

## **ARMY SBIR 09.2 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:

Chris Rinaldi  
Program Manager, Army SBIR  
[army.sbir@us.army.mil](mailto:army.sbir@us.army.mil)

US Army Research, Development, and Engineering Command (RDECOM)  
ATTN: AMSRD-SS-SBIR  
6000 - 6th Street, Suite 100  
Fort Belvoir, VA 22060-5608  
(703) 806-2085  
FAX: (703) 806-0675

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**

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.

**Army Phase I proposals have a 20-page limit (excluding the Cost Proposal and the Company Commercialization Report). Pages in excess of the 20-page limitation will not be considered in the evaluation of the proposal (including attachments, appendices, or references, but excluding the Cost Proposal and Company Commercialization Report).**

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

09.2 Solicitation Pre-release	April 20 – May 17, 2009
09.2 Solicitation Opens	May 18 – June 16, 2009
09.2 Solicitation Closes	June 17, 2009; 6:00 a.m. ET
Phase I Evaluations	June - August 2009
Phase I Selections	August 2009
Phase I Awards	October 2009*

*\*Subject to the Congressional Budget process*

## **PHASE II PROPOSAL SUBMISSION**

**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](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**

All final technical reports will be submitted to the awarding Army organization in accordance with Contract Data Requirements List (CDRL). Companies should not submit final reports directly to the Defense Technical Information Center (DTIC).

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**ARMY SBIR PROGRAM COORDINATORS (PC) and Army SBIR 09.2 Topic Index**

<b>Participating Organizations</b>	<b>PC</b>	<b>Phone</b>
<b><u>Aviation and Missile RD&amp;E Center (Aviation)</u></b>	<b>PJ Jackson</b>	<b>(757) 878-5400</b>
A09-013	Airworthy Cable Angle Measurement System for Slung Load Operations	
A09-014	Crack Initiation Resistant Processes for Case Hardened Steels	
A09-015	Self-Powered, High-Temperature, Wireless Sensors for Rotorcraft Applications	
A09-016	UAV Sensor Controller for Manned Aircraft	
A09-017	Reactive Real-time Planners for Coordinated Aggressive Maneuvers	
A09-018	End-User Development of Robust Part-Task Pilot Models for Simulated ATC	
A09-019	Embedded Component Health Management for Rotorcraft	
A09-020	Hybrid Vorticity Transport Method for Rotorcraft Comprehensive Analysis	
A09-021	Open Source Comprehensive Optical Diagnostic Analysis Suite	
<b><u>Aviation and Missile RD&amp;E Center (Missile)</u></b>	<b>Otho Thomas</b>	<b>(256) 842-9227</b>
A09-022	20 year backup battery	
A09-023	Aberration corrected imager for missile dome and window applications	
A09-024	New Thermal Battery Electrochemistry	
<b><u>Armaments RD &amp; E Center</u></b>	<b>Carol L' Hommedieu</b>	<b>(973) 724-4029</b>
A09-025	Wafer-level manufacture, energetic loading and packaging of metal MEMS S&A devices for fuzes	
A09-026	Innovative Real Time Probes	
A09-027	Nanostructured High Performance Energetic Materials	
A09-028	Innovative High Strength Nanostructured Aluminum-Based Composites	
A09-029	Advanced High Energy Density Propellants	
A09-030	Advanced Weapon Sighting Systems	
A09-031	Automated Manufacturing of Composite Materials including Armament Applications	
A09-032	High Energy Density Inertial Harvesting Power Source for Spin Stabilized Small- and Medium-Caliber Fuzing	
A09-033	Miniaturization of Sensors on Flexible Substrates	
A09-034	Image Analysis for Personnel Intent	
A09-035	Tamper-proof Protection of Critical Combat Ammunition Fuze and Guidance Technologies	
A09-036	Swarm/agent Technology For Small Unit Scalable Effects	
A09-037	Smart Dense Detector Arrays	

- A09-038 Innovative Wide Area Forward/Side Looking On-the-Move Laser Based Explosives Detection System
- A09-039 Innovative Coatings for Lightweight Alloys

**Army Research Laboratory**

**John Goon**

**(301) 394-4288**

- A09-040 Scalable and Temporal Data Analytics for Mobile ad hoc Networks
- A09-041 Scalable Programming models for Battle Command Applications on emerging multi-core architectures
- A09-042 Approaches and Techniques for Specialized Character Recognition (CR) and Hand Writing Recognition (HWR) of Named-Entity Categories in Arabic Script and Romanized Document Images
- A09-043 Gas Phase Sulfur Sensor for JP-8 Fueled Auxiliary Power Generation System
- A09-044 Novel flexible sensor array integrated with a Flexible Display
- A09-045 Development of GaN Substrates for High Power and Multi-Functional Devices
- A09-046 Ultra Resolution Camera for C4ISR Applications
- A09-047 Eye-safe fiber-coupled laser pumps for high power laser applications
- A09-048 Controlled Bandwidth Transmission Systems for Ultra-Wideband Radars
- A09-049 High-G Simulator for In-Flight Test Article
- A09-050 Consolidation of Materials by Liquid Particle Acceleration
- A09-051 Innovative manufacturing research on forming of large light armor alloy sections resistant to blast and penetration
- A09-052 Novel Variable Explosive Yield Concept
- A09-053 Disruptive fibers and textiles for flexible protection
- A09-054 Full Field, Out-of-Plane Digital Image Correlation (DIC) from Ultra-High Speed Digital Cameras
- A09-055 Versatile Micro/Nano-mechanical Load Frame For In Situ Studies

**Army Research Office**

**Dr. Roger Cannon**

**(919) 549-4278**

- A09-056 Photonics-enabled Radio-Frequency Arbitrary Waveform Generation
- A09-057 Ultraviolet photodetectors based on wide-bandgap oxide semiconductors
- A09-058 ZnO alloy based LEDs and laser diodes
- A09-059 The Energetics of Cognitive Performance: Regulation of Neuronal Adenosine Triphosphate Production

**U.S. Army Test & Evaluation Command**

**Nancy Weinbrenner**

**(703) 681-0573**

**Joanne Fendell**

**(410) 278-1471**

- A09-060 Virtual RF Environment
- A09-061 Compact, Robust, Real Time, High Capacity Data Storage for test Instrumentation
- A09-062 Causality & Prediction of Radio Frequency Encroachment on Test & Training Ranges

**Communication Electronics Command**

**Suzanne Weeks**

**(732) 427-3275**

- A09-063 Chaotic Modulation for Satellite Communications (SATCOM) Communications Systems
- A09-064 Micro Cryocooler for Low Temperature Superconductor Electronics Systems
- A09-065 Free Space Optical Connections for Airborne On-the-Move Nodes at High Data Rates Over Extended Distances
- A09-066 Distributed Satellite Communications (SATCOM) On-the-Move (OTM) Aperture
- A09-067 Content Dependent Bandwidth (BW) Enhancement
- A09-068 Conformal, Printable Antennas for VHF and UHF Applications
- A09-069 High Output and Multi-Band Laser for Electro-Optical/Infra Red Counter Measure (EO/IRCM)
- A09-070 Detection and Neutralization of Explosive Hazards
- A09-071 Window Mounted UHF Antenna System
- A09-072 Network Fault Management and Self Healing
- A09-073 Clutter Mitigation Techniques for Ground-Based, Ground Moving Target Radars
- A09-074 High Efficiency, Highly Linear, Solid-State Power Amplifier for Wide Band Applications
- A09-075 Advanced Algorithms and Architecture for Multimodal Biometrics Fusion (A3MBF)
- A09-076 Forward HUMINT (Human Intelligence) Automatic Collection
- A09-077 Domain Name Server (DNS) Protection Techniques

A09-078 A Dynamic and Knowledge Driven Architecture for Airborne Minefield Detection  
A09-079 Transition Metal Oxide Optical Switch  
A09-080 Array Processing Techniques for III-V Material, Strained Layer Superlattice, Mid and Long Wavelength, High Sensitivity Infrared (IR) Sensors  
A09-081 Identity Management of Biometric Data (IMBD) across the Global Information Grid (GIG) using a Service Oriented Architecture (SOA) Framework  
A09-082 High resistivity VOx for Continuous Bias Read-outs  
A09-083 Develop High Operating Temperature Infrared Detectors and Systems  
A09-084 Small Pitch Flip-Chip Interconnects for Focal Plan Arrays/Readout Integrated Circuit Hybridization  
A09-085 Proactive Adaptive Channel Reconfiguration (PACR)  
A09-086 Refillable Liquid Fuel Cartridges for Portable Methanol Fuel Cell Systems  
A09-087 Any-Time Cognition for Network Centric Environments  
A09-088 Context Based Data Abstraction  
A09-089 Innovative Silicon Imager for Head-Mounted Night Vision  
A09-090 Heat Actuated Cooling System  
A09-091 Rapid Frame Rate Focal Plane Arrays for Active Electro-Optic Applications  
A09-092 50- 100 Watt Wind Energy Harvesting in Light Tactical Applications  
A09-093 Metadata Databases  
A09-094 Novel Growth and Processing of an Extremely High Performance, Low Defect FPAs Utilizing HgCdTe on InSb Substrates

**Engineer Research & Development Center**

**Theresa Salls**

**(603) 646-4591**

A09-095 Integrated Multi-Criteria Decision Analysis and Geographic Information System for Environmental Management  
A09-096 Self Healing, Self-Diagnosing Fiber Reinforced Multifunctional Composites  
A09-097 Tension/Extension Test Device for Ultra High Strength Concretes  
A09-098 Vehicle Payload Detection at Low Speeds through Weigh-in-Motion  
A09-099 Optimally Designed Wireless Seismic/Acoustic Ordnance Impact Characterization System

**JPEO Chemical and Biological Defense**

**Larry Pollack**

**(703) 767-3307**

A09-100 Point and Stand-off Microwave-Induced Thermal Emission (MITE) of Chemical, Biological, and Explosive Materials  
A09-101 Passive Standoff Detection of Chlorine

**Medical Research and Materiel Command**

**Dawn Rosarius**

**(301) 619-3354**

A09-102 Application of Finger-Mounted Ultrasound Array Probes  
A09-103 Surgical Debridement Assist Device  
A09-104 Improved Robot Actuator Motors for Medical Applications  
A09-105 Developing a Point-of-Care Diagnostic Assay for Leptospirosis  
A09-106 Biocompatible Materials for Repair of Bony Defects in Craniofacial Reconstruction  
A09-107 Malarial Vaccines Utilizing Antigen/Adjuvant Display on Viral-Like Particles  
A09-108 Development and Commercialization of Analyte Specific Reagents (ASRs) for the Diagnosis of Selected Arthropod-Borne Viruses on FDA-Cleared Real-time PCR Platforms  
A09-109 Personnel High Rate Data Recorder  
A09-110 Personnel Borne Blast Dosimeter  
A09-111 Development and Commercialization of Analyte Specific Reagents (ASRs) for the Diagnosis of Rickettsial Diseases on FDA-cleared Real-time PCR Platforms

**Program Executive Office Ammunition**

**Seham Salazar**

**(973) 724-2536**

**William Sharpe**

**(973) 724-7144**

A09-112 Dual Purpose Handgrenade with Enhanced Non-Lethal and Lethal Effects  
A09-113 Advanced low-power personnel/vehicle detecting radar for smart unattended ground sensor/munition systems

**Program Executive Office Aviation**

**Layne Merritt**

**(256) 313-4976**

**Iris Prueitt**

**(256) 313-4975**

A09-114 Automatic Test Equipment (ATE) for Non-Destructive Test/Non-Destructive Inspection/Non-Destructive Evaluation/Non-Destructive Test Evaluation (NDT/NDI/NDE/NDTE) of Composite Rotor Blades

A09-115 High Integrity, Low Cost Rotor State Measurement System

**Program Executive Office Soldier**

**King Dixon**

**(703) 704-3309**

**TJ Junor**

**(703) 704-3310**

A09-116 Man Portable Desalination System

A09-117 Mild Traumatic Brain Injury Mitigating Helmet Pad

**Space and Missiles Defense Command**

**Denise Jones**

**(256) 955-0580**

A09-118 Ultra Compact Energy Efficient High Voltage Switches for Switching Very Small Energy Stores

A09-119 Coherent High Power Diode Laser Array

A09-120 Lightweight Nanosatellite Deployable Array

A09-121 Rapid Identification of Ordnance and IED Materials

**Simulation & Training Technology Center**

**Thao Pham**

**(407) 384-5460**

A09-122 HemSim - Hemostatic Agent Hemorrhage Control Simulator

A09-123 Interactive Simulation on High Performance Computers

## 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. The proposal, including the Phase I Option (if applicable), is 20 pages or less in length (excluding the Cost Proposal and Company Commercialization Report). Pages in excess of the 20-page limitation **will not** be considered in the evaluation of the proposal (including attachments, appendices, or references, but excluding the Cost Proposal and Company Commercialization Report).
- \_\_\_ 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 09.2 Topic Index

A09-013	Airworthy Cable Angle Measurement System for Slung Load Operations
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A09-027	Nanostructured High Performance Energetic Materials
A09-028	Innovative High Strength Nanostructured Aluminum-Based Composites
A09-029	Advanced High Energy Density Propellants
A09-030	Advanced Weapon Sighting Systems
A09-031	Automated Manufacturing of Composite Materials including Armament Applications
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A09-035	Tamper-proof Protection of Critical Combat Ammunition Fuze and Guidance Technologies
A09-036	Swarm/agent Technology For Small Unit Scalable Effects
A09-037	Smart Dense Detector Arrays
A09-038	Innovative Wide Area Forward/Side Looking On-the-Move Laser Based Explosives Detection System
A09-039	Innovative Coatings for Lightweight Alloys
A09-040	Scalable and Temporal Data Analytics for Mobile ad hoc Networks
A09-041	Scalable Programming models for Battle Command Applications on emerging multi-core architectures
A09-042	Approaches and Techniques for Specialized Character Recognition (CR) and Hand Writing Recognition (HWR) of Named-Entity Categories in Arabic Script and Romanized Document Images
A09-043	Gas Phase Sulfur Sensor for JP-8 Fueled Auxiliary Power Generation System
A09-044	Novel flexible sensor array integrated with a Flexible Display
A09-045	Development of GaN Substrates for High Power and Multi-Functional Devices
A09-046	Ultra Resolution Camera for C4ISR Applications
A09-047	Eye-safe fiber-coupled laser pumps for high power laser applications
A09-048	Controlled Bandwidth Transmission Systems for Ultra-Wideband Radars
A09-049	High-G Simulator for In-Flight Test Article
A09-050	Consolidation of Materials by Liquid Particle Acceleration
A09-051	Innovative manufacturing research on forming of large light armor alloy sections resistant to blast and penetration
A09-052	Novel Variable Explosive Yield Concept
A09-053	Disruptive fibers and textiles for flexible protection
A09-054	Full Field, Out-of-Plane Digital Image Correlation (DIC) from Ultra-High Speed Digital Cameras
A09-055	Versatile Micro/Nano-mechanical Load Frame For In Situ Studies
A09-056	Photonics-enabled Radio-Frequency Arbitrary Waveform Generation
A09-057	Ultraviolet photodetectors based on wide-bandgap oxide semiconductors
A09-058	ZnO alloy based LEDs and laser diodes
A09-059	The Energetics of Cognitive Performance: Regulation of Neuronal Adenosine Triphosphate

Production

A09-060 Virtual RF Environment

A09-061 Compact, Robust, Real Time, High Capacity Data Storage for test Instrumentation

A09-062 Causality & Prediction of Radio Frequency Encroachment on Test & Training Ranges

A09-063 Chaotic Modulation for Satellite Communications (SATCOM) Communications Systems

A09-064 Micro Cryocooler for Low Temperature Superconductor Electronics Systems

A09-065 Free Space Optical Connections for Airborne On-the-Move Nodes at High Data Rates Over Extended Distances

A09-066 Distributed Satellite Communications (SATCOM) On-the-Move (OTM) Aperture

A09-067 Content Dependent Bandwidth (BW) Enhancement

A09-068 Conformal, Printable Antennas for VHF and UHF Applications

A09-069 High Output and Multi-Band Laser for Electro-Optical/Infra Red Counter Measure (EO/IRCM)

A09-070 Detection and Neutralization of Explosive Hazards

A09-071 Window Mounted UHF Antenna System

A09-072 Network Fault Management and Self Healing

A09-073 Clutter Mitigation Techniques for Ground-Based, Ground Moving Target Radars

A09-074 High Efficiency, Highly Linear, Solid-State Power Amplifier for Wide Band Applications

A09-075 Advanced Algorithms and Architecture for Multimodal Biometrics Fusion (A3MBF)

A09-076 Forward HUMINT (Human Intelligence) Automatic Collection

A09-077 Domain Name Server (DNS) Protection Techniques

A09-078 A Dynamic and Knowledge Driven Architecture for Airborne Minefield Detection

A09-079 Transition Metal Oxide Optical Switch

A09-080 Array Processing Techniques for III-V Material, Strained Layer Superlattice, Mid and Long Wavelength, High Sensitivity Infrared (IR) Sensors

A09-081 Identity Management of Biometric Data (IMBD) across the Global Information Grid (GIG) using a Service Oriented Architecture (SOA) Framework

A09-082 High resistivity VOx for Continuous Bias Read-outs

A09-083 Develop High Operating Temperature Infrared Detectors and Systems

A09-084 Small Pitch Flip-Chip Interconnects for Focal Plan Arrays/Readout Integrated Circuit Hybridization

A09-085 Proactive Adaptive Channel Reconfiguration (PACR)

A09-086 Refillable Liquid Fuel Cartridges for Portable Methanol Fuel Cell Systems

A09-087 Any-Time Cognition for Network Centric Environments

A09-088 Context Based Data Abstraction

A09-089 Innovative Silicon Imager for Head-Mounted Night Vision

A09-090 Heat Actuated Cooling System

A09-091 Rapid Frame Rate Focal Plane Arrays for Active Electro-Optic Applications

A09-092 50- 100 Watt Wind Energy Harvesting in Light Tactical Applications

A09-093 Metadata Databases

A09-094 Novel Growth and Processing of an Extremely High Performance, Low Defect FPAs Utilizing HgCdTe on InSb Substrates

A09-095 Integrated Multi-Criteria Decision Analysis and Geographic Information System for Environmental Management

A09-096 Self Healing, Self-Diagnosing Fiber Reinforced Multifunctional Composites

A09-097 Tension/Extension Test Device for Ultra High Strength Concretes

A09-098 Vehicle Payload Detection at Low Speeds through Weigh-in-Motion

A09-099 Optimally Designed Wireless Seismic/Acoustic Ordnance Impact Characterization System

A09-100 Point and Stand-off Microwave-Induced Thermal Emission (MITE) of Chemical, Biological, and Explosive Materials

A09-101 Passive Standoff Detection of Chlorine

A09-102 Application of Finger-Mounted Ultrasound Array Probes

A09-103 Surgical Debridement Assist Device

A09-104 Improved Robot Actuator Motors for Medical Applications

A09-105 Developing a Point-of-Care Diagnostic Assay for Leptospirosis

A09-106 Biocompatible Materials for Repair of Bony Defects in Craniofacial Reconstruction

A09-107 Malarial Vaccines Utilizing Antigen/Adjuvant Display on Viral-Like Particles

A09-108 Development and Commercialization of Analyte Specific Reagents (ASRs) for the Diagnosis of Selected Arthropod-Borne Viruses on FDA-Cleared Real-time PCR Platforms

A09-109 Personnel High Rate Data Recorder

A09-110 Personnel Borne Blast Dosimeter

A09-111 Development and Commercialization of Analyte Specific Reagents (ASRs) for the Diagnosis of Rickettsial Diseases on FDA-cleared Real-time PCR Platforms

A09-112 Dual Purpose Handgrenade with Enhanced Non-Lethal and Lethal Effects

A09-113 Advanced low-power personnel/vehicle detecting radar for smart unattended ground sensor/munition systems

A09-114 Automatic Test Equipment (ATE) for Non-Destructive Test/Non-Destructive Inspection/Non-Destructive Evaluation/Non-Destructive Test Evaluation (NDT/NDI/NDE/NDTE) of Composite Rotor Blades

A09-115 High Integrity, Low Cost Rotor State Measurement System

A09-116 Man Portable Desalination System

A09-117 Mild Traumatic Brain Injury Mitigating Helmet Pad

A09-118 Ultra Compact Energy Efficient High Voltage Switches for Switching Very Small Energy Stores

A09-119 Coherent High Power Diode Laser Array

A09-120 Lightweight Nanosatellite Deployable Array

A09-121 Rapid Identification of Ordnance and IED Materials

A09-122 HemSim - Hemostatic Agent Hemorrhage Control Simulator

A09-123 Interactive Simulation on High Performance Computers

## Army SBIR 09.2 Topic Descriptions

A09-013      TITLE: Airworthy Cable Angle Measurement System For Slung Load Operations

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

DESCRIPTION: Slung load dynamic feedback will be necessitated by future heavy-lift vertical resupply operations with large flexible airframes and large load mass fractions. Also, unmanned helicopters with low-frequency position stabilization will require accurate cable angle feedback to conduct sling load operations. Fleet helicopters currently undergoing fly-by-wire upgrades could benefit greatly from having the ability to stabilize external loads by means of load position and rate feedback. In addition helicopters without cable angle feedback control systems would benefit from a means to provide display guidance to the pilot for stabilizing the load.

A key component in being able to do any of this is an airworthy and robust sensor system that can provide slung load cable angle and angular rate measurements to the flight control system. This is a difficult and challenging problem given the loads involved and the difficult operational environment. However, such a system would allow load stabilization and rapid precision load placement in degraded visual conditions or turbulent atmospheric conditions.

There are a large number of approaches to cable angle sensing as outlined next, with components that might be distributed in the hook hatch, the hook, the sling or the load, depending on the approach taken. The principle effort is in selecting and applying a sensor type and developing a system that is feasible for field use and accommodates to operations with a variety of slings and loads and environmental factors. Previous experience in the application of the proposed sensor type and in flight instrumentation should be included in the proposal.

PHASE I: Develop a preliminary system design, confirm accuracy, range, and data rate performance, and show through analysis or other means that the concept can meet requirements for field operations, including vibrations, robustness, reliability, interface requirements and safety of flight in a feedback load control system. It is desirable that brown-out conditions be considered.

PHASE II: Demonstrate a prototype system first as the data source for a panel-mounted pilot display system and then as part of a load feedback system on an existing fly-by-wire Black Hawk helicopter. The Black Hawk, the cockpit displays and the feedback control system are provided as Government- furnished equipment (GFE). The prototype package should facilitate alignment with helicopter axes with analog or 1553 outputs and pass safety of flight review for research flight testing. The prototype system for these tests can be single string, but it should be indicated how safety of flight in field operations with load feedback control would be met.

