that the head tracking technology to be both un-tethered and insensitive to environmental changes to allow information to transfer from the DAS to the user seamlessly.

PHASE I: Design a head tracking system that will allow for multiple users to operate within the same volume un-tethered and provide unique five dimensional coordinate information for each. The threshold operational zone is 6'

x 8' x 4'. The design will allow users to exit and re-enter the operating volume and have tracking information update upon reentry without user initiation. Provide analysis to show the system meets the following threshold performance parameters: latency - 16msec, angular pointing accuracy – 1 degree, positional accuracy -1 inch. Provide analysis of multiple user environment and how the system performance would be affected. Provide system level cost analysis per user. Provide analysis of the signature(s) created by the tracking system that could be a liability in a military operating environment.

PHASE II: Develop prototype based on Phase I design that will allow two users to operate un-tethered in the same volume demonstrating real time five dimensional coordinate tracking. Demonstrate the systems' insensitivity to user environmental changes for both removal and placement of ferrous and non ferrous items sufficiently large to change the walking paths with operating volume. Characterize system latency and accuracy for five dimensional coordinates. Characterize power needed for un-tethered user borne portion of the tracking system and total system power.

PHASE III: Development of a head track system that interfaces with a distributed aperture system under development in an Army program such as (Objective Pilotage for Utility and Lift) or a gimbal sensor system. Other applications include control of unmanned ground/air vehicles gimbal sensors for remote viewing.

Potential commercial applications for this technology include the interactive gaming market which requires motion capture to control character motion of the game.

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KEYWORDS: head, tracker, tracking, motion capture, motion tracking, motion, distributed aperture, DAS, gimbal

A10-024 TITLE: Real-Time Vis-SWIR Multispectral Sensor for Day / Night Operations

TECHNOLOGY AREAS: 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: The objective of this SBIR is to develop a compact SWIR or Vis-SWIR multispectral sensor capable of both daytime and nighttime real time operations. This primary use for this sensor will be in the areas of anomaly detection, counterintelligence research, and camouflage concealment and detection. Targets will be located at relatively close range (< 1km). The sensor must be adaptable to either ground to ground operations or low altitude aerial surveillance operations. In daytime operation, the sensor should have at least eight spectral bands, with 16-20 being preferred. The sensor must have the ability to acquire spectral information from 950 nm to 1700 nm. In addition, an enhanced spectral coverage of 550 nm to 1700 nm is preferable, even if the performance in the extended wavelength range is slightly degraded. All spectral bands should be acquired simultaneously, while maintaining as fine of a spatial resolution as possible. The sensor should also have the ability to change IFOV through the use of different fore-optics. An example would be a near field of view with an IFOV of 1.0 mrad, and a far field of view with an IFOV of 0.2 mrad.

The sensor shall have the ability to acquire data at night through the use of an illuminator, or a set of illuminators. If necessary, the nighttime spectral resolution may be reduced to a minimum of no fewer than three bands, with one band in each of the SWIR atmospheric windows. The standard nighttime illumination operation should not be detectable to visible sensors. The illumination should enable nighttime operations at a minimum of 200m, with operations out to 1 km preferred. The illumination should take into consideration standard eye safety requirements.

The sensor should have a display capable of identifying targets of interest in real time in a method that does not confuse the user. The control software should include the ability to perform standard COTS spectral processing routines, such as Spectral Angle Mapping, Endmember collection, and Principal Components Rotation, Anomaly detection, as well as display standard false color three band images. In addition, the software should have the ability to have additional user-defined algorithms read in for real-time processing as operational requirements change.

The sensor should have the ability to save full daytime or nighttime multispectral data for offline analysis that is tagged with meta information such as time, GPS, pointing direction, and meteorological information – although it is not necessary to include GPS, pointing, etc. as an integral part of the sensor. In addition, the user should have the option of saving the real time target detection information. Finally, the sensor and its supporting hardware should be man portable and not physically extended or overly heavy.

DESCRIPTION: From buried land mine detection to basic chemical analysis, the possible applications for spectral imagery are just beginning to be explored. Thus far, several prototype spectral systems have been produced, each with its own strengths and weaknesses. This project will focus on the creation of a real-time Vis-SWIR multispectral sensor capable of day and night operation. By providing one or all functions of imaging, spectral and temporal data, a single reconnaissance sensor system can support automated counter mine algorithms, aided target cuing, Aided Target Recognition (AiTR) of difficult targets, and anomaly detection and identification in complex/urban areas with day / night capability.. This will enable the warfighter to surgically attack foes and provide spectral analysis of potential threat areas for counter CCCDD.