PHASE III: In addition to the military applications noted above, potential civil applications based on a cable angle sensor package include (1) passive displays to monitor difficult loads for impending load instability in forward flight (e.g. Bambi buckets in firefighting, transporting trailers and sheds) or (2) flight director guidance for load stabilization by the pilot in the case of difficult loads (e.g., the system tested in [5]), and (3) precision load control in hover in such operations as rooftop equipment installation and air rescue with a Helibasket.

### BACKGROUND & OTHER INFO:

For this discussion, cable angles are the direction angles of the hook-to-load-cg line segment relative to helicopter body axes. These can be measured as the direction angles of the cable in a single cable sling, or as the direction of the hook force vector or directly as the direction angles of the hook-to-load-cg line segment.

A large number of sensor types and approaches to this problem have been mentioned in the literature. A few nascent single-string mechanical and optical systems for load position measurement have been implemented to support research flight tests (refs [1] to [6]). However, none of these has been developed to a level of accuracy, reliability and robustness for airworthy operational use.

A 1974 survey of cable angle measurement methods [1] notes three general approaches; (1) plane piercing methods in which the location of the cable in an x-y field is detected, (2) force resolution with load cells or strain gauges on the hook or sling attachment assembly, or, more generally, instrumented hooks, and (3) load position sensing. Cable following methods can be added to the list.

In the plane piercing methods, the position of the (single) cable is measured in an x-y field below the attachment point. Cable position detection hardware such as LEDs and diode detectors has been developed in other applications and might be brought to bear here.

Force resolution was proposed in [1] to instrument a winched cable with 3-axis strain gages on a winch assembly. Other instrumented hook assemblies include the Navy's gimbaled winch for sonar detectors in which cable angles are given directly from the gimbal angle readouts. A version of the UH60 hook has been instrumented with a 2-axis strain gage for the limited purpose of measuring weight and this could be expanded to include a measurement of the roll axle angle to obtain the cable angles and the hook force magnitude. Alternatively the hook could be redesigned to rotate around a pitch axle imbedded in the roll axle, thus giving a gimbaled hook with angle readouts. Another example of an instrumented hook is mentioned in [2], [3] using string pots to determine hook angles in the trolleyed KMAX hook and this system has been flown in an experimental load feedback control system.

Direct load position tracking can be done using radar, LIDAR, IR, etc or image processing in passive systems with or without reflectors or in active systems with transponders on the load, some with multiple transponders and triangulation data processing. Image processing of video from a pen camera mounted to the side of the hook hatch was done post-flight in work related to the flight-testing in [4]. The load had a large circular target on top and existing software was used to locate the target and its center in the image frame. This optical approach can potentially evolve to a real-time flight system. Image processing was carried further into flight test in a system that used a hatch camera and marker ring around the (single) pendant cable [5] to track the cable position in the image frame. A cable following system was included in an advanced controllable suspension designed for the HLH in the early 70's [6]. This consisted of a gimbaled ring mounted below the helicopter thru which the pendant cable passed, thus giving cable angles from the gimbal angle read outs. This was used on both cables of a dual point suspension.

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KEYWORDS: slung load, helicopter, cable angle, sensor system, position feedback

A09-014      TITLE: Crack Initiation Resistant Processes for Case Hardened Steels

TECHNOLOGY AREAS: Air Platform, Materials/Processes

## ACQUISITION PROGRAM: PEO Aviation

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

**OBJECTIVE:** This topic seeks to increase the high cycle fatigue strength of case carburized steels through the development of a manufacturing process that can create a shallow, highly compressive, crack initiation resistant surface structure with negligible effect on the roughness of the existing surface.

**DESCRIPTION:** Improvements in power density (horsepower/lb) of rotorcraft drive trains is critical to increased performance of the total aircraft. The fatigue strength of mechanical elements such as gears, shafts and bearings typically sizes these components. These components are typically manufactured from high strength case carburized steel. To achieve the desired dimensional precision and surface finish, the parts are typically finish ground. To enhance the fatigue strength, shot peening is often applied to critical areas as a final process. It is well known that shot peening imparts a compressive residual stress in a shallow layer at the material's surface, and that this residual compressive stress resists the formation of fatigue cracks as the part is exposed to cyclic tensile stresses. Shot peening is also recognized as an affordable manufacturing process. Achieving greater depth of surface residual compression (and hence fatigue strength) via higher intensity shot peening (or harder peening media) produces unacceptable surface roughness. In addition, the shot peening process involves a high degree of cold work. It is thought that there is the potential for relaxation of these residual stresses after exposure to high localized temperatures and repeated stress cycles. This topic seeks to develop a technique which can create a shallow (0.005 inches), highly compressive surface layer in a typical case carburized steel (9310 or X-53) with a near-surface magnitude in excess of -175 ksi (compressive). The process should also have minimal impact upon the surface roughness characteristics thus enabling the process to be final process applied to the part. The proposed process and required equipment should have operation and maintenance costs comparative to conventional shot peening. The process should be able to effect small radius corners such as those on small gear teeth and splines.

**PHASE I:** During the phase I effort, analysis and small scale experiments shall be conducted utilizing the technical approach proposed. This analysis should include discussions with rotorcraft airframe manufacturers to identify the specific requirements for application of the process to a gear typically used in a rotorcraft transmission. A preliminary analysis of the potential power density increase and projected cost of the proposed approach should be conducted. Small scale manufacturing trials and material characterization testing may be conducted to establish basic feasibility and guide the effort to be conducted in Phase II.

**PHASE II:** The results of the Phase I effort shall be further developed to scale-up the proposed approach and optimize the manufacturing methods. The specific approach to conducting this optimization and scale-up effort shall be closely coordinated with a rotorcraft airframe manufacturer. This development work shall be supported by necessary design and modeling effort. Manufacturing trials and material property development of increased complexity shall be conducted to evaluate the performance of the specific approach. Application of the process to a full scale gear shall be conducted. Fatigue testing to establish the potential benefits shall be conducted. Potential target applications shall be identified and plans for technology insertion and product development conducted.

**PHASE III:** Effort in this phase would involve further collaboration with the helicopter manufacturer regarding design and manufacture of a specific component to which the process could be applied. Additional specimens would be fabricated incorporating any improvement resulting from the Phase II effort. Additional testing necessary further prove the advantages of the process and potentially qualify it for service could be performed.

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KEYWORDS: Shot Peening, Residual Stress, Gears, Shafts, Bearings, Steel, Fatigue

A09-015 TITLE: Self-Powered, High-Temperature, Wireless Sensors for Rotorcraft Applications

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop an advanced self-power reliable wireless sensor for measuring temperatures and pressures on turboshaft rotorcraft engines.

DESCRIPTION: The ability to monitor the health of rotorcraft turboshaft engines is limited by the suite of sensors on the engine. In order to take advantage of emerging engine diagnostic algorithms, additional sensors need to be added to engines. However, the weight associated with the additional sensors and wiring needs to be overcome. To reduce weight, wireless sensors are a potential solution. Thus, there is a requirement for self-powered, wireless sensors in order to take full advantage of engine monitoring algorithms that provide improved on-board performance evaluation, improved diagnostics for reduced false removals/maintenance, improved troubleshooting, and prognostic capabilities for fleet management. However, the extreme environment of a turboshaft engine offers challenges that make wireless communication very complicated and must be overcome.

The standards to be applied are: sensor will be self-powered (no batteries), operate in extreme temperature environments (-40 - +250 degrees centigrade), contain a self-test, capable of storing and wirelessly transmitting data to an on-board Health and Usage Monitoring System (HUMS), measuring temperatures (0 -1000 degrees centigrade), and pressures (0-500psi) with less than one percent error in locations such as engine inlet temperature (T1), compressor discharge temperature (T3), compressor discharge pressure (P3) and inlet pressure (P1).

Other desired attributes to consider for phase III are (1) impact per Mil-Std 810F, Method 516.5; (2) vibration requirements of Mil-Std 810F, Method 514.5; (3) acceleration per Mil-Std 810F, Method 513.5; (4) altitude per Mil-Std 810F, Method 500.4; (5) rain per Mil-Std 810F, Method 506.4; (6) fungus per Mil-Std 810F, Method 508.5; (7) humidity per Mil-Std 810F, Method 507.4; (8) salt spray/fog per Mil-Std 810F, Method 509.4; (9) sand/dust per Mil-Std 810F, Method 510.4; (10) fluid susceptibility per Mil-Std 810F, Method 504; and (11) electromagnetic interference (EMI) per Mil-Std 461E as modified by ADS-37A-PRF Table 1.

PHASE I: Design and develop the architecture for the electronic sensor(s) to include its wireless communication configuration. Perform an analysis/bench test of the feasibility for the self-powered, concept electronics and that the wireless sensor weighs less than a wired configuration.

PHASE II: Develop and fabricate a prototype new sensor(s) and related electronics to demonstrate on a turboshaft engine via a test cell.

PHASE III: The technology is applicable to both military and commercial turboshaft engines (qualified to military standards listed in description) to monitor components and performance in real time. The sensor will alert the both user and monitor to component(s) stressed beyond their intended boundaries. Besides alerting the user this technology should reduce both weight and maintenance required to operate safely thereby saving both down time and resources.

As this technology matures it can be transition to other turboshaft engines. Presently within the Army there are both ground and air vehicles using turboshaft engines, and many more throughout the DoD force. With the reduction of the wire weight and related problems and issues associated with maintaining electronic and aerial platforms so prove to be very beneficial.

REFERENCES:

1. MIL-STD-810F, DOD Test Method Standard for Environmental Engineering Considerations and Laboratory Tests, 1 January 2000.
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3. ASD-37A-PRF, Electromagnetic Environmental Effects (E3) Performance and Verification Requirements, 28 May 1996.

KEYWORDS: Sensors, Self-powered technology, High temperature applications, wireless technology

A09-016            TITLE: UAV Sensor Controller for Manned Aircraft

TECHNOLOGY AREAS: Air Platform, Sensors

ACQUISITION PROGRAM: PEO Aviation

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: Define, design and develop an innovative sensor control interface for US Army aircrew members operating in manned aircraft to easily and intuitively operate the sensor systems on Unmanned Air Vehicles (UAVs). Operating the UAV sensor systems from within the noisy, vibrating, maneuvering environment of a manned aircraft cockpit is very different from operating the UAV sensor systems from within the stable UAV Ground Control Station (GCS). The Army is proliferating UAVs, and as the Army moves forward with the implementation of manned-unmanned teaming, an improved Man-Machine Interface (MMI) for control of the UAV sensors from the manned aircraft cockpit during flight conditions is required.

DESCRIPTION: US Army Research & Development (R&D) programs that prototyped, tested, demonstrated, and evaluated manned-unmanned teaming between US Army helicopters and UAV aircraft have show that manned-unmanned teaming provides significant added value to Army Aviation operations. Consequently, the Army is developing and incorporating manned-unmanned teaming capabilities into fielded systems like the AH-64D Longbow Apache. During the R&D programs, one area that needed improvement that was consistently identified was the control interface for the UAV sensor.

The GCS UAV sensor control interface is typically a sensitive joystick which provides precision manipulation of the UAV sensor's pointing vector with some additional control input devices (switches, knobs, etc.) While not tested in flight, the precision joystick type of control interface is believed to be unsuitable for use in a manned helicopter during flight conditions. Other types of man-machine interfaces have been tried with limited success. Recent flight test programs used thumb force controller type of interfaces. While this type of interface was successful in controlling the UAV sensor within the flight environment, the aircrew members who used them universally disliked the interface. When operated for more than a short period of time, the constant pressure on the thumb became uncomfortable, and this type of sensor controller was felt to be insufficiently responsive for military missions.

This SBIR topic seeks an innovative, reliable, control interface system (hardware and possibly software) that can transfer precise joystick like pointing inputs smoothly to the UAV sensor system while operating in the hot, noisy,

vibrating, pitching, and rolling aircraft environment. The controller should be able to operate optical sensors such as TV cameras and FLIR cameras, safely operate laser rangefinder/designators, and provide growth capability to control other currently fielded sensor systems such as a laser spot tracker. The controller should be able to point and move the pointing vector of the optical sensor system, zoom, select between multiple fields of view, select between multiple sensor types (ie TV and FLIR) and engage/disengage the autotracker. In addition, the controller should be able to handle all commonly used sensor control functions such as contrast, brightness, selecting black/white hot, etc. The controller should be suitable for installation into a manned aircraft cockpit, not impede aircrew egress in an emergency, and be useable while wearing standard Army pilot gloves. The sensor controller should be suitable for use for controlling the UAV sensor for an extended period of time; up to 20 minutes of continuous operation, and comfortable enough to use for up to 2 hours of operation with short breaks of up to 5 minutes. The control input system should be simple, intuitive, and easy to use.

The environment in an Army cockpit is very saturated from a sensory and cognitive workload point of view. Within the cockpit, there are a large number of audio and visual alerts and cues, high noise levels, and a situational awareness split between real world outside the A/C and the displays, controls, and teammates inside the cockpit. Many technologies have been looked at for controlling a cursor on the cockpit display that are potentially applicable. Relevant technologies include, but not limited to: eye tracking, head tracking, virtual controls (gesture, hand), touch screen, touch pad, thumb force controllers and many variations on the joy stick theme. Many of these, while providing good control in a lab environment, are either not applicable to the environment of an aircraft cockpit, or are too cumbersome and/or complex to implement. While the scope of this effort does not exclude any of the technologies or combinations of technologies listed above, the need to keep it simple from an implementation point of view should guide contractors on the applicability of their concept.

**PHASE I:** Define an appropriate control input interface concepts to control the sensor on a UAV that will be suitable for integration into the manned aircraft cockpit and that will be useable in the high vibration, high motion flight environment. Include some analysis and explanation on why the controller interface is appropriate. This may potentially include top level human factors testing and analysis of the controller system to assess the usability, sensitivity, and accuracy of the system in an equivalent or similar environment. These factors will be compared to the overall simplicity of the system to ultimately produce and integrate into a manned aircraft. If feasible, create bread board mockups and conduct proof of concept assessment of any critical technologies.

**PHASE II:** Develop the controller design from Phase I. Using mockups and simulation, bench test the technology to conduct and validate the human factors and accuracy analysis, and refine the design to enhance the control of UAV Sensors. As a minimum, high resolution simulated or surrogate UAV sensors may be used in testing and should be able to test the system in a variety of UAV operational environments to include some degraded sensor control. Conduct testing to characterize system performance. Define requirements and goals for follow-on system development efforts based on the results of this research.

**PHASE III:** Commercialization will include refinement, ruggedization, and productionization of the controller from Ph II. This technology addresses a core need for the Army's current aviation systems and similar related DoD systems. The need for simple, accurate and intuitive controls for remote sensors, like on UAVs, is crucial to enable teaming of manned and unmanned systems on today's battlefield. Application of this technology does extend to controlling remote sensor systems from both the ground vehicles and watercraft. As sensor systems are added to more and more Army aircraft, this control interface system would also be suitable for operating the manned aircraft's ownship sensors. Application of innovative new technology from this program could have far reaching application across both military and commercial markets, and could enable a vast assortment of new and unanticipated applications in as control of unmanned systems and remote sensors in environments that currently are deemed too hostile for such interaction.

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KEYWORDS: UAV, sensor, helicopter, control, man-machine, interface, intuitive, sensor

A09-017            TITLE: Reactive Real-time Planners for Coordinated Aggressive Maneuvers

TECHNOLOGY AREAS: Air Platform, Information Systems

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: Develop a system that can dynamically plan 3-D routes for a team of manned and unmanned aircraft to aggressively maneuver in a coordinated manner avoiding collisions to accomplish a required mission. This effort will seek to develop a reactive planner that balances navigation, mission and survivability needs exploiting the flight envelope of the unmanned or manned aircraft to the maximum extent.

DESCRIPTION: In flight with manned and unmanned aircraft, there is a need for quick aggressive maneuvers to evade threats and avoid collisions. Manned aircraft rely heavily on the experience of the pilot. As the increasing workload and multiple system interface duties draw the pilot away from purely pilotage responsibilities, it is anticipated that future aviators will be relying more heavily on automated navigation functions inherent in fly-by-wire aircraft. In order for these future automated navigation systems to be able to handle pilotage duties, the ability to control the air vehicle over the entire flight regime is needed especially as it reacts to threats and stationary and moving obstacles. Similarly unmanned systems have a need to be able to react in the same way but in a fully autonomous manner. Complicating the matter, future systems envision teaming manned and unmanned vehicles together, adding a further requirement that entities in a team do not collide with each other during maneuvers. Real-time dynamic vehicle route planners have been developed under multiple UAV autonomy programs to fly the vehicle in real-time avoiding obstacles or tracking targets as it progresses between previously planned way points (planned from a mission planner). To date they have demonstrated limited capability and their latencies restrict vehicle forward speeds. In order to show true operational capability and allow operations in mixed airspace in the vicinity of manned aircraft, they need to be able to support highly responsive flight by aircraft balancing the needs of evasive maneuvering while accomplishing the team’s mission. To meet this need research is needed into algorithms and sensor data processing software that enable highly reactive, real-time route planning. Although this type of planner needs to be very vehicle specific, feasibility of a modular approach with common algorithms that can be tailored to individual manned and unmanned platforms should be assessed. It is conceivable that different instantiations of similar algorithms will need to be associated with each vehicle. This technology should enhance the ability of unmanned and automated manned systems to maneuver in a coordinated fashion to avoid detection & targeting by threats, avoid collisions in a constrained air space, enable target tracking in complex environments, or advance tactical team behaviors like avenge kill or coordinated urban reconnaissance.

This SBIR topic comes out of an effort by the Army Aviation and Missile Research, Development and Engineering Center (AMRDEC) out of Ft Eustis VA, to develop a Team Survivability Planner for Manned and Unmanned Aviation Team under the program, "Survivability Planner Associate Re-router (SPAR)". The near real-time route

planning portion of SPAR was not achieved and this effort is meant to develop technology capable of filling this need. The three main objectives that were not addressed during the SPAR program were; the addition of specific vehicle flight constraints for aggressive maneuvering (for instance to break line of sight and minimize exposure to threats to prevent being targeted), collaborative countermeasure planning (for instance two vehicles flying in close proximity to use a single vehicle's RF jammer without colliding), and maintain line of sight communication planning with team and higher echelon, all integrated into the 3-D route optimization engine. While this effort will not include development of or integration with a communication or survivability planner, it will seek to develop a real-time, dynamic, 3-D route planner that supports use of the full flight envelope of the air vehicle to meet multiple potentially conflicting mission constraints and objectives. Although there is substantial research into dynamic path planners throughout industry and academia, they have primarily focused on the obstacle avoidance function; the need to manage survivability and adapt dynamically to multiple missions, flight vehicle and team coordination constraints in real-time has not been addressed and makes this effort extremely challenging.

This effort will focus on developing a software set of one or more real time dynamic route planners that can be adapted to individual aircraft be they fixed wing or rotary wing air vehicles. At a minimum, the path planner(s) need to account for vehicle states, aircraft rate limits, external safe airspace constraints imposed that account for restricted operating zones, terrain types, datalink and line-of-sight limits, actions by threats, potential collisions and obstacles in the flight path and other mission constraints imposed by pilots or air vehicle controllers. The system must work in conjunction or augment other planners for UAVs and equivalent autopilot on manned vehicles. This effort can include approaches that are directly tied to the autopilot and actually control the flight vehicle but the ability to adapt to a variety of different types of interfaces is preferred. The system should be adaptable depending on the desired constraints of the maneuver and urgency or priority set by pilot or operator. It is desirable that the software work with both autonomous and piloted flight factoring in appropriate reactions time and coordination constraints for a mixture to provide new flight paths and flight cues. For this effort, the offeror can assume that all external data needed such as airspace constraints and safe flight zones, obstacle and threat data, 3D representation of terrain and position data for entities in the vicinity including team members are provided to the planner system.

**PHASE I:** The phase 1 end product should assess proof of concept and key components of your approach in simulation. This effort could include a trade study to identify/determine what algorithms should be used but is not limited to best methods. It should identify top level differences between different manned and unmanned platforms as far as how they integrate on the autopilot on each.

**PHASE II:** The contractor shall continue development of their dynamic route planner software system for either a fixed wing or rotary wing aircraft configuration at a minimum and conduct performance testing as needed. The software will be integrated into a high resolution flight simulation environment (hardware in the loop preferred) representing a surrogate manned aircraft and UAV and tested to assess the system performance. At the end of the program, the dynamic characteristics of the software should be demonstrated (flight test preferred) to the Government. The contractor is encouraged to work with platform (manned and unmanned) developers in Phase 2 in order to make sure they are designing to an interface and control system representative of military systems.

**PHASE III:** This technology addresses an essential capability for manned aircraft and autonomous UAVs for the Army's FCS goals and similar related DoD systems. This technology should enhance the ability of unmanned and automated manned systems to maneuver in a coordinated fashion and advance tactical team behaviors. This technology is necessary to make unmanned and pilot-optional-vehicles safer and allow them to fly with very tight flight constraints, which would contribute to making them applicable to flying in NAS. Moreover this technology could play an important role in manned aircraft as an emergency maneuvers system to avoid collision especially in case of pilot injury and inability. Besides all future DoD aircraft, this technology would also be an enabler in any future commercial markets for unmanned and automated air vehicles. Applicable industries include commercial aviation, logging, emergency rescue, medical evacuation, etc.

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KEYWORDS: route planner, real-time, kinodynamic, aggressive maneuvers, manned, unmanned, dynamic, MUM, team survivability, SPAR

A09-018            TITLE: End-User Development of Robust Part-Task Pilot Models for Simulated ATC

TECHNOLOGY AREAS: Air Platform, Information Systems, Human Systems

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop capabilities that allow for rapid, end-user scripting of robust behavior models that can bridge the gap between simulation-specific Computer Generated Forces (CGFs) interfaces and human Air Traffic Control (ATC).

DESCRIPTION: There is a growing need in the military and commercial sectors to reduce the cost and improve the fidelity of multi-aircraft aviation simulations to support airspace deconfliction, air traffic management experimentation, and forward air control training. Because of the difficulty in (and cost of) staffing simulated experiments and exercises with qualified human controllers, many make do with a large number of scripted aircraft behavior models that control embedded computer-generated forces (CGFs). While cost-effective, these models are often simplistic and minimally responsive to events and other exercise stimuli. This significantly limits the effectiveness of the experiment or exercise. A third option that is widely employed is to employ human operators (or 'pucksters') who, rather than simulate the exact operation of aircraft in the exercise (e.g. via flight simulator), instead control CGFs via its simulation's native graphical user interface (GUI). However, because training and experimentation systems are often constructed from multiple, federated simulations - each with its own capabilities and control GUI - training human controllers to perform this function can be costly. In addition, because these varied aircraft simulations have varying capability levels, simultaneous control of CGFs within different simulations can be confusing and inefficient.

To shield the human controller from the inefficiencies of managing these aircraft simulations, AMRDEC seeks to develop variable-capability pilot behavior models that control for the variations in simulated aircraft capability and command protocols. Such models act as a proxy between the human controller and the aircraft simulation, providing a unifying command grammar and additional automation where the simulation lacks required capabilities. While recent research has shown that human behavior modeling techniques can be used to develop such proxy

models (Stensrud et al, 2008), the cost of updating the proxy models (to handle new domain knowledge, CGFs with unsupported capability sets, or new command protocols) can be expensive and time-consuming. To make such a capability viable, these proxy model behaviors must be exposed for end-user modification and development. We propose a GUI language editing, compiling, and runtime engine tool(s) that will work across the board with current simulation architecture like IDEEAS, OneSAF, ModSAF, JANUS, etc. that can be commercialized into both existing and future military applications and the industry sector as well.

This SBIR envisions the development of an end-user programming environment consisting of a textual or visual scripting language, an integrated development environment with debugging capabilities, and a behavior execution engine. Phase II would construct a prototype GUI interface to provide this environment(s). These environments must be usable to expert military controllers or trainers, who are typically not engineers or programmers. These environments must enable the development of behaviors that can act as proxy pilots, providing control instructions for a wide variety of underlying simulated aircraft over varying capabilities. This SBIR is interested primarily in the development of new rapid behavior editing and execution tools and, where possible, respondents should leverage COTS/GOTS simulation systems, behavior engines, human-system interfaces, and aircraft models. Simulation-independent solutions are required.

PHASE I: Design end-user programming language/environment, and run-time engine for variable-capability proxy pilot models. Identify target military training or experimentation system and related user population. Determine feasibility of candidate language and engine in supporting this population.

PHASE II: Develop a prototype GUI language editing, compiling, and runtime engine tool(s) that will work across the board with current simulation architecture like IDEEAS, OneSAF, ModSAF, JANUS, etc... Integrate this GUI tool(s) with selected simulation and human-systems interface, as in a Air Traffic Controller console. Evaluate, Demonstrate and plan for commercialization.

PHASE III: Military applications: The product could provide a flexible and cost-effective mechanism for improving the human control of a wide range of kinetic simulations and training systems. The product can also be applied to human control of military robotics, providing a means to unify operator control units across a range of platforms. Commercial applications: Similar to military systems, this product could enable cost-effective end-user control and customization of commercial simulations, training systems, robotic, and automation control systems.

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KEYWORDS: Modeling and Simulation, Human Factors, Automation, End-User Programming, Computer Generated Forces, Pilot, Aircraft, Air Traffic Control, ATC

A09-019            TITLE: Embedded Component Health Management for Rotorcraft

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PEO Aviation

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 comprehensive and networked health management capability that can be embedded directly into a rotorcraft component. The capability should include unique identification, health status, performance monitoring, remaining useful life and component history. Army Aviation has initiatives to convert to a condition based maintenance (CBM) philosophy. Implementing CBM requires knowledge of the health of critical components across the entire aircraft fleet. Tracking individual components and the associated data creates a burden in infrastructure and management. The dynamic environment of Army aviation complicates this requirement as aircraft must operate for periods disconnected from main operations and without network connectivity. This project would embed the capability to monitor and store the applicable information on to the component itself, minimizing the infrastructure burden and the probability of lost or corrupted data. The goal is to provide seamless configuration and parts management.

Current Health and Usage Monitoring Systems (HUMS) include numerous external sensors and associated wiring that adds weight to the aircraft. Sensors and wiring can account for 70% of the HUMS weight. The wiring and sensors can be difficult to install and can cause maintenance issues. There is a need to embed the health management capability into components to minimize the weight and maintenance impact.

**DESCRIPTION:** This effort will develop an embedded system capable of component self assessment, usage tracking and part history. The system should include unique identification to enable tracking both installed and uninstalled. Health, performance or usage indicators that correspond to the failure modes of the component should be calculated from embedded sensors. Remaining useful life estimates should be made if possible. This information needs to be stored in a rugged and reliable manner to ensure that the part history is accurately maintained for flight safety. This data needs to be assembled at an aircraft level with minimal effort by the crew or maintenance personnel. The process for removal and installation of a component should be considered.

Technologies are available to uniquely identify parts and digitally store information directly on components. Technology advances have been made in embedded sensors, low power microprocessors, wireless data transmission and energy harvesting/energy transmission. The focus of this effort is to synergistically combine these technology areas to meet CBM requirements.

**PHASE I:** Phase I of the effort will prove the feasibility of the proposed technology approach. Phase I will develop the technology sufficiently to prove the ability to embed the required capabilities and implement an aircraft level system for consolidation and reporting. The Phase I effort should address the system requirements for a representative aircraft component. The effort should address the monitoring requirements for the chosen component, as well as the associated sensors and processing. Technology to embed the capability such as power requirements (replacing batteries is not acceptable), and any wireless or wired network architecture should be identified. Low weight and high reliability are essential. Aircraft level network topology for consolidation and reporting should be considered. The source of data for the selected component as well as any performance, usage or diagnostics models should be identified in the Phase I proposal. A roadmap for implementation should be defined under this phase.

**PHASE II:** Phase II will develop the Phase I technology into a fully functional prototype. The system will be tested to assess the accuracy of the embedded capabilities as well as an aircraft level architecture. Component testing would be conducted along with the ability to combine multiple components in an aircraft level system.

**PHASE III:** This technology could be used for any rotorcraft. Commercial operators as well as other military services could use the technology developed to better manage the aircraft, track components and manage fleet logistics. This technology could be integrated into high value and flight safety critical aircraft components.

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KEYWORDS: Condition Based Maintenance, Unique Identification, Health and Usage Monitoring

A09-020 TITLE: Hybrid Vorticity Transport Method for Rotorcraft Comprehensive Analysis

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

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 hybrid aerodynamics methodology combining a vorticity transport method with a near-body CFD solver and interface this methodology with a rotorcraft comprehensive code for accurate, computationally efficient airloads and flowfield predictions for interdisciplinary rotorcraft applications.

DESCRIPTION: Computational modeling and simulation tools are critical for all phases of rotorcraft research, design, development, and engineering. Fast, accurate, easy-to-use computational tools are the foundation for developing future rotorcraft having mission performance, life cycle cost, and reliability needed to meet tomorrow's requirements. Rotorcraft aeromechanics specifically deals with both the airloads and the interacting flowfields of lifting surfaces and immersed bodies. Unsteady rotor wake modeling remains one of the most challenging aspects of rotorcraft analysis. Current modeling techniques for rotorcraft wakes typically either use grid-based Navier-Stokes computational fluid dynamics (CFD) methods or Lagrangian discrete vortex free wake methods. Both methods have serious drawbacks. Traditional Lagrangian methods are lower-order models based on discrete vortex singularities that are severely limited by the potential flow assumption and are heavily dependent on numerous modeling assumptions and input parameters. Vortex interactions with wakes, airframes, ground, ships, etc., are poorly modeled. Current Navier-Stokes methods are overly dissipative of vorticity and the grid density required to accurately model tip vortex structures and reduce dissipation makes full resolution exceedingly expensive computationally.

Alternative approaches for solving the Navier-Stokes equations have shown promise. For example, the Eulerian vorticity transport method (VTM), Ref. 1, uses a vorticity-conservation form of the Navier-Stokes equations, rather than a conservation variable (density, momentum, energy) formulation, to convect wakes more accurately over long distances with reduced dissipation. Another method coupled CFD method with a particle vortex transport method (PVTM) for application to rotorcraft and fixed wing problems, Ref. 2. More recently, significant progress has been reported applying a viscous vortex particle method (VVPM) to rotorcraft wake flowfields, Ref. 3. The VVPM is based on first principles and addresses the fundamental vortex physics to accurately solve for complex wake distortion and diffusion/dissipation of vorticity.

A first-principles-based, vorticity transport method combined with a near body computational fluid dynamics (CFD) solver and interfaced with a rotorcraft comprehensive analysis is sought. Under the hybrid approach, the CFD solver will address the surface near field and boundary layer flow while the vorticity transport method will accurately resolve the wake flowfield. Given the state-of-the-art in rotorcraft CFD, Ref. 4, a model which can interface with a well-validated conservation-variable CFD formulation is preferred. Similarly the U.S. Army's RCAS code provides an ideal comprehensive analysis for interfacing the aerodynamic methods with full interdisciplinary aeromechanics applications. It has been extensively used for CFD/CSD coupling methodology, Ref. 5. Other promising opportunities exist for leveraging emerging tools. The DOD HPC Modernization Office HI-ARMS Program at AFDD is developing the Helios rotorcraft analysis CFD/CSD tools with coupling protocols based on a Python scripting framework. Possible integration and leveraging opportunities include employing Helios-SAMRAI grid adaptation (adaptive mesh refinement), and an accompanying Poisson solver.

Areas of interest for enhancing vorticity transport methods include improving computational efficiency, inclusion of realistic and resolved viscous effects, evaluation of modeling (grid or particle) requirements, and turbulence issues (RANS, LES). With respect to interfacing the hybrid vorticity transport and CFD methods, compressibility, viscosity, interface/equation compatibility, stability, and construction of the velocity field may be addressed. Other potential issues include CFD numerical coupling issues at interfaces such as overset methods, equation matching, wave reflection, etc. Computational efficiency is important and parallelization and scalability for implementation on high performance parallel processors should be considered. The accuracy of the methodology should be evaluated against experimental data, including rotor airloads in separated flow and BVI conditions and flowfield problems such as brownout and rotor-fuselage interaction.

PHASE I: Phase I will formulate a vorticity transport method hybrid interface. As required, research and preliminary development to demonstrate the feasibility of an interface with an existing conservation-variable CFD code will be performed.

PHASE II: Phase II will refine the vorticity transport method with full interface implementation with existing CFD codes. Efficiency and parallelization will be addressed. Validation of airloads and wake flowfield solutions will be performed on a range of rotorcraft datasets. The hybrid method will be interfaced with the comprehensive analysis and demonstrated with suitable test problems.

PHASE III: The resulting technology will have application to the analysis, design, and development of current and future military and civilian rotorcraft configurations. Numerous government agencies and industrial manufacturers would be interested in obtaining this technology as part of their rotorcraft design methodology to improve vehicle mission capabilities and cost effectiveness and to increase design cycle effectiveness by reducing development risk and cost.

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KEYWORDS: vorticity transport method, CFD, wakes, rotors

A09-021 TITLE: Open Source Comprehensive Optical Diagnostic Analysis Suite

TECHNOLOGY AREAS: Air Platform, Information Systems, Materials/Processes

OBJECTIVE: To perform the required research and development work for an open source comprehensive optical diagnostic analysis suite.

DESCRIPTION: The ability to rapidly and accurately evaluate new and innovative rotorcraft concepts and configurations in rotorcraft testing is vital to the development of next generation rotorcraft for the Army. A variety

of non-intrusive optical diagnostic techniques are currently used (e.g. particle image velocimetry (PIV), pressure sensitive paint (PSP), photogrammetry, projection Moiré interferometry (PMI), laser Doppler velocimetry (LDV), Schlieren, etc). These techniques deliver critical information enabling rapid evaluation. One of the most time consuming tasks is the transform of optical data to qualitative measurements. Currently a mixture of commercial and research code is used to reduce the data. This applies not only to the different techniques, but can also apply within a technique (i.e. multiple codes for preprocessing, other codes for processing and finally another set of codes to post process the data). Increasing the complexity of the data reduction process is the lack of a common data format to enable data from the various measurement techniques to be examined and interrogated simultaneously. This capability is critical to enabling rapid understanding of the flow field thus enabling rapid decision making.

The goal of this SBIR is to research and develop a comprehensive optical diagnostic analysis suite. The suite shall have a modular structure consisting of a front end and open-source modules for the data analysis (i.e. a module for each diagnostic technique). The front end must be able to incorporate the results of each module into a global dataset that can be mapped onto a surface grid or measurement plane as appropriate to enable visualization and interrogation of the global dataset. The open source modules should be written in a language commonly found in the engineering community (e.g. MatLab or FORTRAN) to enable tweaking by the researchers.

PHASE I: Phase I of the project begins with a state-of-the-art assessment of the large volume of work to date on optical analysis techniques, data integration, interrogation and visualization techniques. In Phase I and II, only PSP and PIV analysis techniques will be considered. From this, provide new technology software that will address the objectives of the topic. Provide the top-level preliminary design of the proposed software including the interfaces and PSP and PIV analysis modules. Develop the mathematical basis and algorithms needed to address the problems defined in the topic. Outline the technology approaches and tools for the software modules to be implemented in Phase II. In key areas, design and implement prototype software modules to demonstrate viability and benefits relative to existing technology.

PHASE II: Based on the top-level system design and prototype demonstrations in Phase I, complete the detailed design for the full software system. Following the detailed design, complete all math basis and algorithm development, and implement all software modules. Integrate the software modules in the comprehensive optical diagnostic analysis suite. In Phase I and II, only PSP and PIV analysis techniques will be considered. Test the integrated software and generate representative results based on Government furnished PIV and PSP data. Generate timing results to measure improved runtime efficiency and throughput, where applicable. For software components having increased functionality and accuracy, demonstrate the new capabilities and compare results with existing codes to quantify improvements. Prepare test reports, software documentation, user manuals and example application descriptions.

PHASE III: The comprehensive optical diagnostic analysis suite will be transitioned to, and used by, DoD R&D organizations (such as U.S. Army AMRDEC) and equivalent Government organizations (such as NASA) for ongoing research investigations and engineering analysis support of rotorcraft research and development. The suite will be transitioned to the rotorcraft industry for application to rotorcraft testing, to reduce the time required to evaluate advanced concepts and configurations. Development of additional modules (PMI, model deformation, etc) to enhance the suite's capability is anticipated at this time. This advanced analysis, visualization and interrogation methodology will be equally applicable to both military and civilian vehicles. Particularly relevant for DoD rotorcraft will be the new joint heavy lift rotorcraft. Extensive testing will be required to aid the understanding of the associated aeromechanics and validation of design and predictive methods.

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KEYWORDS: Particle Image Velocimetry (PIV), Pressure Sensitive Paint (PSP), Video Model Deformation (VDM), photogrammetry, optical diagnostics, data reduction, open source, data analysis, flow visualization

A09-022      TITLE: 20 year backup battery

TECHNOLOGY AREAS: Ground/Sea Vehicles, 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: Contractor shall develop a low power battery capable of providing 3.3 volts DC at 10 microamps average current for 20 years. The battery shall have a 20 year storage life.

DESCRIPTION: Contractor shall develop a long shelf life, low power battery, for embedded sensor applications. The phase I section describes the requirements for the 20 year backup battery.

PHASE I: Contractor shall research and determine the feasibility of developing a battery to meet the following requirements:

- (1) operating temperature range of – 40 degrees C to + 85 degrees C. Operation over a wider temperature range up to the full military temperature range of – 55 degrees C to +125 degrees C will be considered a plus.
- (2) battery output voltage shall be between 3.0 and 3.5 volts.
- (3) battery shall provide 10 microamps average current,  
100 microamps for 0.1 seconds per day,  
1 time peak current of 1 milliamp for 1 second.
- (4) environmentally friendly battery, with minimal disposal issues.  
conventional chemical batteries will be given a higher priority than nuclear batteries
- (5) battery that can be certified flight worthy
- (6) battery shall be no larger than 1.5 by 1.5 by 1 inches.
- (7) battery shall weigh no more than 2 ounces.

PHASE II: Contractor shall develop proposed 20 year backup battery. Contractor shall perform an accelerated aging test to verify 20 year battery life at -40 degrees C, +25 degrees C, and +85 degrees C. Contractor shall provide the government with a report describing the test and test results.

Contractor shall have an independent test and evaluation conducted on the prototype battery. Contractor shall provide the independent test and evaluation report to the Government. Contractor shall deliver 2 prototype batteries to the government point of contact.

Contractor shall provide a final report, and a preliminary data sheet for the prototype battery.

PHASE III: Batteries are problematic in military systems. Current batteries do not have more than 5 to 10 years of shelf life at -40 degrees C or +85 degrees C. A new battery that has a 20 year shelf life over the -40 to +85 degrees C temperature range would reduce system maintenance by not requiring batteries to be replaced every 5 years.

Low power consumer electronics would benefit from low cost, and long life batteries. In the PC computer world, a long life CMOS backup battery would be beneficial. High end computer redundant array of independent disks (RAID) disk controllers would benefit from a longer life backup battery.

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KEYWORDS: Battery, long shelf life, low current.

A09-023            TITLE: Aberration corrected imager for missile dome and window applications

TECHNOLOGY AREAS: Electronics, 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:** The goal of this topic is to develop novel methods or techniques for correcting aberrations introduced in the seeker by the missile dome.

**DESCRIPTION:** Multimode seekers are of interest to the Army as well as other services. Much of the increased optical demands of the seeker depend heavily on the properties of the missile dome. As a result, missile dome designs have become more complicated and optical specifications have become tighter. Meeting transmitted wave front specifications is difficult. Optical finishing of these domes accounts for a large percentage of the final dome cost. By shifting the aberration correction from the dome to the imager, dome tolerances can be relaxed. The result should be a reduction in finishing costs leading to less expensive domes.

Compensating for transmitted wave front error in the imager could also eliminate the need for specialized corrective optics. If the seeker optics could be reduced or eliminated, the size and weight of the seeker could also be reduced. This technology is of interest to the Navy for their conformal windows and dome work. Corrector optics for these shapes is difficult and expensive to manufacture. Eliminating the need for these corrective elements could expedite the use of conformal optics in military systems.

The goal of this topic is to produce and demonstrate a functional prototype imaging mid-infrared sensor capable of imaging through hemispherical domes with high aberrations using wave front sensing and digital aberration correction. This sensor will be developed for missile systems using 4 to 7 inch diameter domes.

**PHASE I:** Establish feasibility of the proposed concept by modeling and bench-top demonstration of key components. Demonstrate imaging with phase reconstruction of the wave front. Provide hardware requirements, such as size, power, and weight, for implementing the algorithm in seeker/imaging applications.

**PHASE II:** Develop and demonstrate a prototype aberration correcting imaging seeker compatible with 4 to 7 inch diameter missile domes. Demonstrate real-time digital correction of dome related aberrations in the mid-infrared. Develop and provide required calibration procedures. Package in a form factor that does not exceed 8 pounds and 125 cubic inches. Provide design specifications including size, power, weight, field of view, resolution, and frame rate. The government may provide aberrated domes to be included in the final system demonstration.

**PHASE III:** Demonstrate commercial production capability for building the sensor developed in Phase II by integrating the sensor into a missile seeker package chosen by the Army. The seeker will be for Army missiles in the range of 2.75 to 7 inch diameter. Since this is an imaging sensor, this technology could potentially find its way into commercial cameras and video systems. The commercial applications may include security and surveillance, rugged robotic vehicles for police, firemen, and first responders, and in biomedical imaging including endoscopy. It could also have application space imaging and underwater photography where the harsh environments may limit the usefulness of conventional techniques. This technology could also be used by the military for surveillance, robotic vision, and medical applications.

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KEYWORDS: aberration correction, imaging sensor, missile dome, seeker

A09-024 TITLE: New Thermal Battery Electrochemistry

TECHNOLOGY AREAS: Ground/Sea Vehicles, 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 and demonstrate a new thermal battery electrochemistry based on higher energy density cathode and anode materials, to obtain improvements in specific energy of reserve power systems for long term storage munitions.

DESCRIPTION: Future thermal battery performance demands were recently defined and delineated by a DOD Power Sources Working Group in report entitled: "Technology Roadmap for Power Sources: Requirements Assessment for Primary, Secondary and Reserve Batteries", dated 1 December 2007. This government/ industry consortium identified several areas of improvement needed, relating specifically to thermal batteries.

The present thermal battery technologies, including the cobalt disulfide batteries, cannot currently meet future requirements. As systems become smaller, lighter and more capable, they require increased energy and operating life, preferably in a smaller, lighter package. Based on these requirements, their recommended goals included a specific energy increase of 25% in 5 years and 50% in 10 years.

The principle avenue for dramatically increasing thermal battery specific energy is to identify and develop new cathode and/or anode materials and electrolytes which provide higher specific capacity (amp-hr per gram of active material) at higher operating voltages across the range of discharge rates typically required of thermal batteries. The combination of higher specific capacity and higher operating voltage translates directly to higher specific energy at the battery level.

Cobalt disulfide (CoS<sub>2</sub>) cathodes enabled a significant improvement in specific energy over conventional iron disulfide (FeS<sub>2</sub>) cathodes; however, it is clear that this is still not sufficient for future weapon systems. New electrode and electrolyte materials based on recent improvements in materials synthesis and processing (nano structured, doped materials) have shown promise of much higher specific energies.

Lithium-silicon alloy (LiSi), nominally comprised of 44 w% lithium and 56 w% silicon, has been the standard anode material in thermal batteries for the last 25 years. The cobalt disulfide thermal battery has been a significant improvement while retaining the basic manufacturing process. However, other materials capable of providing higher cell voltage, higher peak current, and higher specific energy need to be evaluated.

The goal of this program is to combine improvements in cathode and anode materials and create a battery which can deliver more than twice the specific energy of the LiSi/FeS<sub>2</sub> electrochemistry (baseline) while maintaining or improving the peak current capability.

PHASE I: Outline a technical approach to an improved lithium iron disulfide or cobalt disulfide thermal battery that considers both electrochemical and manufacturing processes. Determine candidate compounds for testing, including nanostructured compounds currently available, and estimate performance improvements. Particular attention should be paid to manufacturing methods and improvements in processing these materials. Conduct test cell performance characterizations of the various chemistries. Thermal stability analyses using techniques like Thermo-Gravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC) may be necessary in addition to cell voltage determination and internal resistance. The selected candidate compositions will be developed further in Phase 2.

PHASE II: Demonstrate an improved lithium iron disulfide or cobalt disulfide thermal reserve battery suitable for use in munitions. Finalize the candidate designs from Phase I cell testing, and scale up to full-size prototype batteries. Identify and resolve any compatibility or manufacturing issues. The goals are to obtain a specific energy of 100 Wh/kg, and improve specific power to 1200 W/kg. Phase II deliverables should include a prototype demonstration of an assembled unit meeting the improvement goals as described, and include a complete description of the fabrication and test processes, test data and results, and a sufficient model to describe these results.

PHASE III: Demonstrate the increased energy storage system improvements in a relevant environment, and provide complete engineering and test documentation for development of manufacturing prototypes. A Phase III application for Army missile systems could include battery miniaturization in legacy programs as well as incorporation into emerging programs. Programs that would benefit from this technological innovation would include, but are not limited to, the following programs: TOW, Excalibur, Stinger, Javelin, NLOS, Griffin and JAGM. The development of other military applications of this technology may include future urban warfare surveillance/reconnaissance unmanned aerial vehicles. This technology is applicable to sonabuys, which are large users of thermal batteries. Commercial applications of this technology could include smaller emergency backup power sources for the aviation industry.