PHASE I: Design and demonstrate by analysis a new SWIR or Vis-SWIR multispectral sensor. Determine physical and performance specifications of the sensor such as: spectral range and resolution, field of view, and amount of background radiation emitted to the system. If the component contains optical elements, determine by analysis the amount of distortion (chromatic, keystone, curvilinear, coma, etc.) present in the design. If the design incorporates an FPA, include estimates for the NEP, signal to noise ratio, and spectral crosstalk if applicable. The cost estimates shall include the projected cost of a full imaging system. Comparison of proposed approach with existing technology is highly desirable.

PHASE II: Build, demonstrate, and deliver the multispectral sensor. Prior to delivery, characterize the performance of the system and compare the results to the design calculations performed in Phase I.

PHASE III: Potential applications include sensors for urban warfare, threat analysis, land mind detection, chemical analysis, monitoring of terrestrial and atmospheric conditions, and the ability to discriminate between man made and naturally occurring materials. The ability to spectrally and temporally view a scene will also allow near real-time Battle Damage Assessment (BDA) and Threat detection/identification/location. The ability to scan an area multi/hyper-spectrally would allow advanced algorithms to locate hard to find CCCDD targets and mine threats. This will greatly enhance the reconnaissance capability of the existing system without loss of current functionality. All reconnaissance systems would greatly be enhanced by the ability take advantage of potential unique spectral/temporal target signatures. Commercial applications include the potential to provide inexpensive spectral sensors for geological, soil and crop analysis as well as potential stand off chemical analysis.

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KEYWORDS: Multispectral, temporal, imaging sensor, spectral, spectrometer, IR, SWIR, VNIR, countermeasure, anomaly detection, spectral matching, illumination.

A10-025 TITLE: Large Format Dual Band FPA ROIC for Low Flux Environments

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The objective of this SBIR is to develop a read out integrated circuit (ROIC) and associated camera electronics for the US Army's dual band MWIR / LWIR Dual Band Compact Hyperspectral Imager (DBCHI) that operates in a lower flux environment than current Dual Band FPA ROICs. The DBCHI sensor currently employs an FPA from the Dual Band FPA program. FPAs from this program are typically sensitive from 3.4 to 5.0 microns and from 7.5 to 10.5 microns and designed to operate in a broadband flux environment. As such, the ROICs typically are based on a direct injection design. This ROIC design is typically not ideal for the flux levels present in thermal hyperspectral sensors due to the large charge wells and minimum flux requirements. Therefore, a new ROIC is desired that is optimized for the unique challenges of a thermal hyperspectral sensor.

The ROIC should be designed to mate with a current 640 x 480 format 20 micrometer pitch detector arrays. An FPA detector array may be supplied to mate with the ROIC designed in this topic. The new ROIC should be optimized for low noise and lower flux environments (down to approximately 1 microwatt per square centimeter at the detector) consistent with multispectral and hyperspectral sensing applications. The ROIC should operate at frame rates up to 60 Hz, have relatively high dynamic range, very high injection efficiency, and integrate while read capability. In addition, some form of dark current subtraction is preferred. The ROIC must have variable gain between MWIR and LWIR bands, and it is desirable that each column have independently variable gain or integration time to compensate for a high variability in flux across the FPA. In addition, a serial interface for adjusting the gains is desired. On chip clock generation from a single master clock should also be provided. Additional options, such as windowing, super-pixel operation, and on-chip A/D conversion may be desirable. The ROIC should be able to handle operational temperatures down to 50K. Camera electronics and operational software to interface between the ROIC and a standard CameraLink data acquisition system should be provided.

DESCRIPTION: The US Army currently has a dual band FPA program that produces large format, small pixel pitch MCT detector arrays and FPAs for high performance FLIR systems. Compared to the current 2nd gen FLIR, The new third gen FPA sensors allow the 3rd gen FLIR systems to identify targets at further distances with the added MW band capability. A great deal of funding has been invested by the government to develop this dual band detector technology.

The US Army RDECOM CERDEC NVESD has developed the Dual Band Compact Hyperspectral Imager (DBCHI) to acquire hyperspectral imagery from a 3rd Gen FPA. DBCHI is involved in the investigation of camouflage, IED detection, disturbed earth detection, and concealed target recognition. Although DBCHI has demonstrated acceptable performance with the current FPA and ROIC combination, a significant improvement should be possible through the use of a ROIC optimized for hyperspectral flux conditions. The present ROIC/FPA was designed to operate in a high dynamic range photon rich environment. However, hyperspectral imaging systems such as DBCHI, operate in a much lower flux environment where the incident radiation is split into many narrow spectral bands. A typical band in a hyperspectral sensor of interest is on the order of 20 nm. Therefore, the current dual band ROIC is not particularly suited for hyperspectral imaging applications.

PHASE I: Design and demonstrate by analysis a new combination of ROIC, and drive electronics. Estimate the noise performance of the system design. Prepare a cost estimate to build the system. The cost estimates shall include the projected cost of a ROIC and drive electronics. Comparison of proposed approach with existing technology is highly desirable.