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KEYWORDS: thermal battery, cobalt disulfide cathode, nanomaterials

A09-025            TITLE: Wafer-level manufacture, energetic loading and packaging of metal MEMS S&A devices for fuzes

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Establish an innovative process for high-rate, low-cost wafer-level manufacture of micro-scale components used in Army Micro-Electro-Mechanical System (MEMS) safe and arm (S&A) device and micro-scale firetrain designs. The process would utilize advanced metal plating, explosive ink loading and wafer-scale packaging techniques to create packaged S&A mechanisms, explosive components, and electrical interfaces.

DESCRIPTION: The mechanical separation of primary and secondary explosives in munition fuzes has long been a safety requirement for all existing and new fuzes. Historically, these mechanical S&A devices are relatively large and also costly to produce in large quantities in applications like submunition or medium-caliber munition fuzing. Miniaturization of S&A devices in a cost effective manner (on the order of \$1-\$10/S&A) will be of significant benefit to the Army because of the wide application of MEMS fuzes across munitions. It will also enable smaller smart munitions. MEMS-based technologies have been identified as a solution by USA RDECOM-ARDEC through the completion of a successful science and technology demonstration phase. Currently, the program is maturing manufacturing technologies by evaluating production technologies that will increase design manufacturability in high quantities. Technologies evaluated include electro-plating into both UV and X-ray photolithographic molds,

deep reactive ion etching, sintering of molded polymer and metal powders, and micro die-casting. These micro-system production capabilities are ever evolving and becoming more capable and cost effective. Recent developments in wafer-level production and assembly of metal MEMS parts has shown promise as being the ultimate solution for cost effective S&A device production. These wafer-level assembly processes are proving too immature and costly to integrate at the current state of the art but show tremendous promise for high volume cost savings and throughput. Because of this potential payoff for the Army, ARDEC would like to evaluate these emerging technologies for applicability to MEMS products in development.

**PHASE I:** Phase I would include the process development for wafer scale replication of an Army-designed MEMS S&A to include electrical initiation components, mechanical safe and arm device components, and energetics. Technical risk areas to be addressed include but are not limited to the wafer bonding process, high aspect ratio plating of the MEMS parts, and the energetic loading process. Though phase I is intended to be a paper study, if possible, small scale experiments to identify major hurdles would better define technical risk areas. Hermetic sealing of the MEMS S&A device is a desired attribute but not required. The required deliverables for Phase I is a report outlining the wafer-level replication process flow and an analysis of any major risks to a successful Phase II. Contractor should make the case if the state of the art can achieve the Phase II demonstration goals outlined below.

**PHASE II:** The Phase II effort would implement and demonstrate the feasibility the wafer scale process developed in Phase I and demonstrate the function and reliability of an S&A developed in this fashion. The government will supply lithographic mask layouts or geometries to be used in fabricating the following functional layers: initiator board layers, MEMS mechanism device layers, and the explosive output base layers. This demonstration would include metal plating and bonding of the layers that make up the MEMS components as well as the energetic loading of the parts. The offeror would load the government-supplied ink or paste -formulation energetic components into the fire train layers in a batch process where all energetic cavities are loaded at the same time. The goal for a final step is to singulate the wafer of fully functional S&A devices ready for placement into the munition. The build process is complex and should be broken into ARDEC reviewed demonstrations of the initiator, demonstration of explosive train transfer, and demonstration of the inertial response of the MEMS S&A components.

**PHASE III:** The Phase III effort transitions the Phase II process into a commercially viable enterprise. It would scale up the high rate production capability of wafer-level replicated MEMS S&As. The government, at its option, may supply a new or revised set of devices layouts or geometries for the Phase III lithography processes. Full reliability testing of the Phase III devices will be conducted. High rate process yield will be determined and maximized as well. The offeror will work with fuze contractors and ARDEC representatives to maximize the applicability across wide families of munitions from 25mm-155mm applications. The wafer-level assembly and metal MEMS technology should be evaluated for applications across the military and commercial sectors. In the military, this technology could be applied to all fuzing and improving harsh environment sensor applications. The offeror will provide an analysis as to whether wafer-to-wafer level packaging of electrical, metal, and explosive components for commercial and military applications like, 3D metal MEMS, electrical sensing using electro-plating based MEMS, and medical micro-systems will benefit from the improvements in the process integration of electrical initiation components, mechanical safe and arm device components, and energetics. Other non-defense related dual use applications of this technology include safety devices for explosives used in oil field pyrotechnics, mining operations and demolition.

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**KEYWORDS:** Metal plating, micro assembly, wafer-scale, micro, MEMS, safety and arming, fuze , S&A, lithography

A09-026

TITLE: Innovative Real Time Probes

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: Design, develop and demonstrate innovative, hazardous duty, explosion proof probes for quality assurance of explosive production which can provide real time characterization in the following capacities:

- 1) Particle Size and bulk density measurement in an industrial still during the coating of explosives.
- 2) Measurement of viscosity of a melt cast explosive as it is mixed and poured into an explosive round.
- 3) Measurement of water content of an explosive as it is dried.
- 4) As a caveat, the probes should be rated safe to work with explosive materials.

DESCRIPTION: Three problems plaguing production of explosives, measuring particle size in a still during coating in real time, determining viscosity of a melt cast explosive as it is poured, and analyzing the water content of an explosive as it is dried, can all theoretically be solved by similar devices, explosion proof probes which can measure mechanical properties in real time. The following areas can all be addressed with very similar probes:

1) Measurement of Particle Size: Many plastic bonded explosives (PBX) are produced using a slurry process where micron-sized particles of solid explosives are slowly bound together by polymer binders. The particles then grow to the millimeter sizes suitable for molding powders. The slurry process starts by mixing a water phase containing the high explosive crystals, and a lacquer phase containing solvent, dissolved polymer, and other additives. The solution is then heated to distill off the solvent. The polymer falls out of solution and "coats" the explosive crystals. To produce PBX explosives at an acceptable cost for munitions, the slurry process must be optimized for yield and product quality. To control the slurry process, a new analyzer is needed that can monitor the particle growth and lacquer composition in the production still.

2) Measurement of Viscosity: The viscosity of the material as it is melted is important for process control because low viscosity indicates insufficient solids loading, while excessive viscosity would show that the material would not cast. The ability to measure viscosity would also be helpful in determining the degree of settling which occurs in a melt cast munition, which is an increasing concern in the IM Melt cast munition projects.

3) Measurement of Water Content: The amount of water in an explosive, such as RDX, as it dries is a critical process control parameter. Excessive water can cause decreases in performance and sensitivity, which would result in faulty ammunition. The ability to measure the amount of water in an explosive during the drying process would allow for improved drying procedures and ensure consistency in the drying process, reducing manufacturing variation.

Overall, a company which could develop and provide probes that cover these areas would be improving 3 areas of critical importance to the Army's production of explosives. This would provide a tremendous boon in product quality, product consistency, and decreasing costs. As the more complicated IM explosives gain usage, the ability to control manufacturing parameters will become even more important. This project is very exciting because it's showing the ability to solve three problems with one similar solution, making it very cost effective. Improved explosives quality will result in greater insensitivity and safety, improved reliability and lethality, and more manufacturing efficiency.

The probes will have to match the following specifications and environmental conditions:

Particle Size Range: 5-5000 micrometers

Particle Type: Metal or explosive powder

Safety: Rated for explosive conditions

Temperature: 20 – 120 Celsius

Probe Diameter: 2.5cm or less

Probe Length: 10cm up to 100cm (to extend into explosive mixing vessels) Explosives Slurry Water Content: 0-100% Explosives Slurry Solids Content (Viscosity): 0-90% Slurry Air Content: Up to 50% for some explosive mixing Kettle sizes 10 Liter- 6000 Liter

PHASE I: Design innovative lab-bench probes with computer controls and shield sensors/transducers from solvents and explosives, to include real-time particle size measurement on inert/solvent mixtures.

Deliverables:

- 1.) Drawings for Lab Probes.
- 2.) Final Report

Metrics:

- 1.) Size of Probe
- 2.) Amount of Data obtained by Probe

Milestones:

- 1.) Initial Research
- 2.) Perform Modeling to determine necessary specification of system.
- 3.) Design Probes.

Success in this phase would be demonstration of technical feasibility to obtain real time data on explosives during the manufacturing process while maintaining reasonable costs.

PHASE II: Fabricate demonstration probe for inert materials, calibrate equipment depending on particle size of explosives in question, and test at lab on inert systems. Improve software to add additional features and ensure quality data output. Develop an explosion proof design for equipment capable of being tested at ARDEC. Deliver, install, and prove-out a system that can be used in contractor facilities. Calibrate the equipment depending on results for initial testing. Demonstrate that real-time outputs from the system can be used for process control.

Deliverables:

- 1.) Probes which can be tested at ARDEC.
- 2.) Probes which can be tested at contractor facility.
- 3.) Final Report.

Metrics:

- 1.) Reliability of Probe
- 2.) Data Acquisition of Probe
- 3.) Estimated cost of building and maintaining probe.

Milestones:

- 1.) Fabricate prototype probe and troubleshoot in lab.
- 2.) Deliver probe to ARDEC for testing.
- 3.) Deliver probe to contractor facility for further testing.

Success in this phase would be the fabrication of probes and delivery to a contractor for initial testing. Final report of manufacturing knowledge gained for these probes should show ability to improve manufacturing processes.

PHASE III: Innovative probes developed with this SBIR would be useful in the processing of energetics and polymer materials, making it highly useful for Army production facilities.

In the commercial sector, this technology could be used for quality inspection in food, for example, determining the water content in fruit, finding impurities during a manufacturing process, or determining the viscosity of a liquid. In polymer processing, these probes could be used in a modified fashion to investigate the mechanical properties of plastics during production, allowing for greater quality and efficiency. Finally, in pharmaceutical processes, such as coating, these probes would be useful in controlling particle size and other relevant material properties. Phase III would involve proving out applications in other industries, providing both a military and civilian benefit.

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KEYWORDS: ultrasound, quality assurance, process control, manufacturing

A09-027      TITLE: Nanostructured High Performance Energetic Materials

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: Develop a cost-effective method to synthesize an environmentally safe and stable (under ambient conditions) polymeric nitrogen material with high energy density and reduced sensitivity, which can be used in new energetic material formulations. High volume production and potential civilian applications should be addressed.

DESCRIPTION: High-energy density energetic materials with increased stability and vulnerability, which are environmentally safe, are needed to meet the requirements of the Department of Defense's Joint Visions and Future Force. Over 20 years ago it was proposed that polymeric nitrogen would meet and exceed these requirements, with energy release which is about five times that of any conventional energetic material in use today [1,2]. Recently, a polymeric nitrogen phase was synthesized from molecular nitrogen at temperatures exceeding 2000 K and pressures above 110 GPa [3]. This phase could be quenched to ambient pressure but only at low temperatures, which precluded energetic performance testing of the material. X-ray diffraction measurements provided strong evidence for a cubic polymeric nitrogen phase. Related recent experiments [1] have also shown that a polymeric nitrogen phase that is stable under ambient conditions for 2 weeks can be formed by pressurizing sodium azide in the presence of hydrogen to 40 GPa, whereas ab initio calculations and molecular dynamics simulations [4] indicate that singly bonded polymeric nitrogen can be encapsulated and stabilized within a carbon nanotube [4]. In the light of these experimental and theoretical results, it is likely that a stable polymeric nitrogen phase can be produced for application as an ingredient in high performance, green munitions. Moreover, highly nitrogenated nanomaterials produced for this purpose can also function as promising sensors for gases, such as hydrogen.

PHASE I: Identify and describe the most promising method for the production of an environmentally stable polymeric nitrogen material. Deliverables must include demonstration of a prototype set-up and process, description of methods to characterize structure and energetic performance, and preliminary chemical and structural characterization of the material produced. Readiness for Phase II will be judged on meeting the milestones for these deliverables and overall feasibility of the process identified.

PHASE II: Optimize the synthesis process from Phase I. Deliverables must include successful fabrication and demonstration of a scaled up set-up for production and detailed characterization in accordance with the plans from Phase I. Characterization should include measurements of energy density and insensitive properties both in pure form and in munition formulations.

PHASE III: Partner with DoD Program managers to develop application of this novel energetic material in US Army munition formulations and replacement for igniter lead composite compound that is less sensitive to impact and shock. Also partner with companies to develop civilian applications which could involve the use of polymeric

nitrogen functionalized carbon nanotubes as sensors for hydrogen and related gases. Techniques such as Atomic Force Microscopy would also benefit from these materials since they already use nanomaterials as tips for imaging surface topology at the nanometer scale.

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KEYWORDS: Energetic materials, polymeric nitrogen, carbon nanotubes

A09-028            TITLE: Innovative High Strength Nanostructured Aluminum-Based Composites

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design a novel composition and process to produce a high-strength, nano-structured, dispersion-strengthened, aluminum-based composite for structural and lightweight armor applications.

DESCRIPTION: Research at Allied Signal and NIST has lead to the discovery of quasi-crystalline alloys and nano-structured dispersion strengthened aluminum alloys. The quasi-crystalline alloys have been the basis for extensive fundamental research and some very strong and tough materials have been discovered, while the dispersion-strengthened alloys discovery pointed the way to an alloying approach for high temperature aluminum alloys (aluminum superalloys) that would have a great impact on turbine engines, perhaps replacing titanium in some applications [1-4]. It is believed that a composite combining the strength and toughness of the quasi-crystalline alloy with the high temperature resistance of the nano-structured, dispersion-strengthened alloy could yield a novel high-strength, nano-structured composite for many applications, including structural and lightweight armor applications. The goal of this SBIR is to design and develop new alloy composition of nano-aluminum metal matrix composites with tensile strength greater than 1 GPa (145 ksi) and tensile failure strain greater than 5 % at room temperature. Cryomilled aluminum composites have demonstrated high strength but little or no ductility.

The challenge is to design a formulation and develop a process to consolidate it into a fully dense composite with good properties, including strength and ductility. Additionally, it is believed that a nano-scale microstructure will enhance the properties of the composite. As such, techniques that use nano or nano-grained powders and consolidation techniques that can be used to preserve the microstructure of the starting powder and achieve a nano-structured composite are of special interest.

PHASE I: Design a formulation and develop the process to produce a fully dense, nano-structured high strength aluminum composite with tensile strength greater than 1 GPa (145 ksi) and a tensile failure strain greater than 2.5 %. Fabricate specimens, and characterize the tensile and compressive strengths and failure strains under static and dynamic loading .

PHASE II: Optimize product formulation to maximize the strength and increase ductility (tensile failure strain greater than 5 % is required), and develop and demonstrate a prototype capability for production of components for sub-scale prototype testing. Characterize the mechanical properties of the fully dense, nano-structured high strength aluminum composite for structural applications and for lightweight armor applications. Mechanical property measurements are required at room temperature and elevated temperature for structural applications. Processing of

plates with dimensions of 24" x 24" x 1" (610 mm x 610 mm x 25.4 mm) will be required for demonstration of lightweight armor applications.

PHASE III: Transition the processing technology for structural applications in the aerospace and automotive industries, and for lightweight armor for military and law enforcement applications. This will include partnering with major aerospace and military suppliers with high production capacities.

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KEYWORDS: nano-structured aluminum composite, dispersion-strengthened aluminum alloy, aluminum-based composite, lightweight armor, nano-structured material processing

A09-029            TITLE: Advanced High Energy Density Propellants

TECHNOLOGY AREAS: Electronics, Weapons

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

OBJECTIVE: The objective of this program is to develop nanoparticle energetic propellants for guns.

DESCRIPTION: The potential of nanoparticles to drastically enhance the energy density of gun propellants has been demonstrated recently in laboratory and pilot scale studies (1). Nevertheless, there are formidable challenges in implementing these nanoparticle-enabled propellants in the field. The objective of this effort is to overcome technical limitations associated with energetic nanoparticle applications and develop scalable processes that can overcome the limitations.

During the past several years a significant amount of research has been performed to evaluate nano-sized materials in energetic compositions (1), (2). The bulk of this research has been directed toward the evaluation of nano metals in rocket propellants and high explosives. In these applications it is suggested that the very finely divided metal will react more rapidly than the commonly used micron sized materials, thereby increasing the efficiency and burning rate of metalized rocket propellants and explosives. It has been demonstrated that the addition of small amounts of nano metals or other nano sized materials to advanced gun propellants provides improved burning rate tailorability and possibly improves mechanical properties. From the burn rate increase, it would be possible to significantly enhance the system level performance of selected weapon systems. The nanomaterials to be explored in this effort (Al, B, AIB, BNNT) are of significant interest due to their reactivity and tailorability. Of primary interest, is the process to disperse these nanoparticles uniformly throughout the propellant thereby creating a useful intermediate or end product.

While laboratory studies utilizing nanoparticles of aluminum and other energetic materials have shown remarkable "nanoparticle effects" in propellants, there are several problems pertaining to the use of these additives on a larger

scale in a practical situation. Nanoparticle dispersions suffer from long term instability: the homogeneous single phase characteristic of a nanoparticle suspension is lost over time, and the material phase separates. Additionally, agglomeration of the nanoparticles during combustion could also reduce the beneficial effects of nanoparticles. Accordingly, the present effort is aimed at delivering “practical” propellant compositions that have nanoparticles incorporated in them. Propellants must be characterized by their ballistic properties, thermal expansion and dispersion in the material. Levels of ballistic and thermal properties to be achieved are those comparable to JA2 propellant.

PHASE I: A feasibility study and theoretical modeling/analysis should be performed on various nano material compositions having good uniformities and dispersion qualities leading to production of nano particle energetic gun propellants. After the theoretical analysis is completed, small scale mixes of gun propellant formulations will be made for initial laboratory scale characterization. Using simulants analogous to A1, B, A1B, and BNNT, demonstrate the feasibility of novel approaches to producing nanoparticle-containing propellants that are both scalable and practical.

Deliverables: A study on the potential theoretical improvements over standard propellant formulations will be provided to the government along with a feasibility study and cost analysis of the proposed process.

PHASE II: Develop and deliver to ARDEC the capability to produce versatile nano particle energetic propellants for guns. The thermochemical data from the candidate propellant formulations incorporated with nanoparticles will be evaluated for thermochemical and ballistic properties. The test data will be analyzed using JA2 propellant as the baseline for tanks and M1 /M30 propellants for the 155 mm artillery.

Differences in the behavior of the simulant and propellants used in the field should be addressed in Phase II with a continued focus on A1, B, A1B, and BNNT. Additionally, the potential hazards of utilizing nanoparticles in this application should be documented. The down-selected formulation will be tested in a small scale gun test fixture such as the 30mm gun using JA2 propellant as the baseline.

Deliverables: Samples will be delivered to the Government for sensitivity, compatibility, and performance testing. Provide full documentation of the process, comparison of theoretical to actual performance data, and data demonstrating the relationship between the quality of the dispersion and the performance and sensitivity characteristics of the material.

PHASE III: The military application is to demonstrate the technology developed in Phase II in large caliber gun systems such as the 120mm tank and the 155mm artillery after the successful small scale testing in Phase II. One possible commercial application for the nano material BNNT would be its use in the aerospace industry due to its structural properties. Another application for the nano material nano Al is its use in developing novel energetic materials for the air-bag industry.

#### REFERENCES:

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2. T.G. Manning and L.E. Harris, US Army, Army Research and Development Engineering Center, Picatinny Arsenal, NJ 07806 and H. A. Bruck, University of Maryland, College Park, MD,20742 and J.R. Luman, B. Wehrman, K.K. Kuo\*, and R.A. Yetter, The Pennsylvania State University, University Park, Pennsylvania 16802, “Development and Characterization of High Performance Solid Propellants Containing Nanosized Energetic Ingredients”, JANNAF Propellant Characterization, PEDCS, March 2006, San Destin, FL.

KEYWORDS: simulants, nanoparticle, energetics, propellants, dispersion, energy density

A09-030            TITLE: Advanced Weapon Sighting Systems

TECHNOLOGY AREAS: Materials/Processes, Weapons

**OBJECTIVE:** Develop and establish techniques for creating an advanced aiming reticle (crosshair) in bulk glass while yielding a reduced retro reflection signature.

**DESCRIPTION:** Currently, weapon sight reticles can be fabricated only on a flat surface via etch/fill or metal deposition techniques. Reticle surfaces in focal planes produce retro reflections, increasing detectability. Presently these signatures are reduced by cementing a cover plate to the reticle surface with index matching cement. This index match is never perfect over the spectrum due to mismatch in the dispersion between glass and cement. A considerable advantage would be provided if the reticle could be etched within the bulk of the glass: reduced signature, reduced assembly, reduced parallax, improved optical system design flexibility. One option to accomplish this is using high power laser systems. Laser systems are now powerful enough that a focused beam can be used to create an aiming reticle inside (not on the surface) of a piece of glass, thereby reducing the size and weight of an optical system while also reducing the ability to detect a reflection off the reticle glass. This method of reduced reflection has not been researched and would provide added security for soldiers in active combat. Current research focuses on an anti-reflective coating deposited on the surface of the glass or laser etching on the surface of the glass. Other methods can be used to accomplish this effort, but should meet the application standard (10 micron line width in 10 - 25mm diameter glass lenses) at a depth of 3 - 5 mm and ideally produce zero reflectivity.

**PHASE I:** Investigate new and innovative ways for an aiming reticle to be created within a glass material. Various optical glass types and processing methods will be analyzed to determine candidate combinations for additional evaluation. Perform laboratory experiments to validate the theory that using specialized processing conditions (i.e. highly focused laser energy) could be used to create a sub-surface aiming reticle within optical glass. The results of these experiments will be evaluated to determine the quality of each reticle made during this phase.

**PHASE II:** Develop and fabricate a prototype advanced aiming reticle. The reticle will be integrated into a small arms direct view weapon sighting system (to be determined) and test fired to demonstrate they can survive the pyrotechnic shock associated with live fire testing and can maintain similar or better firing accuracy when using laser etched reticles (or commercially available ones). Conduct testing to demonstrate feasibility of the new aiming reticle within a developmental environment and acquire user feedback. The sighting system will also be tested to verify reduced retro reflection (Optical Augmentation).

**PHASE III:** Military applications for this type of technology involves any weapon sighting system or any system that needs visual superposition of a permanent image on a transparent medium. Commercial applications are hunting rifle scopes, telescopes, binoculars, touch screens, mirrors, and artistry.

#### REFERENCES:

1. Woo, DK; Hane, K; Lee, SK. (2008). Fabrication of a multi-level lens using independent-exposure lithography and FAB plasma etching. In J. of Optics A: Pure and Applied Optics, Vol. 10, Issue 4, pp. 044001.
2. Huang, ZQ; Hong, MH; Do, TBM; Lin, QY. (2008). Laser etching of glass substrates by 1064 nm laser irradiation. In Appl Physics A, Vol. 93, Issue 1, pp.159-163.
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4. Niino, H.; Kawaguchi, Y; Sato, T; Narazaki, A; Kurosaki, R. (2008). Surface microstructures of silica glass by laser-induced backside wet etching. In Photon Processing in Microelectronics and Photonics VII, Proceedings of the SPIE, Vol. 6879, pp. 68790C-68790C-9.