PHASE II: Build, demonstrate, and deliver the combined, ROIC, drive electronics, and drive software. Prior to delivery, characterize the performance of the system and compare the results to the design calculations performed in Phase I.

PHASE III: Potential applications include sensors for urban warfare, threat analysis, land mine detection, chemical analysis, monitoring of terrestrial and atmospheric conditions, and the ability to discriminate between man made and naturally occurring materials. The ability to spectrally and temporally view a scene will also allow near real-time Battle Damage Assessment (BDA) and Threat detection/identification/location. The ability to scan an area multi/hyper-spectrally would allow advanced algorithms to locate hard to find CCCDD targets and mine threats. This will greatly enhance the reconnaissance capability of the existing system without loss of current functionality. All reconnaissance systems would greatly be enhanced by the ability take advantage of potential unique spectral/temporal target signatures. Commercial applications include the potential to provide inexpensive spectral sensors for geological, soil and crop analysis as well as potential stand off chemical analysis.

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KEYWORDS: Hyperspectral, thermal, DBCHI, infrared, ROIC, dual band, temporal, imaging sensor, spectral, spectrometer, IR, LWIR, MWIR, drive electronics, MCT.

A10-026 TITLE: A Viable Method for Metal Nano-Coating of Graphite Microfibers

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop a viable method for coating of individual graphite microfibers with a continuous, highly-conductive metal layer.

DESCRIPTION: Currently graphite fibers are regularly produced with diameters ranging from tens of nanometers to microns. Graphite fibers have many military and industrial applications because of their strength, heat resistance, and optical properties. Metal coatings on graphite fibers will enhance their electrical and optical properties, thus opening the doors for new military applications and improving current applications. The increase of infrared attenuation by metal coating of graphite fibers has been proven in theory (Alyones, et al.).

The ability to apply less than 100-nanometer metal coatings to flat plates has been achieved. The application of those coatings to 3-D structures (such as fibers) has been shown in only limited cases. Often, what results is an assortment of “domains” or “nuclei” on the surface, not a continuous coat. This obscurant application requires a conformal coating with the electrical conductivity of iron or better measured from one end of the fiber to the other.

PHASE I: Obtain or produce graphite fibers with diameters in the 50-100 nanometer range and having lengths of several micrometers. As an alternative core material, a non-conductive (dielectric) fiber with a diameter of less than 200 nanometers will work. Develop a procedure to coat the fibers with different high-conductivity metals. Demonstrate with appropriate methodology that high electrical conductivity exists along entire length of fiber and that the coated fibers are NOT agglomerated. Produce 5- to 10-gram quantities of the metal-coated graphite fibers - in dry form, preferably. Perform aerosol optical tests to determine infrared screening performance (can be performed at ECBC). Note that attenuation efficiencies are achieved only if the coating itself is of high conductivity. Coatings of only a few nanometers may not exhibit bulk conductivity, that is, there will be a minimum effective coating thickness.

PHASE II: Scale-up metal coating process to produce 10-kilogram runs and perform product quality tests. Aerosol chamber tests will be conducted to measure the infrared attenuation performance and to characterize the fibers. In Phase II, a design of a manufacturing process to commercialize the production of low-cost metal nano-coated graphite microfibers should be developed.

PHASE III: This product is a material that can be integrated into current military applications: Electromagnetic Interference (EMI) shielding, vehicle parts and combat uniforms. New military application would be infrared threat sensor countermeasures. Industrial applications for the metal-coated graphite microfibers include electronics, fuel cells/ batteries, furnaces and others.

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KEYWORDS: Metal coating, graphite microfiber, infrared attenuation

A10-027 **TITLE:** Improved Methods of Explosively Disseminating Bi-Spectral Obscurant Materials

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop improved methods for explosively disseminating obscurant flakes and spherical powders while minimizing particle damage and agglomeration due to initial explosive forces. Materials of interest will have

bispectral properties either as a single obscuring material, or a combination of both infrared and visible obscuring materials.

DESCRIPTION: Currently infrared and visible grenades employ high explosives configured as a center burster to disseminate metal flakes and non-metallic spherical powders. It is believed that obscurant material performance is degraded when disseminated by this configuration. Lower performance is attributed to either from particles being agglomerated during the densely packing process, or being damaged during the explosive dissemination process. From past research it has been determined that conducting, flake-shaped anisotropic particles are ideal for infrared obscurants while spherical shaped particles are ideal for visible obscurants. According to theoretical modeling by Janon Embury (see reference #6 below), ideal infrared obscuring metal flakes will have major dimensions between 5 to 10um with a minor dimension between 50-100nm. Ideal visible obscuring non-metallic flakes will have optimum dimensions at 250nm in diameter. Current standard materials that are readily available do not achieve ideal limits.