**KEYWORDS:** laser, optics, reticle, reflection, weapons sight, optical augmentation, parallax, etching

A09-031

**TITLE:** Automated Manufacturing of Composite Materials including Armament Applications

## TECHNOLOGY AREAS: Materials/Processes, Weapons

### OBJECTIVE: Automated Manufacturing of Composite Materials including Armament Applications

Research, develop and demonstrate novel methods to improve cost, schedule, and performance, of composite tape placement technologies to include improved safety and environmental impact.

DESCRIPTION: Commercial off the shelf technology in the automated manufacture of composite components has provided a true breakthrough in armament technology for highly mobile lightweight and lethal combat systems as well as advanced electromagnetic railgun armaments. These technologies have benefited from prior investment including DARPA funding in composite manufacturing technology and the University of Delaware's College of Engineering, the Center for Composite Materials (CCM) In particular the use of automated thermo-plastic carbon fiber tape placement to wind composite jackets around large caliber gun barrels and railgun cores has enabled dramatic increase in lethality while meeting aggressive maneuver requirements. A key breakthrough was achieved by the Army as a lead user to aggressively pursue tape placement under maximum wind tension. This achieves essential compressive pre-load to the gun liner or railgun core.

Three opportunities for substantially increased utility of this technology have been identified. They are operator safety, manufacturing speed, and increased thermal capability. To understand these, the thermoplastic tape placement approach must first be described for the current application of composite jackets to the Army's four meter railgun, the Navy's proposed ten meter railgun, and the XM360 120mm tank main armament in system development and demonstration for the Army's future combat system (FCS) mounted combat system. For these applications, Polyetheretherketone (PEEK) is used as thermoplastic matrix to bind high strength carbon fibers into a unified structure. To ease manufacture, the composite fibers are pre-impregnated with the matrix material used to bond them together. This raw commercial off the shelf prepreg material is supplied as a thin half inch wide uni-directional tape wound on a spool. Very hot nitrogen gas is blown into the crotch formed between the substrate material and tape as it is unwound from the spool and wound around the launch tube. The hot gas temporarily melts the surface of the matrix material of both the substrate and new feed tape. A compaction roller then passes over the tube to consolidate the material into a unified structure as the melted matrix re-solidifies due to heat transfer to the substrate and full thickness of the tape. Tape may currently be applied at three to five inches per second of feed. Technicians, operating the machine, use simple tools, experience, and a careful eye to start new tape placements and to splice occasional tears in the prepreg.

Safety: Machine technicians work very close to high temperature nitrogen gas feeds (electric torches). Although we have not yet had a serious burn in our facility, it has occurred in industry. Alternative technologies could prove safer.

Manufacturing speed: The electric torches employ electrical resistance heating to supply hot nitrogen gas. Hotter gas could conceivably enable a faster feed speed. However, hotter gas can also overheat prepreg tape, causing it to lose too much strength and subsequently tear. Technology that would allow rapid feedback control of the rate of matrix heating, to correlate it to feed rate and design requirements may allow higher feed rates and improved control of structural properties.

Thermal capability: gun tubes tend to get hot when fired. This is particularly true of sustained non-line-of-sight (NLOS) applications desired for NLOS forced entry, FCS NLOS cannon system, naval railguns, and extended area protection systems that provide counter rocket, artillery, and mortar protection. New technology to heat and temporarily melt prepreg matrices may enable higher temperature matrices. (It should be noted that in general terms, matrices that tolerate higher operating temperatures require a higher manufacturing temperature to melt during tape placement.) Nominal improvement in thermoplastics is anticipated. The potential to enable a breakthrough in metal matrix tape placement is exciting.

PHASE I: Investigate innovative means of achieving a temporary melting of matrix material between substrate and prepreg tape as the tape is applied to build structure. Such innovations could include electromagnetic wave energy (e.g., lasers), plasma injection, alternative inert hot gas feeds, conduction heat transfer, and ultrasonic's. Although heating at the crotch is anticipated, heating behind the crotch is acceptable providing it does not hinder the desirable tension winding benefits. The technology must not be incompatible for later integration as a tape placement head replacement to the Army's existing commercial off the shelf technology tape placement machine. (Access to the

machine and informal discussions of machine operation with government engineers and operators will be granted upon request to phase 1 contractors to assist. Figure 2 of the first reference includes an image of machine tape placement head in operation. The principle requirement is that the technology employed can articulate and move along the piece under construction). Develop and document the overall technology advance specifically citing findings or predictions on safety, manufacturing speed, and thermal capability. Proof of principle shall be demonstrated by constructing a cylindrical structure representative of a half meter long 105mm or 120mm steel lined gun tube section using standard geometry for 1/2" tape. (Suitable gun tube sections may be government furnished if requested.) Advance in speed of manufacture shall be evaluated based upon model predictions, validated to the extent possible by the demonstration tube with a target sustained speed of 25 cm/sec while maintaining over 60MPa of strength subject to ASTM D 2344/D 2344M. Advance in safety shall be evaluated based on size, proximity, and temperature magnitude of hot components within reach of the operator during fabrication and other factors associated with novel approaches (such as laser retinal damage propensity). Advance in thermal performance shall be evaluated based upon model predictions of max temperature that may be tolerated of a tension jacket for a period of 4 hours with less than a 5% loss of pre-stress, validated to the extent possible by the demonstration tube. (Historically, a test to shear out the steel liner from the composite jacket has been used.) Credible progress towards 360C from current standard of 200C is desired. 500C would exceed expectations. It is anticipated that metal matrices would be required to exceed expectations.

Suitability for advancement to phase two shall be based upon anticipated weighted sum of benefit of speed, normalized by 13cm/sec and max tolerable temperature in centigrade, normalized by 200C with a weight of two on temperature. Anticipated safety shall be qualitatively assessed as less safe, as safe, or more safe than the current process using '-', '0', and '+' respectively. Safety shall be used to discriminate between numerical ties in qualitative speed and thermal capability assessment.

It is anticipated that a minimum quantitative benefit required for advancement to Phase II is 140%.

PHASE II: Further demonstrate the overall technology advance specifically verifying prior predictions on safety, manufacturing speed, and thermal capability for the following three applications: 1) 120mm XM360 gun, 2) forcible entry NLOS cannon, and 3) Army or Navy railgun.

Develop and demonstrate manufacturing capability for improved fabrication of composite cannon and transfer this capability to the US Army. The Army's existing commercial off the shelf technology tape placement machine may be leveraged if seamless integration with it can be verified. (Suitable gun tube liners may be government furnished if requested.)

PHASE III: Advances in this key domestic manufacturing technology would aid virtually all applications for thermoplastic tape placement systems. Such systems are used to fabricate aircraft including the joint strike fighter, Airbus 310, and Boeing 787. Also, increased focus on construction and enhancement of wind turbine generators is creating an even stronger market for fabrication of their airfoil blades. Interestingly, due to their gargantuan proportions (bigger than a Boeing 747) on site tape placement manufacturing technology is being sought. This successful SBIR could facilitate all of these applications.

#### REFERENCES:

1. A. Littlefield and E. Hyland, Prestressed Carbon Fiber Composite Overwrapped Gun Tube, <http://handle.dtic.mil/100.2/ADA481065>
2. J. B. Root and A. G. Littlefield, Minimizing Rail Deflections in an EM Railgun, <http://handle.dtic.mil/100.2/ADA481582>
3. E. Kathe, Large Caliber Pre-stressed Launchers: Fabrication via Wind-In Tension, NDIA Classified Seminar on the Applications of Electromagnetic Launch Technology, 03 May 2007.
4. A. Littlefield, E. Hyland, A. Andalaria, N. Klein, R. Langone, and R. Becker, Design, Fabrication and Testing of a Thermoplastic Composite Overwrapped Gun Tube, available at: [http://www.automateddynamics.com/tech\\_papers\\_final.html](http://www.automateddynamics.com/tech_papers_final.html)

KEYWORDS: Thermoplastic tape placement, manufacturing railgun, XM 360 NLOS cannon gun, EM gun, heating safety stress

A09-032            TITLE: High Energy Density Inertial Harvesting Power Source for Spin Stabilized Small- and Medium-Caliber Fuzing

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics, Weapons

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop and demonstrate an inertial setback generator/energy harvester for powering munition fuze electronics and initiation circuits based on micro-fabrication material processing and hardware to achieve greater energy density (smaller overall size), lower cost, optimized power delivery, greater ruggedness and shelf life, and improved reliability and safety compared to those characteristics with existing munition setback generator technology.

DESCRIPTION: A new power generation and delivery system is needed in small to medium-caliber projectile munition fuzes to replace existing setback generators and chemical reserve batteries with cheaper and smaller sources. Recent efforts in miniaturization of fuzing components have led to the integration of Micro-Electro-Mechanical Systems (MEMS) technologies. In particular, the US RDECOM-ARDEC identified MEMS as a solution to reduce the volume and increase the reliability of safety and arming (S&A) devices. Consequently, fuze power sources—e.g. inductive setback generators, reserve batteries, etc.—are another area where a large percentage of the fuze volume is consumed. Batteries have been problematic in life, storage, size, weight balance and cost. Furthermore, existing setback generators are expensive and are bulky, when volume is at a premium for current and future advanced munition fuzing. Miniaturization of fuzing components will enable small to medium-caliber munitions to be smarter (proximity fuzing, airburst, point detonating, and point detonating delay) and cheaper, while maintaining (if not increasing) weapon safety and lethality. Micro-system production capabilities are ever evolving and becoming more cost effective. Micro-fabrication material processing is recognized as a solution to the energy density (energy divided by the system's total volume) struggle for existing fuze power sources. A power scheme is sought that will complement the MEMS S&A Device with a target volume on the order of 1.5 cm<sup>3</sup>.

Technical efforts include a concept based on micro-fabrication material processing and analysis of hardware used to achieve harvesting methods. Additionally, proof of concept should be shown utilizing both physics based calculations and coupled-physics based finite element analyses (FEA). Technical risk areas to be addressed include but are not limited to the robustness in harsh inertial environments (up to 100k G's where G is the acceleration of gravity), 20 year shelf life, -45 to 145 degrees Fahrenheit functional temperature range, and justification that an energy density greater than 40 mJ/cm<sup>3</sup>—delivering power during a functional time range of 5-15 seconds—is achievable for a setback acceleration greater than 40k Gs. Furthermore, peak setback generation voltages are desired to be less than 50 volts.

PHASE I: The required deliverables for Phase I is a report outlining the inertial energy harvesting method and energy density along with mathematical and computer based models illustrating proof of concept. The report should also include proof of concept laboratory experiments and any major risks impeding a successful transition to Phase II.

PHASE II: The Phase II effort would implement and demonstrate the feasibility, size reduction (relative to existing systems), and energy production of the inertial harvester. Energy production of the prototype inertial harvester will be demonstrated by the contractor's preferred method. Safety also has to be demonstrated by successfully passing 5 foot drop test where, subsequently, the round remains fully functional and the 40 foot drop safety (round is safe to dispose of), insofar as the safety of the round depends on the setback generator.

PHASE III: The Phase III effort will transition the Phase II inertial harvester design into an optimal and low-cost product. Demonstration and full reliability testing of the energy harvesting device will be conducted via live fire testing through collaboration with ARDEC engineers at an Army test facility. The offeror should work with fuze

contractors and ARDEC representatives to maximize the applicability across wide classes of munitions from 25 mm – 40 mm applications. The micro-fabrication material processing technology should be evaluated for additional applications across the military and commercial sectors. Potential commercial and military uses include but are limited to vibration energy harvesting to power wireless sensor nodes in environments where low maintenance is required, secondary power source for harsh environment sensors, and impact sensing applications.

#### REFERENCES:

1. FCS ORD: 3469 (Soldier Survivability)
2. FCS ORD: 1182 (LOS Lethality)
3. FCS ORD: 1248 (Non-Lethal)
4. OICW ORD: 8) Program Affordability, 4A1S) P3I-Reduced weight and reduced cost
5. MIL-STD-1316

**KEYWORDS:** energy harvesting, piezoelectric, power, micro, MEMS, fuze, electromagnetic, inductive, setback, energy, acceleration

A09-033            **TITLE:** Miniaturization of Sensors on Flexible Substrates

**TECHNOLOGY AREAS:** Materials/Processes, Sensors

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

**OBJECTIVE:** Develop and demonstrate the use of materials printing as low cost method of manufacturing printed electronics on flexible substrates for use in Army smart munition sensors.

**DESCRIPTION:** The U.S. Army is transforming into a lighter yet more lethal objective force. To that end, U.S. Army scientists and engineers are capitalizing on new technological breakthroughs in nanotechnology, micro electro-mechanical systems (MEMS), microelectronics, etc., to develop flexible electronic capabilities for sensing, communications, data collection/storage, and power alternatives.

Significant advancements have been made in printed electronics that print function-specific active sensor systems using nano-inks and novel materials on a variety of flexible substrates via ink-jet printers and/or other advanced approaches. These capabilities allow the further design and development of various active sensors systems that meet the Army's needs for decreased size and weight, lower power requirements, and greater range, sensitivity, and resistivity.

Native properties of select individual nano-materials should be researched to determine which combinations can create specific "recipes" for the development of active sensor systems via materials printing technologies. Similar efforts are required to identify the substrates and polyimide films upon which the inks will be printed and which can be used in the ink-jet printing process.

As the success of the nano-ink recipes are tied to the substrate upon which it's printed, changing the substrate also requires changing the ink formulation. Research is required to match the recipe formulation to the specific substrate to design and develop various active sensors systems for intelligent munitions systems, focusing on the antenna and GPS of (Medium Range Munitions) MRM's. Consideration should be given to sensor systems recipes that combine detailed battlefield intelligence with precision munitions, enabling the U.S. Army to add advanced capabilities while maintaining weight and lethality requirements.

This program directly supports AMC Mission & Vision 2015 Goals Strategic Priority #2 for the development of breakthrough technologies and new capabilities. More specifically items 2(a) (3)(b) Nanotechnology and 2(a) (3) (c) Electronics and sensors. As stated in the proposal "This manufacturing technology combines different fields of

nanotechnology to print flexible circuits using novel manufacturing equipment.” Furthermore, this effort indirectly supports 2(a)(3)(d) Munitions and 3(g) Performance Based Maintenance and 3(f) Conditioned Based Maintenance by providing low cost, low power and flexible sensors and electronics to accomplish these objectives.

PHASE I: A feasibility study will be conducted to down-select the most appropriate ink formulation and substrate material(s). Process parameters for device manufacture will be developed. The deliverables for phase I shall be an ink formulation and substrate material along with process parameters. Properties of the inks fall into two classes. The first is related to what is necessary for uniform deposition of these materials via ink jet printing. They include; solvent type, dilution, viscosity, particle size and distribution and process parameters. The second is related to the electrical properties of the applied materials. Measurement is accomplished through standard methods.

PHASE II: Based on process parameters developed in Phase I, fabrication of antenna and GPS sensor devices will be initiated. Parameters will be modified as required to manufacture components. Metrics for these inks will be that the ink can be reproducibly applied to the substrate and exhibit the desired electrical properties and these properties exhibit long term stability within the duration of the phase.

PHASE III: Based on previous work in the area of MEMS reliability and the impacts of long term storage, device testing protocols will be developed and initiated. Furthermore, system level testing of the integrated devices will be conducted. Recommendations for device redesign will be made based on the results of these tests.

The development of innovative materials printing technologies can also benefit the technology, automotive, manufacturing and other industries where active sensor systems with the ability to perform condition-based, rather than scheduled, maintenance can improve productivity and reduce costs. Commercially available inks that provide reproducible and stable electrical properties are essential to adoption of this technology. Demonstration of the inks in devices is required to show they can be deposited, function as intended and have long term stability.

#### REFERENCES:

1. AMC Mission & Vision 2015 Goals
2. Army ManTech Manager, “ATO-M: Embedded Sensor Processes for Aviation Composite Structures,” RDECOM Army ManTech / 2008 Brochure, U.S Army RDECOM, ATTN: AMSRD-SS-T, Pg. 9, 2008. <http://www.armymantech.com/highlights.html>
3. Development of Active Systems for Military Utilization, J. Zunino III\* and H.C. Lim\*\* \*U.S. Army RDE Command, AMSRD-AAE-MEE-M, Bldg 60 Picatinny Arsenal, NJ, james.zunino@us.army.mil\*\*Physics Department, University Heights, New Jersey Institute of Technology, Newark, NJ, hcl4186@njit.edu
4. J. L. Zunino III, L. Ayers, D. Skelton, “Advancement of Prototyping and Manufacturing Techniques for Active Sensor Systems,” Defense Manufacturers Conference, DMC 2008, Dec 2008 [3581].

KEYWORDS: Materials printing, flexible electronics, MEMs, MEMs manufacture, sensors, intelligent munitions

A09-034            TITLE: Image Analysis for Personnel Intent

TECHNOLOGY AREAS: Information Systems, Electronics, Human Systems

OBJECTIVE: The purpose of this investigation is to develop an imaging system for biometric intent identification applications.

DESCRIPTION: This solicitation is for the research and development resulting in an imaging system to optimally provide intent related information from both spatial and spectral biometric data. The ability to collect imaging data over a wide range of wavelengths, in addition to identifying physiological temporal changes such as expressions, gait, and pose, will create an advance in the collection of biometric information. The imaging system must collect and analyze the biometric data to extract relevant information regarding possibly suspicious and harmful intent

through physical indicators. Current biometric data collection systems are configured to function for controlled applications and not for unconstrained surveillance purposes as desired herein. Various factors influence the ability to accurately acquire this data including user co-operability and environmental conditions. Merging both spectrally and spatially abundant data can overcome these obstacles.

The use of spectral data to determine intent based on psycho-physiological indicators such as skin coloration due to sub-dermal changes within the vasculature of the body, abnormal perspiration, and changes in body temperature is an area which has not been adequately researched. These physiological indicators have shown direct correlation to transient physiological stress and the ability to monitor these responses non-intrusively will present applications especially for interrogatory scenarios [1]. The system solicited should be able to collect biometric data both spatially and spectrally at a stand-off distance. The proposed device should be a relatively light, portable, tactically robust sensor system.

PHASE I: Phase I should be a study and determination of what psycho-physiological indicators are suitable and most likely to succeed in the ability to identify intent based on temporal, spatial and particularly on spectral data. Phase I should result in functional design that can be implemented in Phase II.

PHASE II: The Phase II effort will involve the production of a prototype to demonstrate functionality. The system should be a high-speed and high throughput. System will consist of algorithms that provide real-time interactive recognition for all target individuals including those who are uncooperative in unconstrained indoor and outdoor situations at a distance of at least 45 meters from the target. Real-time testing and evaluation of system should verify functionality.

PHASE III: Intent recognition is a prominent area of research with countless applications for both military and commercial use. Surveillance in conjunction with intent recognition will allow for an appropriate response when faced with a person recognized as suspicious. Phase III effort involves integrating the results into existing military and commercial applications as well as exploring additional applications. Military applications include border patrol, stand-off interrogation, access control, surveillance and target acquisition and airport security. Surveillance and access control are also applicable for commercial uses. In addition, automated systems can be developed commercially in which the system would initiate by attaining information about users intent rather than making it necessary for the user to initiate it manually (e.g. user focuses gaze on a switch, therefore initiating the switch to turn on a light).

#### REFERENCES:

1. R.R. Rice and D.A. Whelan, Hyper-spectral Means and Method for Detection of Stress and Emotion. Harness, Dickey & Pierce, P.L.C. PATENT 10657338, Sept. 8, 2003.
2. V. Shusterman and O. Barnea, "Spectral characteristics of skin temperature indicate peripheral stress-response," Applied Psychophysiology and Biofeedback, pp. 357-367, 2005.
3. S. Yanushkevich, V. Shmerko, A. Stoica, P. Wang, S. Srihari. "Synthesis and Analysis in Biometrics." Biometric Technology Laboratory: Modeling and Simulation, University of Calgary, Canada.
4. O. Masoud and N. Papanikolopoulos, "Recognizing Human Activities," Proc. of IEEE Conference on Advanced Video and Signal Based Surveillance, pp. 157-162, 2003.
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KEYWORDS: spectral, surveillance, biometrics, individual's intent, face analysis, physiological, imaging

A09-035            TITLE: Tamper-proof Protection of Critical Combat Ammunition Fuze and Guidance Technologies

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

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: Explore, design, develop and demonstrate a cost-effective tamper-proof solution that protects critical enabling controlled technologies required by advanced combat ammunition projectiles to engage diverse Non Line of Sight (NLOS) targets in complex environments.

DESCRIPTION: Current advanced combat ammunition projectiles use a variety of advanced fuzing and guidance technologies to engage difficult NLOS targets in complex terrains and urban environments. Many of these technology-enabled capabilities (such as Height of Burst (HOB) fuze functionality) are restricted/controlled to avoid potential reverse-engineering and/or countermeasure development of these US/Allied combat multipliers by our enemies. In recent times, the indirect fire lethality materiel development (MATDEV) community has experienced a significant increase in requests for international military sales of advanced US artillery/mortar projectiles with their corresponding superior fuzing and guidance packages. These capabilities leverage key state-of-the-art technologies in both the hardware and software domains that were enabled by sustained significant US taxpayer investment, including microwave and millimeter-wave integrated circuit technology, advanced antenna designs, ultra-reliable micro-electro-mechanical (MEM) safe and arm designs, and anti-jam/anti-spoof solutions required by precision guided munitions. While it is essential that critical technologies remain under positive US control, the expansion of Foreign Military Sales (FMS) and Direct Sales represents a significant source of future income for the US ammunition industrial base that can sustain production throughput and quality if/when US government-funded production volume is reduced. The mainstay US positive technology control approach to date has been the development and enforcement of policy-based export controls. Given the volume, proliferation, and inventory of advanced US combat ammunition systems found across our multi-national allies and the continued benefit of increased FMS transactions, it is imperative that additional positive control measures such as stable, cost-effective, long-life, tamper-proof material-based solutions be explored, developed, and implemented to protect current and future advanced US fuzing and guidance technologies, including current proximity fuzing based on Frequency Modulating Continuous Wave – Directional Doppler Ratio Ranging (FMCW-DDR).