PHASE I: Army Edgewood Chemical and Biological Command (ECBC) will provide two standard obscuring materials of brass flakes (infrared) and TiO₂ (visible) particles. These materials are defined as EA-B-1341 brass flakes by US Bronze and CR470 by Millimen. The properties of these standard materials are not ideal, but are currently available. For example, EA-B-1341 flake thickness is 200 to 400nm (minor dimension) and a major dimension of 30-40um. The spherical particle size of CR470 is 0.5 to 1um. In addition to the standard materials, Army ECBC will provide newly developed experimental materials consisting of copper (infrared) and carbon black (visible) materials. Flake thickness for the copper approaches 100nm and new carbon black particle sizes approach 0.5um diameter. With these four materials, the contractor shall: 1) develop a small laboratory scale process to combine infrared and visible materials into a center buster container at approximately 100cc volume; 2) research and investigate ways to inter pack different shaped materials to obtain maximum packing density while reducing agglomeration of individual particles; 3) investigate ways to reduce agglomeration by adding non-binding agents; 4) research the effects of various fill to burster ratios to maximize extinction and yield of the device and to see how this effects the two different materials; 5) investigate improvements on device geometries, for example, any improvements of cylindrical verses round shaped devices. The use of particle packing models is encouraged to predict the most effective particle mixing rules. Several models are available in the literature. Modeling with appropriate methodology is encouraged to predict sizes of aerosol clouds, pressures, stresses and heat exposures to obscurant materials for damage estimates. Aerosol optical tests will need to be performed to determine visible and infrared screening performance. Some in process testing should be done at ECBC to confirm contractor results. Final testing will be verified and performed at ECBC. The contractor should be able to deliver at least 10 devices at the end of Phase I effort. Since the Phase I effort is time constrained, this effort should be limited to one type of explosive, perhaps similar to RDX used in the current M76 grenades.

PHASE II: For this effort, the contractor will be required to obtain all necessary materials needed for this effort. Phase II will be a two fold process. With the best performing devices determined in Phase I, investigate the effects of scaling-up to full size grenades. Two current full size grenade geometries are of interest. First is a hand held M106 (FOG) grenade with an approximate volume of 200cc. The second is a vehicle launchable M76 grenade with an approximate volume of 400cc. First attempts at optimization should be to maintain the current geometries of the existing grenades. Research should be conducted to determine if the parameters are linearly scalable to maintain optimum extinction and yield performance. Past research efforts have indicated that the larger explosive charges needed with larger devices tend to lower the performance of infrared and visible grenades. Some research should be carried out to determine if the current size grenades are indeed optimum for a bispectral material fill. And if not, how much degradation in performance will be expected to maintain existing grenade geometries from the optimum. Methodologies in testing and evaluation should be developed along side ECBC researchers. An in-process testing schedule should be set up with ECBC chamber support personal. Second part of Phase II will be to investigate the development of a single, bispectral material. This effort should be concurrent with the Phase II scale-up of existing materials so the initial packing and dissemination studies similar to Phase I can be carried out. Determine if the same optimization and agglomeration reduction strategies used for the two part mix packed materials are similar to a single packed material. Determine which material packing strategies and fill to burster ratios yields the most effective devices using the ECBC developed Grenade Figure of Merit formula. Side note on material development for Phase II efforts: For maximum effectiveness in the visible, theory suggest that you need monodispersed spherical particles. Since this is generally not practical, the best performing materials will have very narrow size distribution. Experimental materials that have performed well in the past will have D10 of better than 0.1, D50 at

0.25 and D90 less than 0.4. For infrared materials, major flake dimension should not exceed 5um, and minor dimensions as low as 10nm.

PHASE III: This product is a device that can be integrated into current military obscurant applications. Bispectral devices are needed to reduce current logistics burden in needing to carry two devices to protect the soldier and his equipment. Electromagnetic Interference (EMI) shielding, vehicle parts and combat uniforms will all benefit from agglomeration reduction processes. New military application would be infrared threat sensor countermeasures. Industrial applications for optimized mixed packing research include electronics, fuel cells/batteries, and solar energy.

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KEYWORDS: Bispectral obscurant, visible, infrared, explosive, grenade

A10-028 TITLE: Innovative and Novel Concepts for Eye-Safe Wavelength High Power Fiber Lasers for Increased Performance

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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 research and develop innovative reduced eye hazard wavelength, high energy laser innovative and novel concepts for high power fiber lasers that are scalable to power levels of greater than 75kW while reducing the possibility of collateral eye damage due to laser scatter. Innovative and novel concepts could include fiber based lasers, ceramic slab based laser, thin disk lasers, etc.

DESCRIPTION: While it has been determined that high energy lasers can provide a tremendous benefit to the army for area protection against rockets, artillery, and mortars (RAM) and other potential threats, there is concern about current Nd:YAG based high energy laser systems potentially causing collateral eye damage due to scatter off of target surfaces. This SBIR topic focuses on develop of innovative technologies for high power lasers that operate at reduced eye hazard wavelengths thus reducing the potential for collateral eye damage due to scattering off of target surface while still have good atmospheric propagation and target lethality properties. This topic is to directly address areas to increase the overall laser performance of solid state lasers in the 1.5um to 2.1um wavelength range. Good atmospheric propagation and target lethality will provide constraints to allowable wavelengths and required

beam quality. The proposed architectures and technologies should support propagation of the laser beam for several kilometers while have a reasonable spots size and support coupling the laser energy into military relevant targets. As the mission sets expand for high power laser devices the risk will increase for the potential of collateral eye damage. Early investment in technology that supports efficient, compact, reduced eye hazard wavelength, high power laser research is critical. The purpose of this SBIR is to investigate through laboratory experiments and modeling and simulation and building a scalable prototype in phase III, the potential of high power, reduced eye hazard, lasers to exceed 75kW of average power in a full power system configuration. The proposal should address such items as potential scalability to greater than 100kW class devices, output laser beam quality, run times, efficiencies, and packaging flexibility to include either volume and weight benefits or constraints. The proposed laboratory experiments must have consistent energy density as would a full power laser device.

PHASE I: Conduct research, analysis, and studies on the selected laser architecture and develop measures of performance potential and document results in a final report. Provide analysis supporting the reduced collateral eye-damage claim. The Phase I effort should include modeling and simulation results supporting performance claims. The effort should also produce a preliminary concept and a draft testing methodology that can be used demonstrate the laser system components proposed during the Phase II effort.

PHASE II: During Phase II, a laser system concept design will be completed and selected components will be developed and tested to help verify the design concept. The data, reports, and tested component hardware will be delivered to the government upon the completion of the Phase II effort.

PHASE III: There are many potential applications of a reduced eye hazard wavelength high energy laser. Commercial and Military applications include laser remote sensing, laser communication, material processing, and remote target destruction. Industrial high-power applications of high-power solid-state lasers include welding, drilling, cutting, marking, and micro-processing. High energy DoD laser weapons offer benefits of graduated lethality, rapid deployment to counter time-sensitive targets, and the ability to deliver significant force either at great distance or to nearby threats with high accuracy for minimal collateral damage. Laser weapons for combat range from very high power devices for air defense to detect, track, and destroy incoming rockets, artillery, and mortars to modest power devices to reduce the usefulness of enemy electro-optic sensors. Building and testing a scalable reduce eye hazard wavelength high energy laser breadboard device based on the phase II design with a near diffraction limited beam quality and high efficiency will be the goal in a phase III effort. This phase III breadboard would demonstrate the ability to remotely destroy targets for the CRAM mission. Military funding for this phase III effort would be executed by the US Army Space and Missile Defense Technical Center as part of its Directed Energy research.

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KEYWORDS: Reduce Eye Hazard Laser Wavelength, High Energy Laser, Solid State Laser

A10-029

TITLE: Flux Compression Generators

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: The objective of this effort is to develop methods for converting the energy losses in small Flux Compression Generators (FCGs) into useful energy.

DESCRIPTION: The US Army has programs that require very compact explosive driven power supplies. One such power supply is the Flux Compression Generator (FCG). Flux compression generators convert the chemical energy of explosives into electrical energy by compressing a magnetic field. The main advantage of FCGs is that they are relatively small and can fit into platforms of interest, unlike more conventional power supplies such as battery powered Marx generators. However, as the size of FCGs decrease, they tend to have higher losses due, in part, to size and tolerance scaling. However, it may be possible to take advantage of this tendency for higher losses to couple part of this loss energy out as broadband Radio Frequency (RF) energy. Therefore, the Army is seeking innovative approaches for converting energy typically lost due to such mechanisms as resistive heating and flux trapping into useful RF energy. The FCGs currently of interest, but not limited to, are those that fit into small geometrical spaces; i.e., less than 1.5 inches (40 mm) in diameter and 1 inch (25 mm) in length.

PHASE I: Design and develop new methods for coupling loss energy out of small FCGs as an electromagnetic pulsed and design and conduct proof-of-principle demonstrations 1) to verify that these energy conversion methods are feasible and 2) to assess their utility in producing radiated RF energy.

PHASE II: Design, build, and test compact efficient FCGs, verify that they can efficiently convert loss energy into RF energy, and verify that they can meet the size requirements of a platform with a diameter as small as one inch. Address implementation and manufacturing issues by working with the various government laboratories and contractors developing munitions for the Army.

PHASE III: FCGs are applicable to multiple military and commercial applications requiring pulsed power. These include advanced munitions, expendable RF sources for sensors, portable water purification units, portable nondestructive testing systems, portable lightning simulators, portable X-ray sources for monitoring explosive events, portable neutron sources for inspecting shipping containers, burst communications and telemetry, and oil and mineral exploration. Since several government labs and prime contractors are developing advanced munitions, the contractor will need to develop a business plan for working with these agencies and companies.