PHASE I: Explore, investigate, and identify innovative tamper-proof material-based solutions to protect current and future advanced US fuzing and guidance technologies. Provide specific real-world examples demonstrating

knowledge of proposed tamper-proof material-based technologies and their corresponding potential positive and negative impacts on operation and functionality of critical fuzing and guidance technologies found in US artillery/mortar combat ammunition. These examples should include stability and long-life material interaction risks as well as compatibility with MMIC, Radio Frequency (RF), Electronics, and MEM device technologies, operations, and dependent critical-path fuze and guidance subsystem/system functionality. Where applicable, these examples should also demonstrate a clear understanding of the end-state target environment, problem set, technology transition considerations, and potential beneficial impact. Phase I deliverable is a well-documented, technical accurate report. This Phase I report shall include initial discussion on the following metrics; Protection of electronic components, Cost, volume and integration complexity. Protection discussion must address ability to mask physical part markings and ability to prevent electronic interconnection at critical electronic nodes, while also being assessed for ability to remove, prevent reverse engineering etc. Cost should be discussed in the context of production Artillery and Mortar Fuzes, ie typical production cost of end item is \$200 per copy at 100K quantity per year and successful Tamper proof technologies must have potential to be implemented with only a 20% or \$40- per unit cost growth. Volume and integration complexity shall be addressed with respect to inserting this technology into conventional Artillery and Mortar nose mounted fuzes and overall volume and external profile can not be altered in order to remain in compliance with STANAG 2916 (Mil-Std-333). Finally the above specifics are not intended to limit design solutions therefore if a design solution exists that does not meet one of the above but has significant benefit in another fashion it should be addressed in that manner but not dismissed

PHASE II: Develop at least one implementable, cost-effective, tamper-proof material-based technology to protect MMIC-based Height of Burst functionality and at least one other critical fuze/guidance technology based on the execution plan proposed in PHASE I. These technology deliverables should be developed within the context of existing manufacturing processes, techniques, and infrastructure used in the production of fuzes and guidance packages for advanced US combat ammunition systems. Research activities must consider potential life-cycle constraints from a system-of-systems, material interaction, material stability, reverse engineering, discovery of countermeasures, economic, and operational performance perspective. The merit of these tamper-proof technology deliverables will be judged based on their low risk potential for further development to positively protect multiple current and future advanced US fuzing and guidance technologies and easily be transitioned and inserted into established US combat ammunition production operations. Other judged merits include potential for reuse, efficiency, effectiveness, long-life stability, environmental impact, affordability (including intellectual property rights), and application repeatability. The final work product of this PHASE will provide the government: 1) one implementable tamper-proof material-based technology to protect MMIC-based Height of Burst functionality and at least one other critical fuze/guidance technology with corresponding documented material recipe formulation and characterization, 2) all technology testing, compatibility, and performance results, and 3) a future business implementation plan to further develop these technologies into a full family of more mature tamper-proof material-based technologies. Phase II documentation shall include

Detailed test results and detailed analysis addressing all the above mentioned items and thoroughly characterize ability to protect, cost, volume and integration complexity with regard to conventional nose mounted Artillery and Mortar fuzes per STANAG 2916 (Mil-Std-333). Detailed Cost analysis shall be delivered and demonstrate ability to add tamper proof technology with a maximum of 20% cost increase to production fuzes.

PHASE III: This effort will have a wide range of military applications in precision guided munitions. Advanced miniaturized integrated hardware and software solutions that leverage novel embedded MMIC, RF, and MEM based components are becoming increasingly more commonplace in commercial environments. Such solutions that provide private sector suppliers a product-unique advantage over their international marketplace competitors represent a similar potential opportunity to incorporate novel tamper-proof technologies. Thus, the technologies being researched within this topic will have dual-use value in commercial application. The vendor is responsible for marketing his technology deliverables for further development and maturation for potential Post-PHASE II transition opportunities including any dual-use applications to other government and industry business areas. Examples of potential commercial application areas include Homeland Security related sensors and actuator systems supporting Border Patrol, airport security, and FEMA response operations and well as building/infrastructure monitoring and control systems. Additionally potential commercial uses include protection of embedded electronics in advanced integrated commercial handheld information technology related systems.

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KEYWORDS: Tamper proof, protection, materials, height of burst, proximity fuze, guidance, ammunition, export control

A09-036            TITLE: Swarm/agent Technology For Small Unit Scalable Effects

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: Investigate and leverage emerging soft computing, agent and swarm technologies to develop a highly modular distributed algorithm and open architecture proof-of-concept implementation that includes a network centric prototype operator control station and embedded control software that is capable of adaptive swarm control and event driven behavior of multiple unmanned aerial/ground systems to detect, localize, and track ground and/or small unmanned aerial targets including dismounts, in a man portable configuration. Demonstrate a team of unmanned small aerial vehicles that can optimally search a specified 3-D Area/volume of Interest for threat targets. Demonstrate coordination behavior between the unmanned systems by executing a computationally efficient algorithm that can triangulate and converge on the geo-located target(s) to gather video imagery of target source. Demonstrate the ability to integrate target data and video data with the small unit effects network. Finally, demonstrate the ability to automatically hand-off targets to manned/unmanned platforms to provide effects on target with human oversight.

DESCRIPTION: Unmanned systems such as small unmanned aerial vehicles's/unmanned ground vehicles's are uniquely well suited to perform automated/persistent surveillance, target hand-off and effects delivery in support of small unit netcentric operations. Recent advances in small, low cost multi-spectral sensor technology, Software Defined Radios, adhoc/mesh networks, swarm technologies and distributed computing technologies now make it possible for small unmanned systems with more capable payloads to provide precision targeting and effects delivery in support of small unit operations in complex/urban terrain. Further, advances in manned/unmanned (MUMs) teaming has resulted in the ability to more quickly and easily coordinate between groups of heterogeneous unmanned systems. Coupling these two developing capabilities together results in a system of systems that can collectively cover a larger area and more efficiently acquire, identify, track, designate and hand-off time sensitive targeting data to the small unit effects network. These missions are most useful over areas that are difficult to access due to terrain's topological features.

Innovative algorithms and hardware/software architectures are required to develop and demonstrate a highly collaborative, computationally efficient, and deployable swarm algorithm and open architecture implementation capable of automating the target acquisition, identification, tracking, hand-off and effects delivery mission thread using multiple unmanned systems in a manned/unmanned teaming environment. This algorithm should be scalable

and designed to coordinate a team of at least three small unmanned SUAV/SUGV platforms in a mission that optimizes probability of target detection for a wide range of terrain. Additionally, once detected, the algorithm should present the operator with a variety of engagement strategies that should include the ability to collect video imagery of the target, the ability to actively track the target if it is moving, the ability to minimize observability of the unmanned systems, the ability to provide target track information to the small unit effects network, and the ability to deliver effects to the target while having an operator in the loop. Implementation architectures and algorithms must conform to current DoD standards for messaging of unmanned vehicles and must be capable of integrating with current and future force operational architectures. The modular algorithms must also demonstrate integration with a variety of current and future force ground control stations. Proposals may address the development of this capability using a mix of hardware/software component implementations, emulations and simulations and should culminate with a live hardware-in-the-loop and man-in-the-loop demonstration.

PHASE I: Develop an algorithmic and architectural design and implementation approach to execute the described targeting mission thread. Establish feasibility of the design concept and capability of optimizing target detection, geo-location and hand-off in complex terrain and in a man portable configuration via hardware/software component level design, emulation and simulation.

PHASE II: Develop and demonstrate an integrated hardware/software prototype system. The platforms must be able to self-organize and self-optimize to detect, identify, and track at least one moving air/ground target. The implemented system and algorithm must also be capable of providing geo-referenced targeting information and video imagery integrated with a surrogate small unit effects network. The modular implementation should also be capable of coordinating and executing an effects delivery mission on the moving target with a small unmanned effects platform. Demonstrations will culminate in a live hardware/software man-in-the-loop test of all developed components and platforms.

PHASE III: This work has a very high probability of commercialization. The algorithms, methodology and reusable hardware/software component technology developed in this SBIR are applicable and adaptable to law enforcement, homeland defense, site/border security, drug interdiction and special operations applications to provide low cost persistent surveillance and target interdiction. Technology also has broad applications to the future force to support next generation common controller applications for multiple tactical unmanned air and ground systems.

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KEYWORDS: intelligent agents, swarms, intelligent controls, network effects, cooperative control, multi-agent control.

A09-037            TITLE: Smart Dense Detector Arrays

TECHNOLOGY AREAS: Sensors, Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of

foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

**OBJECTIVE:** The objective is to create a family of Microelectronic Integrated Circuits (IC) called “Smart Dense Detector Arrays” by integration of advanced low power parallel processors with the large format detector arrays and associated memory into a volume no bigger than four times the volume of the focal plane array package without the other IC’s.

**DESCRIPTION:** This solicitation is for multiple IC’s to be integrated into a small volume where the IC’s include one or more low power processing chips having numerous parallel processors per chip and sufficient Input/Output (I/O) channels per chip to be directly connected to a multi-tap detector array, memory, and still have connections for the outside world. The package will facilitate building extremely small, rugged, low loss, compact, low power, low Radio Frequency emission, extreme throughput, and extreme resolution, for low cost cameras for essential military applications. Size of the package is a critical parameter for the multiple intended military applications. For this solicitation the processor array should operate on 3 watts or less while performing upwards to 25 Giga – Floating Point Operations (GFLOPS). The Focal Plane Array (FPA) should be 12 megapixels or more, have a dynamic range of 12 bits or more per low noise pixel. The acquisition rates should be upward to 30 frames per second or greater. The processor must have sufficient processing power to be capable of performing non-uniformity corrections and data analysis of the image data at the incoming data rates, while controlling FPA operation based on criteria sent from off-package, such as framing the data, changing integration time, etc. The processor must simultaneously be capable of large Finite Impulse Response filtering and other Digital Signal Processing (DSP) algorithms at rates in excess of 25 GLOPS to analyze the data for key features, compress the data set, etc. Sufficient memory, roughly 5 to 10 times that required to acquire the data from a single frame, will be required in the package for intermediate values, answers, control parameters, etc., to handle both inter-frame and intra-frame processing. The resulting “Smart Dense Detector Arrays” must be fully programmable by the user. The FPA control criteria and logic, the DSP algorithms, and image analysis algorithms, must be fully programmable by the user. The massive incoming image data is expected to be reduced within the processor to essential information that would be sent by the embedded program to external digital circuitry at much lower data rates than that coming from the FPA.

**PHASE I:** Design the multiple IC package and characterize the design for size, power, circuitry, risk factors, throughput, etc. Create the specifications document for the user community to program the package and to electronically integrate the multi-die integrated circuit package into external circuits.

**PHASE II:** Build and test a fully functional programmable multiple IC package based on the Phase 1 design and demonstrate the module in operation within a breadboard camera application. By the end of Phase 2, the module and documentation should be at Technology Readiness Level 6. A fully functional demonstration TRL 4 camera with the module embedded should be delivered to the government for testing.

**PHASE III:** The product of this solicitation will be a key component in rifle scopes, sniper scopes, and many surveillance and target acquisition equipment, as well as in advanced video equipment in the civilian commercial and military world where megapixels of acquired imagery must be reduced to essential information before being stored or transmitted. Application for domestic and military security operations for the device abound, e.g., Border Patrol, airport security, Search and Rescue, building surveillance, space and aircraft flown surveillance system and the movie industry.

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KEYWORDS: Large Format Cameras, Parallel Processors, Field Programmable Gate Arrays, Focal Plane Arrays, Sensors, Microelectronics, multi-chip modules, multi-die integrated circuit package

A09-038            TITLE: Innovative Wide Area Forward/Side Looking On-the-Move Laser Based Explosives Detection System

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

OBJECTIVE: Develop a wide area/forward looking laser based explosive scanning and detection technology with capability to positively identify explosive type as well as provide real time imaging of the size and dimension of a concealed or exposed explosive threats. Potential deployments include explosive scanning systems at entry control points or on Talon-like robots searching for explosives while on the move.

DESCRIPTION: Several standoff explosive detection technologies including LIBS, Raman Spectroscopy, Terahertz, and Laser Photo-Acoustic have emerged to provide highly positive explosive detection and classification reliability at large standoff distances (10m or more) from a fixed interrogation spot using molecular based "fingerprinting" of the explosive type. Such technologies have also evolved to allow high speed repetition rates making them potentially suitable for evolving from spot detection to scanning area detectors. Explosive detection at a single fixed spot is potentially practical when the location of explosive residue is assumed to be likely, such as on a car door handle or at a specific EOD interrogation spot. However, fixed spot interrogation does not facilitate deployment on moving platforms or allow an efficient assessment of the true size/magnitude of a potential explosive threat within a wide surveillance area.

The vision of this topic is to explore a synergism of emerging laser scanning and imaging technologies capable of precision control, high reliable standoff explosive detection technologies enabled by laser excitation, and software control/display technologies to provide real-time imaging of explosive threats while on the move. The potential exists to excite the surveillance area with precision laser control, sequence explosive detections, and display an aggregate group of detections over a scanned area in such a way that a user can appreciate the size and dimension of the potential explosive threat. Effective wide area scanning holds the promise to significantly improve false target rejection and countermeasure resistance by employing more meaningful assessment of the explosive threat over the total surveillance area and while potentially screening out small area detections which may not represent a true threat. The topic strives to develop and expand the applications for wide area laser based explosive detection imaging initially to slow-speed moving platforms such as a Talon robot, but ultimately the technology may progress to practical hand-held scanners and systems capable of scanning people at entry control points.

Additional topic challenges can be described to include: 1) The ability to quickly assess and potentially tag the central position of any detected explosive threat would facilitate passing explosive threat information to systems which might disable or destroy the threat. 2) Ability for the system to allow user input to adjust and focus the search pattern as well as forward looking search area. A typical scenario might involve the user refining the scan resolution and focusing the search area to improve overall reliability of the threat assessment as the system moves in closer to an identified spot of interest 3) Incorporation of additional laser ranging information or scene LIDAR feature that assists the user's ability to locate or assess the explosive threat 4) Provide high reliability of positive explosive detection with low false alarm rate over as broad a range of explosive material types (e.g. TNT, Tritinol, C4, dynamite, ammonium nitrate, potassium chlorate, or others identified as common in IED construction). 5) Employ non-photo ionizing radiation levels 6) System size goal suitable for deployment on small Talon-like robotic platforms.

Initial solutions to this topic should attempt to produce a forward looking, wide area scanning laser head and associated user interface with future goal to integrate with a TALON-like robot platform. In this deployment concept, the robot may proceed to an area of interest at slow speed and scan while approaching the area. Wide area/forward looking scanning in this case could be defined as a laser radiated area up to 10 feet from the area of interest, with 10 foot wide side to side swath and 3 foot height, approaching the target at speeds of up to 2 mph. The system should be capable of making initial location estimates of the explosive threat and then be capable of generating progressively higher resolution dimensional estimates of the explosive threat as the robot moves closer. A graphical user interface and display should assist the user in identifying initial detections and allow slow speed or fixed examinations if required to improve the threat assessment.

As the system solution evolves the ultimate goal would be to deploy the system on vehicles/platforms designed for in-road/off-road IED searching, these generally operated at speeds between 5 to 15 mph. In these future deployments the forward-looking scanning should provide for an approximate maximum standoff of 25 feet, with 10 foot side to side swath, and 5 foot overall height of coverage.

**PHASE I:** Conduct feasibility assessment of a state-of-the-art explosive detection capability which can detect real time images while on the move. Provide key design parameters including the laser scanner design and control approach, standoff detection technology, and control/display software. Provide potential design and performance tradeoffs involving speed of operation, resolution of explosive threat assessment over the scan area, reliability of explosive detection for a given standoff distance, and ability to capture relevant images for both bulk exposed or concealed explosives as well as trace explosive vapors. The initial feasibility study should be capable of statically detecting 2 sticks of TNT at a range of 5 feet and progressing to slow speed, on-the-move detection.

**PHASE II:** Develop a prototype identified in Phase I, conducting proof-of-principle tests to demonstrate the ability to conduct on-the-move explosive threat assessments for both bulk exposed or concealed explosives of different types. Extend the capability to identify different types of explosives such as Tritinol, C4, dynamite, ammonium nitrate, potassium chlorate, or others identified as common in IED construction. Demonstration success can be defined as obtaining real time images at various speeds up to 10 feet from the source with 5 foot minimum forward looking side-to-side swath.

**PHASE III:** For military applications, this technology can be applied to include 1) low-risk integration on Talon Robot for EOD missions, 2) systems deployed on vehicles or remote control platforms for in-road IED detection at practical speeds of 5 to 15 mph, 3) off-road application for urban GWOT applications.

Commercial applications may include 1) robot or robotic omni-directional explosives scanner for Law Enforcement and SWAT Teams, and 2) highly desired high speed reliable explosive surveillance area scanners to check people, luggage, cars, or other items in airports, malls, or any area suspected of mischief.

Future military and commercial applications of the developed technology could revolutionize on-person explosive threat assessments using hand-held devices or area scanning systems deployed in any public area or critical entry control point.

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KEYWORDS: Explosive, laser, scanner, detection, imaging, Raman Spectroscopy, LIBS, Terahertz, Photo-Acoustic, TALON, robot

A09-039      TITLE: Innovative Coatings for Lightweight Alloys

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Soldier

Objective: Develop novel wear prevention coatings for lightweight alloys used in weapons applications and air platforms.

Description: Light weight alloys of magnesium, aluminum and titanium are difficult to coat using traditional Chemical Vapor Deposition (CVD and Physical Vapor Deposition (PVD) techniques. Titanium alloys are widely used for Army vehicles, the Lightweight Howitzer, and bearing housings and flanges in aerospace propulsion systems due to low density, good mechanical strength, and high thermal conductivity. Cast aluminum alloys and, increasingly, magnesium alloys are also being used for their low weight and low cost. However, these alloys can experience an excessive galling wear when matched to harder steel surfaces, such as alloy 4340, under high fatigue loads, temperature cycling and dusty environments. Of particular interest to the US Army is galling wear elimination technologies, which can economically modify the surface of these light alloys into a hard, lubricious ceramic or functionally graded composite material. Such a coating or wear-resistant system could replace steel bearings and bushings which could simplify designs and reduce mechanism weight. Developed processes must not affect the bulk mechanical characteristics of the components and should be resistant to wear at temperatures between -45 to 500 F. A combination of the coating adhesion tests, corrosion tests, and fatigue tests of the coated specimens or parts is required for coating qualifications. Attention should be paid to thermal expansions to eliminate loose fittings in machine guns and bushings. Project coordination with weapon and platform manufacturers and the US Army is recommended. To be successful the following should be demonstrated: identify key process steps, ensure repeatable

results via metallurgy (coating thickness, hardness, adhesion and composition), ensure producibility and wear-resistance using coupon wear testing in accordance with ASTM Standards (such as G77 and/or similar).

Phase I: Identify and develop novel wear prevention coatings for lightweight alloys made with titanium, magnesium and/or aluminum. Deliverables: Coatings process, prepare test coupons with coating applied and without a coating (substrates: steel 4140, Ti-6-4, Mg HM21A-T8), perform wear testing (ASTM G77). Metrics: Comparison of ASTM G77 results of coupon testing with coating and without coating applied, to determine if there has been an enhancement in wear-resistance. Perform metallography and capture data such as coating thickness, hardness, adhesion and composition. This data will be used to compile an understanding of process repeatability. Milestones: 1. Select & Define Coating Process and key process parameters; 2. Prepare Test Coupons; 3. Perform Wear Testing; 4. Perform Metallography; 5. Phase I Report

Phase II: Demonstrate an ability to coat light-weight alloys made with titanium, magnesium and/or aluminum. Develop and validate the performance enhancement of the surface modification of bearing surfaces, housings, and flanges made of lightweight alloys. Establish performance parameters through experiments and prototype fabrication.

Required Phase II deliverables will include:

1. Finalized process design and parameters.
2. Provide practical implementation of the coating process on actual bearing prototypes.
3. Produce prototype hardware based on Phase I work.
4. Conduct life cycle and environmental testing. This should include exposure to moisture and dust environments.
5. Demonstrate the prototype in accordance with the success criteria developed in Phase I. These include: performance in ASTM G77, metallography and comparison of the coated surfaces to uncoated surfaces.
6. Assess the financial savings of using these surface modification technologies in terms of weight reduction (ie. require less fuel), reduction of hazardous waste and materials during processing, etc.

Phase III: \*Military application: The resulting technology will be applied to military machine guns made with cast titanium front block, where the wear of titanium alloys is a limiting factor. Cast aluminum parts used in HMMWVs and M198 towed howitzers can also benefit from wear-resistant coatings.

\*Commercial application: The new process will help widen the use of lightweight alloys in both commercial aerospace and automotive industry, where fretting wear is a limiting factor.

\*Biomedical applications: This technology can provide bone-like coatings on titanium joint replacements reduce the likelihood of rejection by the body and, perhaps, extend the life of current joint replacements.

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KEYWORDS: coatings, anti-fret, anti-galling, boronizing, ceramic, process

A09-040      TITLE: Scalable and Temporal Data Analytics for Mobile ad hoc Networks

TECHNOLOGY AREAS: Information Systems, Battlespace

OBJECTIVE: Develop and demonstrate novel scalable algorithms and approaches to allow for knowledge gathering and understanding of dynamic, mobile, ad hoc networks. New methodologies will factor in areas of statistical analysis and data mining pulling data from real world sensors and nodes, network simulation and emulation research, and knowledge bases formed from experimental data.

DESCRIPTION: This topic supports the Information Systems Technology DoD key technology area. As the Army continues to evolve to a completely digital battlespace environment, particularly as found in the Future Combat Systems effort, the ability to gather and form useful information in this dynamic environment is becoming problematic. The number of Internet Protocol (IP) devices in the battlespace is large and growing, yet non-deterministic over time with an unknown upper-bound cardinality. That is, nodes may come and go rapidly and scale to unknown heights. These are factors that significantly reduce an Army commanders' ability to use the network as a mission tool as useful knowledge becomes harder to garner from the incoming data streams. R&D is needed that goes beyond post-mortem static data analysis of limited experimental data sets. New approaches for mobile ad hoc networking research will have to factor in elements from network simulations and emulation exercises as these approaches may be used in conjunction with live events to test and optimize mission planning. To truly understand these networks and how to use them for maximum Army advantage, statistical analysis and data mining approaches will need to be developed and expanded to include temporal effects. Analysis after the fact will not work in this context. For example, predictive tools that would reposition network nodes to prevent a critical node (e.g. a network node trying to handle too much traffic flow) from forming in the network would be a key goal. Proper techniques and approaches (e.g. visualization) to present this data to mission planners will need to be addressed. Further, processing speed will be of the essence as non-static analytics will require at or near real-time processing speeds in proximity to the battlespace. Further pushing this need for parallelism will be the need to eventually couple analytics to network planning and optimization research; presumably integrated within a unified search framework. Hence, any approaches and algorithms investigated will need to be scalable and adaptable to approaches that will be deployable to the theater, such as multi-core processors or data-parallel multi-threaded devices such as general purpose Graphics Processing Units (GPUs).

PHASE I: Identify and define approaches, algorithms, and techniques for statistical analysis and data mining applicable to mobile ad hoc networks. Develop a design that extends the state-of-the-art to focus on scalable and temporal approaches targeting deployable parallel assets. Identify key parameters and network protocol stack layers that can best be addressed by scalable and temporal data analytics (e.g. physical or application layer parameters). Visualization applicability and potential should be addressed.

PHASE II: Develop, demonstrate, and validate a scalable data analytics system that scales from the small (squad-based) to large (theater-wide) in digital-based mobile ad hoc networks using the key parameters identified. Any algorithms will be authored in software libraries will be developed using high-level languages and approaches (both compiled and scripted) that will provide at or real-time processing and visualization of network battlespace events. This phase will include and demonstrate robust network design, analysis, or planning features (e.g. identification of critical potential fail points).

PHASE III: Portable, digital, wireless networked computing devices are becoming more pervasive in all sectors of society, from academia to military to commercial. The all digital Future Combat Systems (FCS) has scalability and clustering at numerous layers that will need visualization support to be fully understood by field commanders and military planners. This system will be useful in commercial applications as network planners will have to deal with issues of electromagnetic field propagation, signal strength and loss, and overall infrastructure planning. These are all key parameters likely to be identified in Phases I and II. Network service parameters can be understood and adjusted based in part on the visualization support this SBIR will provide. The use of multi-core processors or GPUs will make this technology attractive due to the potential high speed and throughput of the algorithms being executed.

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KEYWORDS: mobile ad hoc networks, data analytics, data mining, statistical analysis, visualization, net-centric warfare

A09-041            TITLE: Scalable Programming models for Battle Command Applications on emerging multi-core architectures

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective is to develop a programming model that is scalable and supports disparate battle command software applications running concurrently on a cluster of multi-core computing nodes. These battle command applications have been developed in a variety of computer languages including Python, C++, Java, Fortran, etc. Battle command applications are discrete event simulations which need high fidelity for some of the event simulations, hence the programming model must demonstrate scalability and ease of use for battle command applications.

DESCRIPTION: The fidelity of simulations of complex battlefield environments can be improved by coupling multiple existing complementary applications, each providing unique functionality. These applications are often designed independently and are unable to share information natively, resorting to limited to serial input/output operations for data sharing. One application may be run with a set of data in preparation for execution of a second application, which consumes the results of the first. The resulting serial process lacks scalability and does not make effective use of emerging multi-core computing resources.

A more desirable approach is to have the applications required for the simulation working in a distributed environment running concurrently and sharing data on an as-needed basis. Because the applications have no a priori knowledge of other applications' interfaces, a programming model would be necessary to facilitate communications.

The programming model needs to account for the parallel nature of multi-core computing resources; therefore, approaches along the lines of a Remote Procedure Call (RPC) are not appropriate as they are synchronous.

The desired solution involves the description of a programming model. While a specific implementation of a programming model will be used to demonstrate the approach, the solution will be ported to a variety of platforms.

The potential for commercialization of this technology is substantial. Multi-core architectures with 10's of cores are going to be used by business, not only for research, but also for data mining and transaction processing. Commodity computing is driving down the cost of hardware resulting in more affordable systems. As the rate of adoption rises, industry will be hungry for effective utilization of these new resources while leveraging past investments in system software developed for non-parallel environments.

PHASE I: Design a programming model to enable many disparate battle command type applications to communicate in the absence of a priori knowledge of interfaces. The approach will consider application to many multi-core CPUs.

Documentation for Phase I shall include a detailed description of the design.

PHASE II: Develop and demonstrate an approach to enable at least two disparate battle command type applications to communicate in the absence of a priori knowledge of interfaces. The approach will be implemented and investigated on at least two multi-core CPUs using a non-proprietary programming language, such as C, C++, Python, Java, etc. This will serve as a proof-of-concept for the proposed programming model and provide details on implementation difficulties for expanded research.

Communication between applications on the multi-core CPUs should clearly demonstrate capability of proposed applications on multi-core computing resources. Provide documentation of the proposed framework and associated open source software modules developed for Phase II.

PHASE III: Develop a complete solution enabling intercommunication among many battle command type applications running in parallel on multiple cores. Perform scalability and efficiency testing and optimization. Refine the approach and extend compatibility with a wide range of command and control applications. Continue to improve scalability.

COMMERCIAL POTENTIAL: Adoption of multi-core architectures by industry will continue to increase as commodity computing drives down the cost of computing. New multi-core systems will require efficient communication among disparate applications as industry, defense, and academic customers blend existing applications to fully realize the benefits of its investment.

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KEYWORDS: Advanced computing, multi-core systems, battle command applications, programming models, software application communication, communication framework

A09-042            TITLE: Approaches and Techniques for Specialized Character Recognition (CR) and Hand Writing Recognition (HWR) of Named-Entity Categories in Arabic Script and Romanized Document Images

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: To develop and demonstrate innovative algorithms and processes operating on digital images of foreign language documents. These techniques and methods shall identify features and patterns in a manner designed to extract and classify content. Specifically, the digital image feature patterns and classes should allow for association with named entities and named-entity categories. Output of the system will be text in the foreign language of the image to which can be applied post-processors for names which have trained on parallel CR output and ground truthed name data. In this way, the electronic capability will respond to Army requirements for the handling of named entities in degraded document images containing complex structure layouts of graphics and mixed Arabic script and Romanized glyph content.

DESCRIPTION: Named Entity Extraction (NEE) is a specialized area of natural language processing that focuses on discovering, identifying and developing patterns associated with the occurrence of unique identifiers of specific real world entities. Entities can be classified under categories, such as persons, organizations, and locations. Returning soldiers from OIF and OEF indicate that these types of entity information are of strategic and tactical importance to their missions. Problems arise, however, when names are embedded in foreign language document image data. This is especially true of degraded Arabic document images and images containing mixed Arabic and Romanized scripts. In NEE from document images, the quality and age of the printed document poses serious challenges to processing. NEE experiments on artificially created character recognition (CR) output show that NEE system performance degrades at a rate twice that of the level of injected noise or degradation. To make matters worse, Army foreign language material which requires translation--usually performed with machine translation (MT) systems--consists in large part of just such imaged documents. These MT systems are unlikely to properly render the names in the original material if the NEE systems themselves--trained to identify names in monolingual text--are challenged by the noisy CR output. Algorithms, processes, techniques and products to perform name-specialized CR and hand writing recognition (HWR) on imaged documents are especially necessary in current and future GWOT conflicts in which the processing of vast quantities of printed documents and derived information about the enemy is critical for intelligence and current operations.

PHASE I: Identify, develop, and experimentally test actionable approaches including algorithms, techniques and unique processes for NEE from degraded and complex document image data to include, but not limited to approaches for a) detection and localization, b) segmentation, classification and tracking, c) identifying zones with high likelihood/probability of name occurrence, c) text extraction and enhancements algorithms specialized in Arabic CR and HWR extractions for person, organization, and location names, e) specialized algorithms for recognizing and handling of mixed Arabic script and Romanized glyph degraded documents for zoning, identifying zones with high probability of name occurrence and the names themselves, and CR/HWR for person, organization and location names.

PHASE II: The name-specialized document zoning and CR/HWR processes explored in Phase I will be developed as a software prototype system. This system will be demonstrated using relevant data and simulating a realistic military operational environment. Standard metrics, i.e., character and segmentation accuracy, precision, recall and f-measure, will be defined in consultations between government and contractor. Selected metrics will evaluate system efficiency and effectiveness against a baseline of current practice and will be applied to assess both the prototype and the generative processes.

Phase III Dual Use Applications: Military application: Intelligence analysis can be expected to benefit from name-specialized document handling which permits follow-on processes such as relation detection and social network analysis at the strategic level and mapping and matching at the tactical level. Commercial application: Emergency preparedness and first responders can be expected to benefit from the enhanced relevance of the information provided by name-specialized document handling processes.

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KEYWORDS: character recognition, handwriting recognition, document image processing, content extraction, name recognition, pattern recognition and classification

A09-043

TITLE: Gas Phase Sulfur Sensor for JP-8 Fueled Auxiliary Power Generation System

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

OBJECTIVE: Develop a gas phase sulfur sensor for JP-8 reformer and solid oxide fuel cell (SOFC) based auxiliary power generation (APU) system. The sensor should work at temperature range of 300 to 600 °C and detect sulfur species in the hydrogen rich reformat at below one parts per million in volume (ppmV) levels for optimal and safe operation of a JP-8 fueled SOFC based APU system.

DESCRIPTION: Development of advance energy conversion technology is highly desirable to meet the increased power demand by today's Army. Since Army's fuel (JP-8) has the highest energy density and is being widely used in theater, development of technological capability to effectively and efficiently convert JP-8 to electricity will reduce the Army's overall logistic burden. Solid oxide fuel cell fueled with hydrogen rich reformat from reforming of JP-8 fuel to generate electricity in theater offers a solution to meet the power needs. The state of the art SOFC will be fully functioning with a reformat that contains sulfur at level of a few ppmV or less. Recently it has been demonstrated that semiconductor metal oxide based sensors for hydrogen sulfide with high sensitivity, fast response and recovery time at below 200 °C [1-3], and the sensing characteristics of some perovskite oxide based materials can be modified for hydrogen sulfide detection at a higher temperature up to 340 °C [4]. There are still many possibilities to be explored for the investigation of various novel materials for high temperature hydrogen sulfide detection and for the development of the sensors that will meet technical requirements such as high sensitivity, fast response and reliable detection of the signal, short recovery time and reproducible reactivity, chemical and thermal stability in the reformat atmosphere and temperature ... The purpose of this topic is to develop a functioning gas phase sulfur sensor with minimal weight and size burden to the overall JP-8 Reforming and SOFC based Auxiliary Power Generation System.

PHASE I: Demonstrate that suitable materials can be used to construct sulfur sensor for H<sub>2</sub>S and COS operating at 300 to 600 °C. The sensor should be able to respond to hydrogen sulfide at minimum 1 ppmV or below with sufficient signal strength within 30 second in an atmosphere consisting of hydrogen, carbon monoxide, carbon dioxide, light weight hydrocarbon molecules, and water vapor. The sensor also needs to be quickly responsive to baseline condition once the sulfur species is not present in the reformat stream. The responses to sulfur species and to baseline should be reproducible for multiple runs. Present and discuss the design of the hydrogen sulfide sensor that will be fully integrated with a JP-8 reforming system in hardware and electronic control, with desired fail-evident feature. The size and weight of the sensor system should be relatively insignificant compared to the overall Auxiliary Power Generation System's weight and size.

PHASE II: Design, construct, and evaluate a prototype of the complete sulfur sensor system. At the minimum, the sensor system should be demonstrated to have the same life time as the desulfurizer in the JP-8 reforming system for maintenance purpose. Deliver one complete sulfur sensor system to the Army.

PHASE III: Effort to integrate the gas phase sulfur sensor with a JP-8 reformer system (maybe one of the Army sponsored JP-8 reformers) is required to develop a liquid hydrocarbon fuel based solid oxide fuel cell power generation system. Successful development of this technology with higher fuel efficiency and less environmental footprint will have impact on a wide range of military power applications and will enhance the Army's fighting capability and survivability in battlefield with reduced logistic burden. The technology is also applicable to commercial power and energy arena such as emergency power supplies, distributed power generation, and residential/recreational applications, etc.

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KEYWORDS: Sensor, hydrogen sulfide, JP-8, fuel reformation, solid oxide fuel cell

A09-044      TITLE: Novel flexible sensor array integrated with a Flexible Display

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

**OBJECTIVE:** Proposals are sought to develop novel flexible electronic sensor arrays with an integrated flexible display. The SBIR program is to focus on the demonstration of flexible electronics for sensors. The functionality of interest includes sensor arrays on a flexible substrate. The sensor array may include optical, x-ray, acoustic or chemical sensors. The sensor array shall interface to a flexible display for direct imaging to enable large area sensor arrays for improved field of view with enhanced capability.

**DESCRIPTION:** The Army has been developing flexible displays with improved performance to include ultra-low power, sunlight readability, and novel bi-stable imaging. Bi-stable imaging enables a sensor to direct map to a display and the image to remain on the display with zero-power. This unique display characteristic integrated with sensor array will enable novel sensor demonstrators. The Army is developing flexible displays through the Flexible Display Center (FDC) at Arizona State University. The bi-stable flexible displays are based on the electrophoretic (electronic-paper) technology. The FDC displays include 3.8 inch diagonal displays with a 320x240 resolution. This SBIR topic will not fund flexible display development. The proposed effort shall address the development of novel sensor array technology on flexible substrates and the integration of the array to a bi-stable flexible display. The sensor technology of interest shall include; optical imaging, x-ray imaging, acoustic array imaging. Other sensor technologies will be of interest. The sensor array need not be fabricated directly on the flexible display. The sensor demonstrators and flexible displays can be fabricated separately and integrated together. These novel sensor systems will offer unique capabilities current not available with conventional technology. The application can include medical imaging, structural imaging, assessment of high-value assets, and demonstrations towards very large area sensor arrays for ultra-large apertures as well ultra-light weight flexible electronics for UAVs and micro-UAVs.

**PHASE I:** During Phase I, the program shall design the sensor array technology and necessary interface capability for the flexible display. The sensor is to be designed for fabrication on a flexible substrate to include; plastic (such as PEN) or stainless steel. The sensor array may include optical, x-ray, acoustic or chemical sensors. The initial design phase shall include the demonstration of single device performance adequate for the sensors. These demonstrations shall be used to design the array layout. The overall array specifications shall be no smaller than 1.1" diagonal with a 64x64 resolution up to 4" diagonal with a resolution of 320x240 pixels. The Phase I deliverable shall be a final report to include; the individual device performance data, the system level design and architecture as well as the anticipated performance of the device. The Phase I effort shall not include the design or the development of a new flexible technology.

**PHASE II:** During Phase II, the program shall complete the final design the sensor array technology on a flexible substrate and integrated with a flexible display. The Phase II program shall first develop and fabricate the sensor array on a flexible substrate (to include plastic or stainless steel) and demonstrate functionality. Following the successful demonstration of the sensor array, the system shall be integrated with a flexible display for direct imaging. This interface will likely include necessary interface chips and related electronics. These electronics are not necessarily fabricated using flexible electronics. The final design shall include the trade-offs with using COTs chips for these interface designs. The Phase II deliverables shall include a final report detailing the overall system design and performance. In addition, the contractor shall deliver (2) sensor arrays integrated with flexible displays.

**PHASE III:** The final product from the SBIR will be used to evaluate the novel applications for the World's First fully integrate flexible electronic and imaging device. The sensor platform shall transition to the Army's Flexible Display Center for future applications to be developed from the flexible electronics pilot-line current established at Arizona State University. In the long term, the FDC will have the capability of fabricating flexible displays and electronics at 370x470mm scales for these emerging integrate sensor platform applications. The technology will have an opportunity to transition to the more than 21 industry partners that participate in the FDC.

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KEYWORDS: Flexible Electronics, flexible displays, sensor arrays

A09-045            TITLE: Development of GaN Substrates for High Power and Multi-Functional Devices

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Higher quality GaN substrates will lead to better high power devices used in hybrid electric vehicles, more output power in RF radar systems, and will enable multi-function devices such as those used in acousto-optic devices all of which are of great interest to the Army. The objective of this research is to improve upon those GaN substrates currently being grown so that devices made using them are better than those currently being manufactured. Examples are power diodes and transistors. In theory devices made from GaN should out perform those made from SiC, but those fabricated from current GaN substrates do not because the quality of reasonably sized GaN substrates is not good enough.

DESCRIPTION: GaN power devices have the potential to out perform those made from SiC and be made more cheaply, RF HEMTs (high electron mobility transistor) can be made more reliable, and multi-function devices could be enabled by improved GaN substrates. Great strides have been made recently towards increasing the size of these substrates and reducing the number of crystalline defects, but more improvement is still necessary. How these improvements in the quality of the GaN substrates leads to an improvement in the devices made from them must also be demonstrated, and in so doing create a market for these substrates. Currently, the substrates that are of high enough quality to demonstrate the improved device characteristics are too small - < 1 inch in diameter - to be economically viable. Although there have been great improvements recently in the large area crystals, they still contain too many crystalline defects and are not yet uniform enough for good quality devices to be fabricated uniformly across the wafer. The goal of this research is to be able to produce GaN substrates that are large enough to be economically viable, contain few enough crystalline defects such as dislocations and domain boundaries so that devices fabricated on them will have better operating characteristics and be more reliable than those currently being made, and be uniform enough across the wafer so that reasonable yields can be obtained.

PHASE I: Do simulations of a current high power, multi-functional, or RF device that is made using a GaN substrate and one that is made using an alternate substrate. Determine what the parameters of the GaN must be for the device fabricated on the GaN substrate to be as good as the one fabricated on the alternate substrate. Describe what must be done with your GaN substrates so that 50% of the devices over a 2" diameter substrate will meet or exceed the values you have calculated, and provide a meaningful path by which you will obtain the substrates that will meet this goal. One such example is a Schottky diode for the 600 V market. The simulations should show what the parameters for the GaN material must be so that devices made using the GaN substrate will have breakdown

voltages that exceed 600 V and have a switching loss at 20 kHz that is at least as small as that obtained from a comparable SiC device. These simulations and report will be delivered to ARL.

PHASE II: Using your simulations as a guide, develop GaN substrates at least 2" in diameter from which the device you chose in Phase I can be fabricated with the properties that meet or exceed those that you described, and do so with a yield of at least 50%. These substrates and devices will be delivered to ARL for testing and verification.

PHASE III: Develop a plan for selling your GaN substrates by being able to show that customers who use them will be able to make a better device as demonstrated in Phase II and be able to do so with a reasonable yield at a reasonable cost. Show how much better and/or more reliable the devices will be using your substrates and provide justifications for any increased costs that would be incurred if your customer used your substrate. Identify the market for the improved device you have demonstrated using your GaN substrates and provide a plan on how you intend to access that market. Also, suggest what other devices could be manufactured using your substrates that would have properties that were superior to those currently being achieved, and develop a plan for how you would demonstrate this. The goal is to be able to sell these substrates at a reasonable cost to companies manufacturing these devices because they believe they can make a better device or a similar device at a lower cost, and to also identify other devices that could be improved and sold at a reasonable cost using your GaN substrates.

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KEYWORDS: Power Devices, Multi-functional Devices, Diodes, Increased Complexity, Transistors, Gallium Nitride, Silicon Carbide

A09-046      TITLE: Ultra Resolution Camera for C4ISR Applications

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Proposals are sought to develop a novel multiple-FPA visible/infrared electro-optic sensor. The SBIR program is to focus on the design, development and demonstration of a wide area persistent surveillance capability not currently available. While the ability to combine multiple focal plane arrays to form a single image from an individual sensor has been demonstrated over the last few years, a multiple-FPA sensor system able to cover a larger area on the ground with 0.3 meter resolution (instead of the 1 meter resolution that is being used today) has not been designed or developed. In addition, current persistent wide area ISR systems are very expensive, heavy, and require a lot of electrical power. This SBIR program seeks a low cost, light weight, low power, electronically stabilized sensor system that can be flown from small aircraft (manned and/or UAV) and operated at a greatly reduced operational cost.

**DESCRIPTION:** Army and DOD have been developing high resolution cameras for wide area persistent surveillance applications. This topic entails the design, fabrication and demonstration of a combined visible/infrared sensor system with a minimum of 2.3 Giga pixels per frame and capable of operating at 2 frames per second or faster. In addition, the sensor system should have the user-selectable option of operating as a three color (RGB) camera with electronic stabilization capability so the requirement for a stabilized platform can be removed/relaxed. The sensor should use parallel electronic interfaces as a means of transferring data. The assembly, alignment and calibration of this type of sensor will require access to and the use of calibrated precision optical alignment and calibration systems. A FPA sensor system capable of simultaneously measuring visible and infrared will simplify overall sensor system design and development for persistent wide area surveillance applications. The end result will be a highly sensitive, discriminating sensor system that is more reliable, lighter, and less costly than currently available. The proposed sensor system will require innovative research and development. Individual FPA chips and optics can be COTS if available, although this is not a requirement.

**PHASE I:** During Phase I, the program shall design a new and innovative multiple-FPA sensor technology that will improve current wide area surveillance capabilities. Survey of research and development (R&D) efforts currently underway to develop single visible/infrared focal plane array chips and a determination of the feasibility of using existing chips in a multiple-FPA sensor system will occur in Phase I. In addition, a survey of current circuit card development capabilities to determine the best R&D processes currently available for fabrication of multiple-FPA sensor cards will be conducted. Once a specific FPA chip and fabrication process has been identified, a small scalable multiple-FPA sensor system will be designed and the feasibility of the proposed concept and technologies will be demonstrated. Phase I deliverable shall be a final report to include; the individual sensor performance data, the system level design and architecture as well as the anticipated performance of the sensor. The Phase I effort shall not include the design or the development of a new FPA chip technology.

**PHASE II:** During Phase II, the program shall complete the final design of the sensor array technology. The Phase II program shall first demonstration, in a breadboard configuration, a multiple-FPA card sensor system with a minimum 2.3 Giga pixel capability. Card fabrication process verification will be conducted that will require the development of an electro optics alignment station to provide optical input to individual FPA cards during assembly and debugging. Calibration measurements during the assembly and alignment process will allow the removal of any misalignment of individual FPA chips due to the circuit card fabrication process. Following the successful demonstration of the sensor system, the required number of completed FPA cards with individual optics will be integrated into a full-up working sensor system meeting the above stated specifications. The Phase II deliverables shall include a final report detailing the overall system design and performance. In addition, the contractor shall deliver one (1) low cost commercial aerial photography sensor system that meets a large majority of today's commercial aerial photography requirements.

**PHASE III:** the final product from the SBIR will be tested on a small manned aircraft up to 10,000 feet. Engineering and prototype development, test and evaluation, and hardware qualification demonstration in a system-level test-bed which shows application to an insertion potential into one or more unmanned aerial vehicles will be completed.

Possible commercial applications of the ultra resolution camera include, but are not limited to, improved border and maritime management/patrol, critical infrastructure protection, transportation security, search & rescue, crime prevention, land & sea traffic monitoring, pipeline/powerline monitoring, private infrastructure surveillance/security, and aerial photography, and satellite augmentation systems.

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**KEYWORDS:** Intelligence, surveillance, reconnaissance, high-resolution camera, persistent, pervasive

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

**OBJECTIVE:** Develop high-power, high-brightness 1530-1535-nm fiber-coupled laser diode modules with substantially improved efficiency, suitable as pump sources for high-power, eye-safe Er-doped fiber lasers, while minimizing the risk to human eyes. Technology must be developed with the potential for manufacturability, low operating cost, efficiency and ease of use.

**DESCRIPTION:** Defense against fast-moving airborne threats such as rockets, artillery and mortars is an important challenge for the Army, as is destruction of explosives at a safe distance. High-power lasers have the potential to meet these challenges, provided that key technologies are developed. These include improving the efficiency and power levels of solid-state lasers, and the development of versions that operate at wavelengths relatively safe to human eyes.