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KEYWORDS: Flux Compression Generator, Magnetocumulative Generator, Pulsed Power, Switch, High Voltage, Electrical Breakdown

A10-030 TITLE: Electromagnetic Attack Detector

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The objective of this effort is to develop compact detectors that will alert system operators that they have been subjected to an Electromagnetic Pulse (EMP) and/or High Power Microwave (HPM) attack or if the equipment has failed due to electromagnetic interference. This sensor will enable personnel to distinguish between a random failure and that caused by EMP and/or HPM attack.

DESCRIPTION: High power microwave (HPM) and electromagnetic pulse (EMP) technologies have matured to the point that they are being deployed as electromagnetic weapons using a number of delivery techniques. Modern military and civilian systems with unprotected electronic equipment can be rendered useless by EMP and HPM attack. These weapons can cause a wide range of effects ranging from temporary upset to permanent failure, and it is impossible to determine that an electromagnetic attack occurred or just a random software/hardware failure.

The need exists for means to determine when electronic failures are random or are caused by EMP/HPM attack or environmental Electromagnetic Interference (EMI). In addition, if a system has been subject to electromagnetic interference, the detector should have the capability to store information on the irradiating pulse in terms of its temporal and frequency characteristics for after incident forensics. The system needs to either be broadband or consist of an array of detectors to cover the frequency band from 20 MHz to 10 GHz. It should be able to detect a broad range of power densities ranging from milliwatts per square centimeter to kilowatts per square centimeter. It should be as compact as current technology permits.

The system should include both the sensor technology required to detect the attack and the software required to discriminate an attack from electromagnetic interference. It should in its final embodiment include both a simplistic interface to alert for immediate action and a diagnostic interface to collect attack/incident data.

PHASE I: Conduct analytical and experimental efforts to demonstrate feasibility of designing an EMP/HPM attack warning detector. Proof-of-principle experiments with a brass board device must be conducted to determine if the detector can detect signals over a broad frequency band and if it can detect high power pulses.

PHASE II: Based on the results and findings of Phase I, demonstrate the technology by fabricating and testing a prototype in a laboratory environment. Assemble a proof-of-principle device and demonstrate the proposed technology and its ability to signal an attack warning and to identify the attacking pulse's characteristics. Identify and address technological hurdles. The proposed development and demonstration should be limited to what can be demonstrated in a Phase II program and should identify the means necessary to transition the technology.

PHASE III: The end state of this technology would be a free standing piece of equipment with status lights to indicate if a threat existed or that EMI issues could be occurring. A diagnostic port would be included for advanced diagnostics and forensics.

This technology could be used in a broad range of military and commercial applications. Military applications include alerting radar sites, communication systems, sensor suites, missile batteries, and vehicles that they are under EMP/HPM attack or to determine when a field EMI/EMC issue exists. Civilian applications include alerting Emergency Medical Services, police forces, power plants, communication nodes, banks, airports, public transient systems, and so on that they are under EMP/HPM attack. Due to the broad range of applications of this technology, the contractor should develop a working relationship with potential users and vendors of this technology.

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KEYWORDS: Pulsed Power, High Power Microwave, Electromagnetic Pulse Attack, Antennas, Switches, Detectors

A10-031 TITLE: Lightweight Nanosatellite Propulsion System to Enhance Battlespace Awareness and Battle Command Capabilities

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: PEO Missiles and Space

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 lightweight nanosatellite propulsion subsystem based on thrusters that utilizes chemically inert solid propellants with electrically based activation for station keeping and attitude control.

DESCRIPTION: The Operationally Responsive Space (ORS) program has been developed to meet the space-related urgent needs of the warfighter such as battlespace awareness and battle command in order to improve the observation and collection of information worldwide, the command and control of battlespace awareness assets, and communication in the combined/joint environment. The payloads that nanosatellites would carry to enable these capabilities would be Intelligence, Surveillance, and Reconnaissance (ISR) sensors and communications transceivers. These satellites would be launched into inclined low Earth orbits (LEO) and operate for a period of six months to two years. The earliest classes of these satellites would be approximately 3 kg and conform to the “3U” cubesat form factor, with possible expansion to larger spacecraft later as new deployment concepts are developed. A key area of need for these nanosatellites is a low-mass, low-volume propulsion subsystem that would provide attitude control and stationkeeping duties. It is anticipated that the earliest classes of these nanosatellites would be launched as secondary payloads in the P-POD structure. These opportunities imply that the success of the primary payload is paramount, so propulsion systems based on chemical reactivity or pressurized gases should not be considered at this time. Furthermore, it is likely that access to the nanosatellite prior to the launch will be very limited, so charging of pressurants or filling of propellant tanks is unlikely. Therefore, propulsion systems based on small thrusters that utilize chemically-inert solid propellants that are electrically activated are desired.

In order to control attitude, impulses must be applied in directions offset from the centerline of the spacecraft. In order to station-keep, impulses must be applied so that the effective thrust vector is through the mass center of the spacecraft. Therefore the propulsion system should be designed to be able to be “distributed” to various locations on the spacecraft and the thrusters should be able to act alone or in groups to accomplish these objectives.

The objective of this research is to create an experimental nanosatellite propulsion subsystem that has the following features:

- Has a total mass of less than 15% of the available mass, e.g., roughly 0.5kg of a 3U form factor, including reaction mass and control system;

- Fits within less than 15% of the available volume (assume an overall nanosatellite volume of 10cm X 10cm X 30cm);
- Designed to be “distributed” to various locations on the nanosatellite in order to maximize the distance between the center of mass of the nanosatellite and the thruster, improving the ability to control attitude, desaturate momentum wheels, or thrust through the centerline of the spacecraft for stationkeeping maneuvers;
- Provides a Delta V of at least 100 m/s. Greater merit would be given to proposed systems that can provide more Delta-V per subsystem mass;
- Utilizes less than 2 Watts of steady state electrical power or 20% of a typical nanosat electrical power generation subsystem value; and less than 4 Watts peak start-up electrical power;
- Designed such that they can be reconfigured depending upon mission requirements and operated as either individual units or ganged;
- Electrically activated thrusting;
- Provides an in-orbit minimum design life of 1 year.

PHASE I: Conduct feasibility studies, technical analysis and simulation, and small scale proof of concept demonstrations of proposed lightweight nanosatellite propulsion subsystem innovations. Develop an initial conceptual approach to incorporating a nanosatellite propulsion subsystem onto a nanosatellite and include subsystem estimates for mass, volume, power requirements, and duty cycles.

PHASE II: Implement technology assessed in Phase I effort. The Phase II effort should include initial lightweight nanosatellite propulsion subsystem designs, mock-ups, and, if possible, a launch-ready prototype ready to integrate into a nanosatellite bus. Initial technical feasibility shall be demonstrated, including a demonstration of key subsystem phenomena (e.g., thrust levels, acceptance of inputs from ground control segment or autonomous guidance, navigation and control subsystems, etc). The goal should be Technology Readiness Level 4, with component and/or breadboard verification in laboratory environment.

PHASE III: The contractor shall finalize technology development of the proposed lightweight nanosatellite propulsion subsystem and begin commercialization of the product. In addition to military communications or intelligence, surveillance and reconnaissance (ISR) missions, commercial civilian applications for a lightweight nanosatellite propulsion subsystem could include science or education missions. Phase III should solidly validate the notion of a lightweight nanosatellite propulsion subsystem with a low level of technological risk. The goal for full commercialization should ideally be Technology Readiness Level 9, with the actual subsystem proven through successful mission operations. Specifically, Phase III should ultimately produce lightweight nanosatellite propulsion subsystems suitable for nanosatellites applications, i.e., with a total satellite weight of only ten kilograms, yet having capabilities comparable with larger satellites weighing hundreds or thousands of kilograms. The contractor must also consider manufacturing processes in accordance with the president’s Executive Order on “Encouraging Innovation in Manufacturing” to insure that the lightweight subsystems developed under this SBIR can be readily manufactured and packaged for launch and on-orbit operability.

While initial (Phase I and II) sponsorship and funding may come from Army Space and Missile Defense Command, during Phase III that support could conceivably transition or expand to the appropriate division of the Army Program Executive Office for Missiles and Space (PEO M&S) upon full rate production and deployment. PEO M&S could maintain a stockpile of lightweight nanosatellite propulsion subsystems ready to mate to nanosatellite buses, which when launched responsively could meet urgent warfighter needs under DoD’s Operationally Responsive Space enterprise. Simultaneously, commercial versions of the propulsion subsystem could be produced for civilian and scientific applications. Universities could use the propulsion subsystems in research or student project nanosatellites. Commercial satellite manufacturers could incorporate lightweight nanosatellite propulsion subsystems into a variety of commercial nanosatellites for sale of complete units to various interested customers. Commercial companies could also provide competitively priced nanosatellite-based communications or remote sensing services to paying customers, including the national security community.

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2. Ketsdever, Andrew D., et al. "Performance Testing of a Microfabricated Propulsion System for Nanosatellite Applications." Institute of Physics Publishing, Journal of Micromechanics and Microengineering, Issue 12 (December 2005), published 28 Oct 2005, available at http://www.iop.org/EJ/article/0960-1317/15/12/007/jmm5_12_007.pdf?request-id=672f7b87-12eb-4386-adb7-d8ca02041efd , accessed 24 Nov 2008.

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KEYWORDS: thruster, microthruster, guidance, navigation, control, delta-v, reaction control, station keeping, station changing, nanosatellite, nanosat, microsatellite, microsat, responsive space.

A10-032 **TITLE:** Information Security and Trust in a Space Communications Network

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Missiles and Space

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 innovative solutions to ensure trusted information exchange (i.e., confidentiality and integrity) in an Army space communications network.

DESCRIPTION: Within the Army space environment, the Space Operations Officer supports tactical to strategic levels by integrating space capabilities as part of an overall warfighting capabilities. The Space Operations Officer supports Army Operations by exploiting space-based capabilities -- communications, position, velocity and timing, environmental monitoring (space and terrestrial weather), intelligence, surveillance and reconnaissance and theater missile warning -- to allow Army forces to maintain full situational awareness, the position of friendly forces, terrain information, current and projected weather conditions and enemy troop locations and capabilities. Space based capabilities also enable Army units to effectively communicate with other units and Services in their area of operation; provide reach back to CONUS based enablers; and facilitate other capabilities.

The information (data) created, maintained and transferred within the space communications network, which supports the Army space environment, is an important target for potential adversaries. The process of information exchange along the entire communications path over the different segments (exoatmospheric, atmospheric, wired and wireless) as well as through interactive applications in this environment is rapidly becoming a heightened concern due to the requirement to provide space-based information to an expanding information user base as well as the increasing skill level of attackers. The need to securely transfer information and guarantee delivery from the trusted source to the ultimate information user is essential to Army mission success.

In previous communications architectures, if a system was supposed to be absolutely secure, it most often operated as an isolated network. The convergence of voice and data networks and dramatic shift within the overall Army information environment to IP based communications has all but obviated the ability to operate isolated networks in order to maintain high levels of security. Increasingly, all types of information systems must communicate across both wired and wireless IP-based networks in the battlefield and in command centers at all levels. This dramatic shift, while providing unparalleled access to space based information and communications at all operating levels, has also introduced significant opportunity for adversaries to exploit or compromise Army networks, to include space communications networks. Simply implemented encryption solutions are easily compromised by skilled and determined adversaries, while robust encryption techniques are difficult to implement, maintain and use, resulting in improper configuration and misuse. The outcome is that all too often critical communications are either easily intercepted or not sufficiently protected. As Army forces have increasingly come to rely on the availability of

space-based information, there is a concomitant need to protect that information, insure that it is transferred without compromise and guarantee that it is received and viewed only by the intended and authorized recipients.

Existing confidentiality and integrity solutions within current network paradigms and protocols for information transfer are subject to the proliferation of vulnerabilities and exploits in today's IP-based and software intensive communications networks. They are primarily based on some form of encryption and authentication scheme within a traditional network security infrastructure. Experienced attackers have become quite adept at overcoming these current schemes. Based on the increasing significance of space-based information for Army operations, there is a critical need for a new approach to the processes and protocols that will provide enhanced capability to guarantee the security, integrity and the source receipt of information transferred within the managed space communications network.

An innovative solution must go beyond today's commonplace network, encryption and authentication schemes. Research is required into leading edge and creative concepts of quantum cryptography, information exchange, encryption and security that can provide dynamic and provable security for data transmission across non-isolated networks. Researchers should investigate new schemes for the representation of information within a system and how that representation is transferred and reconstituted by the receiver. Proposals should explore innovative solutions for data transfer protocols with trusted source and receipt. Finally, solutions should be holistic and outline the appropriate scheme for each component or segment of the overall space communications network.

PHASE I: Develop initial concept design(s) for enhanced information (data) security and trust for Army space communications focused on IP based networks. Modeling and simulation paradigms are encouraged to model key elements of the resulting solution. Phase I deliverables should include key component technological milestones if implemented.

PHASE II: Develop, demonstrate and validate the best approach from Phase I into a prototype platform/software/hardware and/or modeling and simulation model(s) suitable for integration into the overall Army information environment. The prototype or model should demonstrate advancement of information security and trust by illustrating security status for a subset of the Army space communications network.

PHASE III: The end state of this technology would be software solutions and/or network/hardware interfaces that (1) could be integrated into the Army space communications network, and (2) are applicable to commercial off the shelf components that will provide trusted and secure communications between nodes. Prepare detailed plans for and implement demonstrated capabilities on critical military and potential commercial applications.

Private Sector Commercial Potential: Information security solutions have application throughout commercial industries to include the defense industrial base (DIB). Commercial systems that frequently transmit and store critical but unclassified defense information via the internet and corporate intranets would benefit greatly from this development. In addition to military and homeland defense, the banking, finance, e-commerce, and medical industries would also have a high demand for such technology that could increase the security of sensitive information such as financial transactions and health records.

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KEYWORDS: information security, information trust, network security management, cybersecurity, encryption, quantum computing