Er-doped solid-state lasers (SSL) with direct (resonant) laser excitation around 1530 nm [1-4] have proven to be highly efficient “eye-safe” sources. As a logical continuation of the work [2-4], an Yb-free resonantly cladding-pumped, highly scalable, Er fiber amplifier was recently demonstrated [5]. In contrast to pumping with a 9xx-nm wavelength diode laser, pumping of a fiber laser with a ~1530 nm source provides much higher laser efficiency and better thermal management of the fiber due to a much smaller quantum defect (of the order of 5%). In [5], the booster amplifier was cladding co-pumped by six InGaAsP/InP laser diode modules fiber-coupled into 105/125 micron, 0.15 NA pigtailed. The power of each pump module was in the range of 5-6 W. High power scalability potential was demonstrated, but pumping sources with much higher brightness would be required to achieve multi-hundred kilowatt power output.

Although laser bar coupling technology is efficient for laser diodes with wavelengths shorter than one micron, the thermal load generated by such a device causes thermal management problems. This limits the use of diode bars or arrays for InP-based lasers, which are needed for operation at relatively eyesafe wavelength, due to their sensitivity to temperature. To address this problem, fiber-coupled modules based on single emitters are being developed for coupling into a laser fiber via fused couplers. Single-emitter architecture guarantees better thermal management due to the “distributed” nature of heat generation, and provides more practical operation at low current and high voltage [6] (as opposed to laser bar-based schemes operated at high current / low voltage). Despite all of the advantages, the fiber coupled, high-power, 1530-1535-nm laser diode modules are currently underdeveloped. The power conversion efficiency (PCE) of these diodes is currently considerably lower than that for shorter-wavelength laser diodes, and their beam divergence is higher, with the result that fiber coupling efficiency is also lower.

At present, it is necessary to analyze all available choices for improving the efficiency of fiber-coupled high brightness pump modules emitting at 1530 nm wavelength. These solutions will be immediately employed as pump sources for high-power Er-doped fiber lasers. Later, the same design approaches will be extended to pump sources with even longer wavelengths aimed at resonant pumping of Tm- and Ho-doped fiber lasers.

The development of fiber-coupled pump sources for the 1.5-1.9 micron wavelength range requires progress in three directions: laser diode design (including further improvement of current approaches and radical changes to improve efficiency with high potential for scalability,) development of more efficient fiber coupling schemes, and advancement in thermal management to better deal with the temperature sensitivity of diode devices emitting in this wavelength range.

**PHASE I:** Eye-safe 1530-1535-nm pump module with 105 micron core / 0.15 NA fiber output. Target power 30 W out-of-fiber with PCE at rated current not less than 25%. Maximum PCE (at lower than maximum power output) not less than 30%. It is expected that significant improvements in diode laser efficiency and in fiber coupling efficiency will be required to meet these goals and to provide the potential for the further improvements specified in Phase II. The technologies developed to achieve these goals must have the potential for: (1) efficient thermal management; (2) manufacturability; (3) reliability. In addition to modeling and simulation to develop a design for

the necessary improvements, proof-of-concept device development is expected. A best-effort device with performance goals listed above shall be provided to the Army Research Laboratory for evaluation.

PHASE II: Design and assemble a fiber coupled module emitting a wavelength of 1530 nm with 45 W out-of-fiber (105 micron core / 0.15 NA) power with PCE at rated current >40%. In addition to these improvements in efficiency and power scaling, the phase II efforts should also focus on wavelength stabilization, and on manufacturability, producibility, cost reduction and yield. The deliverables are five modules with specifications listed above with total power over 220 W, to be tested for diode-pumping of a fiber laser or amplifier at the Army Research Laboratory.

PHASE III: Production line of super-high-brightness 1.5-1.9 micron fiber coupled modules with superior PCE, enabling high efficiency, high power fiber lasers operating in this relatively eyesafe wavelength range. Non-military uses include direct processing of plastics, cutting of organic materials, surgery, and various therapeutic and aesthetic procedures.

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KEYWORDS: Fiber-coupled laser diodes, fiber laser, Er<sup>3+</sup>-doped materials, diode pumping, long-wavelength laser diodes.

A09-048            TITLE: Controlled Bandwidth Transmission Systems for Ultra-Wideband Radars

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: The development and demonstration of a low-power, ultra-wideband transmitter whose spectral content can be tailored to fit within certain limits, or to avoid specific frequency bands. The transmitter should thus be able to avoid generating harmful interference to radio frequency systems that operate in the range of its bandwidth.

DESCRIPTION: Ultra-wideband (UWB) radars operate across a wide range of frequencies usually designated for other uses. This presents regulatory and operational problems in producing a fieldable radar system. ARL is developing high-resolution radar support for ground vehicles to provide all weather day/night vision of the region in front of the vehicle. The current ARL proof-of-concept radar system employs a transmitter and transmit antenna

located at each end of a receive aperture. The design is extensible to allow for growth in the number of channels used and improvements in integrated circuit performance to eventually meet the expected unmanned ground vehicle combat pace. The problem is the impulse transmitters used in the system generate energy across a wide swath of the spectrum (300 – 3000 MHz). While the output power is low (5 mW average), the system provides the potential to interfere with a number of other systems that use these frequencies, so test and evaluation is currently restricted to DoD facilities west of the Mississippi. Viable operating parameters are 400 MHz to 2.4 GHz with a number of programmable areas in which little or no energy is produced to avoid interference issues. What is needed is a transmitter that could generate a waveform with this large instantaneous bandwidth in a pulse no longer than 50nS and an algorithm that would allow the target return signal to be compressed into an impulse.

**PHASE I:** Phase I of the program should investigate innovative modulation techniques and hardware that would allow generation of a restricted bandwidth signal (where the measure of quality is the ratio of the out-of-band energy to the in-band energy) that can produce signal levels up to -20 dBm/MHz. An initial goal would be a system that could operate from 500 – 1250 MHz.

**PHASE II:** It is desired to eventually have a pair of reasonably small, affordable transmitters rather than a pair of \$50,000 laboratory instruments attached to the radar. The current transmitters are approximately 5”x3”x3” and cost less than \$2500. The transmitter should be capable of producing its output in response to a digital trigger pulse with low jitter. A pair of prototype transmitters based on the Phase I study will be produced for testing along with the algorithm necessary to turn the received waveform back into an equivalent short-pulse time-domain signal.

**PHASE III:** In the third phase the project will transition from applied science to manufacturing schemes that allow for wide scale commercialization and reduced prices. The desire is to initially support the ground-based, vehicle-borne versions of the radar systems being developed for obstacle avoidance during autonomous navigation of future combat vehicles and robots. There is also a need to support the use of such systems for detecting surface and near-surface objects for explosive ordnance disposal. Such systems need to be able to operate in the presence of other radio frequency sources such as communications links and jammers without causing or being susceptible to interference. This phase will also focus on applications that possess the largest commercial payoff potential, such as through-the-wall sensing radar, intrusion detection, etc. without causing interference to other radio frequency systems.

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**KEYWORDS:** Ultra-wideband, radar, spectrum, impulse, interference

A09-049            **TITLE:** High-G Simulator for In-Flight Test Article

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

**OBJECTIVE:** Develop a new novel technology to stop a 60 lb projectile traveling up to 1,300 ft/s in a well-controlled, repeatable manner resulting in a high-g acceleration test event.

DESCRIPTION: The government seeks to develop a technology that can simulate the interior ballistic environment of a cannon launch as well as other high acceleration events. A cost effective simulation technology is crucial for the development of new weapon systems in which complex electronics are subjected to very high shock loads. The XM982 (Excalibur) program has depended heavily on such a system throughout its development effort. However, the technology used in that program depends on expendable materials (which are no longer available) and is limited in its ability to achieve any particular acceleration curve. A new technology is sought to replace the old technology. Given a projectile traveling at 1,300 ft/s, the new technology should be capable of producing a target deceleration curve that varies between 5 and 50 k-g and durations between 1 and 5 ms. Additionally, the technology should not depend on the use of expendable materials. The projectile will not include energetic materials and it must not be damaged while it is being slowed and stopped. The projectile's motion must be constrained to be axial only. The Army desires to implement this technology for 3", 4" and 7" projectiles.

PHASE I: The phase I efforts focus on designing a concept to controllably and repeatedly decelerate a 7" diameter, 60 lb test article. The projectile's initial velocity is 900 ft/s and it must be stopped with a deceleration pulse that varies from 5 k-g to 50 k-g and a duration that varies from 1 ms to 5 ms. The methodology that produces the desired pulse could make use of new and/or novel technologies and must not be reliant upon expendable materials. Phase I should be utilized to develop a computational analysis to establish the feasibility and limitations of the designed device. The use of modeling and simulation technologies is encouraged as part of the computational analysis. The phase I deliverable is a feasibility study for a 7" projectile. Although the phase I deliverable targets a 7" projectile, the methodology should have the flexibility to be expanded to 3" and 4" projectiles as well.

PHASE II: Phase II efforts will be focused on producing a prototype device for a demonstration of the methodology developed in phase I. The 7" ARL airgun will be made available to the contractor for testing and a final demonstration of the prototype. Throughout development of the prototype, the contractor should consider modifications that may be necessary to implement the system with a 3" and 4" diameter projectile traveling up to 1,300 ft/s. The deliverable for the phase II effort is a prototype of the methodology to stop a 7" diameter, 60 lb projectile traveling at 900 ft/s with a pulse that peaks at 15 k-g and lasts 4 ms.

PHASE III: Once the basic methodology has been demonstrated, the phase III efforts will focus on refinements. Modification to the technology will be incorporated to reduce the cost of each shot and increase the tunability and acceleration level available in the test environment in a laboratory setting that is devoid of energetic materials. As part of the Phase III efforts, a turn-key system for producing acceleration and duration prediction for each shot should be developed. The apparatus could be utilized by defense contractors to provide low-cost in-house validation of device performance in the gun-launch environment. Manufacturers from a variety of industries could have an interest in an in-house, programmable, high acceleration test environment. Some of the industries that could benefit from such a device include the space industry (simulation of explosive bolts), automotive industry (simulation of vehicle crashes of individual components) or the electronics industry (highly controlled simulation of dropped electronic devices). The phase III deliverable includes an optimized system that includes both hardware for producing the desired pulse as well as an algorithm for predicting the pulse that will be generated.

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2. Air Gun Launch Simulation Modeling and Finite Element Model Sensitivity Analysis. AD Number: ADA441366 Corporate Author: ARMY RESEARCH LAB ADELPHI MD Personal Author: Chowdhury, Mostafiz R Tabiei, Ala Report Date: January 01, 2006 Media: 63 Page(s) Distribution Code: 01 - APPROVED FOR PUBLIC RELEASE Report Classification: Unclassified Source Code: 424778 From the collection: Technical Reports.

3. Analytical Simulation and Verification of Air Gun Impact Testing.

AD Number: ADA437152 Corporate Author: ARMY RESEARCH LAB ADELPHI MD Personal Author: Bouland, Adam Chowdhury, Mostafiz R Report Date: August 01, 2005 Media: 54 Page(s) Distribution Code: 01 -

APPROVED FOR PUBLIC RELEASE Report Classification: Unclassified Source Code: 424778 From the collection: Technical Reports.

4. Development of an Air Gun Simulation Model Using LS-DYNA

AD Number: ADA417052 Corporate Author: ARMY RESEARCH LAB ABERDEEN PROVING GROUND MD Personal Author: Chowdhury, Mostafiz R Tabiei, Ala Report Date: July 01, 2003 Media: 51 Page(s) Distribution Code: 01 - APPROVED FOR PUBLIC RELEASE Report Classification: Unclassified Source Code: 425747 From the collection: Technical Reports

5. Simulation of Sequential Setback and Aerodynamic Drag of Ordnance Projectiles. AD Number: ADA043192 Corporate Author: HARRY DIAMOND LABS ADELPHI MD Personal Author: Pollin, Irvin Report Date: June 01, 1977 Media: 37 Page(s) Distribution Code: 01 - APPROVED FOR PUBLIC RELEASE Report Classification: Unclassified Source Code: 163050 From the collection: Technical Reports.

6. Impact Pulse Shaping. AD Number: ADA022351 Corporate Author: HARRY DIAMOND LABS ADELPHI MD Personal Author: Pollin, Irvin Report Date: June 01, 1975 Media: 59 Page(s) Distribution Code: 01 - APPROVED FOR PUBLIC RELEASE Report Classification: Unclassified Source Code: 163050 From the collection: Technical Reports.

KEYWORDS: airgun, gun launch, high-g simulation, artillery simulator

A09-050 TITLE: Consolidation of Materials by Liquid Particle Acceleration

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: To develop and demonstrate a prototype system to accelerate particulates (metals and non-metals) using liquid as opposed to gas to consolidate them and form highly dense deposits that can be applied to surfaces and/or used to produce bulk materials. This technology would result in a new class of materials that would differ significantly from those produced from conventional ingot metallurgy techniques, which involve the melting and re-solidification. These new materials could be used to produce wear and corrosion resistant coatings, as well as to produce reactive materials.

DESCRIPTION: The focus of this research is to develop and demonstrate a prototype system that has the ability to consolidate commercially available powders consisting of metals, and/or combinations of metals with ceramics and polymers without melting or sintering. This will allow for the development of a new class of materials that would differ significantly from those produced from conventional ingot metallurgy or powder metallurgy techniques, which involve the melting and re-solidification of alloying elements or the sintering of powders. These new materials could be used to produce wear and corrosion resistant coatings, bulk materials, free-standing structures/components. Required Phase I deliverables will include the production of 4 (3 inch x 6 inch) samples that have been coated with a metal (i.e. Al, Cu, Zn, Cr, Ni) using the newly developed liquid particle acceleration system. These samples will be used for analysis and materials characterization. Cold spray is one technique that can accomplish this but uses gas to accelerate the particles. Liquid is approximately 1,000 times denser than gas so it is far more effective at accelerating particles. The driving force acting on a particle that is being accelerated is caused by the drag of the fast moving fluid (gas or liquid) which is proportional to the diameter of a round particle and the density of the fluid (among other things). [1,2] Liquids can accelerate larger particles to a higher speed in a shorter length than is practical with gas systems. Commercial liquid pumps can generate fluid velocities up to 1,000 m/s, which is higher than the critical velocity required for many cold spray applications.

PHASE I: The primary objectives of the Phase I effort are to demonstrate a laboratory scale liquid particle acceleration system that can be scaled up for production and to produce a set of coated samples for testing. The laboratory scale liquid particle acceleration system will be required to produce a total of six (3 inch x 4 inch) samples that have been coated with any one or more of the following metals (Al, Cu, Zn, Cr, Ni) to a thickness of at least 0.025 inches.

The substrate material of the first two samples will be a low alloy steel (i.e. 4340) having a hardness of approximately HRC30. The substrate material of the next two samples will be a 1xxx series aluminum alloy in the annealed condition and the remaining two samples will be Ti6Al-4V. These samples will be used by ARL for analysis and materials characterization. The density, hardness, adhesion, grain size and the amount of porosity of the coating will be measured. The coating/substrate interface will be examined for cracks and voids.

The contractor's readiness for Phase II will be judged by the ability of the proposer to adequately address the necessary design and hardware/software features, safety issues and process parameters required to produce a system for large scale production and to present data showing that the deposited material is equal to or close to theoretical density (>99%), has adhesion values equal to or greater than 10,000 psi and has a uniform hardness and grain size distribution.

PHASE II: Building on the successful results of Phase I, the primary goal of the Phase II effort will be to develop a large scale liquid particle acceleration system with the same or improved performance as that from Phase I and to perform a cost analysis assessment for future production to expand the technology to enable the development of a robust production system capable of utilizing commercially available metal powders and combinations of metal and non-metallic powders/particulates including ceramics, polymers and nano-size powders (.5-1um).

Reasonable performance related goals expected to be achieved by the proposer related to the execution of this project are the demonstration of consolidating the metals (Al, Ni, 300 series Stainless Steel, Cr, Ta, Cu, Zn, with and without additions of Al<sub>2</sub>O<sub>3</sub>, SiC, WC, and Teflon) and to present data showing that the deposited material is equal to or close to theoretical density (>99%), has adhesion values equal to or greater than 10,000 psi and has a uniform hardness and grain size distribution.

at the end of the first year of the Phase II effort.

The large scale liquid particle acceleration system will be required to produce a total of six (3 inch x 4 inch) samples that have been coated with any one or more of the following metals (Al, Ni, 300 series Stainless Steel, Cr, Ta, Cu, Zn, with and without additions of Al<sub>2</sub>O<sub>3</sub>, SiC, WC, and Teflon) to a thickness of at least 0.025 inches with one of the samples having a coating thickness of at least 1.0 inches and to present data showing that the deposited material is equal to or close to theoretical density (>99%), has adhesion values equal to or greater than 10,000 psi and has a uniform hardness and grain size distribution. The substrate material of the first two samples will be a low alloy steel (i.e. 4340) having a hardness of approximately HRC30. The substrate material of the next two samples will be a 1xxx series aluminum alloy in the annealed condition and the remaining two samples will be Ti6Al-4V. These samples will be used by ARL for analysis and materials characterization. The density, hardness, adhesion, grain size and the amount of porosity of the coating will be measured. The coating/substrate interface will be examined for cracks and voids.

Similarly, a successful second year of this Phase II effort is to develop the process parameters, demonstrate production capability and deliver a liquid particle acceleration prototype system to ARL having the capability to deposit the aforementioned materials at a rate equal to or greater than that which can be achieved by conventional cold spray and/or thermal spray technology for testing and evaluation.

PHASE III: DUAL USE APPLICATIONS: The development of this technology will allow for the development of a new class of materials that would differ significantly from those produced from conventional ingot metallurgy or powder metallurgy techniques, which involve the melting and re-solidification of alloying elements or the sintering of powders. These new materials could be used to produce wear and corrosion resistant coatings, bulk materials, free-standing structures/components., including nano-size bulk materials and coatings for use in the electronics, aerospace, automobile and petrochemical industries, for the production of conductive-high temperature resistant coatings, corrosion and wear resistant coatings, cutting tools, abrasives, heat exchangers and most critical for the DOD, reactive materials.

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KEYWORDS: Liquid Particle Acceleration, Cold Spray, Particle Velocity, Impact Velocity

A09-051            TITLE: Innovative manufacturing research on forming of large light armor alloy sections resistant to blast and penetration

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat 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: The objective of the innovative research program is to develop cost effective near net shape manufacturing processes that can form large contoured structures from thick plate that are resistant to blast loading and penetration.

DESCRIPTION: Current tactical wheeled and combat vehicles hulls are manufactured from sections of steel or aluminum plates that are welded together. These welds can serve as a source of weakness when subjected to a ballistic threat (see, for example, [1]-[6]). The current research will investigate large scale manufacturing

technologies that can produce large seamless sections that can be utilized as the lower hull of a lightweight vehicle or as an applique kit that can be readily mounted to the underside of an existing tactical or ground combat vehicle. The manufacturing techniques developed should be cost effective and applicable to lightweight armor alloys. Current large scale manufacturing investigations involving lightweight alloys are being performed by NASA, who have and are currently investigating shear forming of large thin walled sections for utilization in launch vehicle applications [7,8]. The present proposal seeks out technologies for thick section forming processes.

PHASE I: Phase I efforts should identify the armor alloys suitable to large scale forming and the corresponding forming techniques that could be applicable to each alloy systems. Full scale dimensions should be on the order of 6' to 8' wide by 8' to 12' long with thicknesses ranging from 2" to 5". Final formed shapes should conform to the hull and lower glacis of a typical ground combat vehicle or the lower body of a tactical wheeled platform and also a notional future blast resistant V-hull geometry. A review of the associated manufacturing processes, their relative cost effectiveness, scalability, and limitations should be performed. In order to develop the manufacturing process parameters, scaled component studies should be performed to identify the most promising manufacturing process or processes and alloy systems based on the ability to form the alloy while maintaining dimensional tolerancing sufficient to allow an applique to be mounted or a lower and upper hull sections to be joined, maintain uniformity of plate thickness and achieve maximum material strength and elongation properties which will be measured in the as-formed system. The results of the review and scaled studies will determine a cost-effective manufacturing process and alloy system that can be utilized for large scale studies.

PHASE II: Phase II efforts will utilize the process parameters developed under the Phase I program to develop full scale manufacturing parameters for prototypical vehicle hull sections and applique kits. Large scale manufacturing tooling will be identified and/or developed, materials acquired and facilities developed or contracted in order to perform full scale manufacturing studies. Mechanical characterization studies will be performed in order to determine the in-situ material properties in the near net shape manufactured part and quality control parameters will be developed to determine and minimize manufacturing variability. Once manufacturing variability is minimized, full scale prototypes will be formed and ballistically evaluated.

PHASE III: When the manufacturing process is matured, this technology can be utilized in the forming of seamless vehicle hulls resistant to underbody IED events and applique kits that can conform to the underside of an fielded platform. This manufacturing technology can be transitioned for the development of hulls for future tactical wheeled (JLTV) and combat (FCS) systems and/or applique mine kits for current combat or tactical wheeled vehicle (TWV) systems. As NASA is presently investigating manufacturing technologies for large, thin plate sections, it is envisioned that thick plate manufacturing technologies will also have use in aerospace applications. Large thick plate sections can be formed and then machined to final shape producing a seamless, near-net-shape part with integrated stiffeners.

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KEYWORDS: blast resistant, armor, manufacturing

A09-052            TITLE: Novel Variable Explosive Yield Concept

TECHNOLOGY AREAS: Weapons

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

OBJECTIVE: Design and build an explosively loaded item that can produce variable blast and/or fragmentation from the single item based on a user selectable input.

DESCRIPTION: The US Army is increasingly being asked to conduct operations in complex environments with friendly forces or noncombatants in relatively close proximity to targets. To minimize collateral damage, therefore, the performance of an ammunition item needs to be tuned to the level required for target defeat and not greatly exceed this requirement. While one solution to this problem is to carry multiple items with varying response, this solution increases the logistical burden on a unit and also limits the capacity of high performance items able to be carried, resulting in potential reduction of capability. A second solution is to provide the ability to vary the performance of a single item so as to increase the flexibility of the item against a range of targets. To this end, the US Army is looking for novel concepts that will produce variable blast levels and/or fragmentation from a single unit of explosive with minimal system integration impacts. The offerors shall propose such concepts and the methodology and plans for demonstrating the feasibility of the concept(s).

PHASE I: Develop a proposed conceptual design for an explosively loaded item, meant to simulate a hypothetical warhead, which would produce a minimum of two levels of energetic response from a single explosive charge. The metrics used to assess the energetic response should be blast (i.e. impulse) and / or fragmentation (i.e. velocity / size), see ref [1-2]. Phase I development is to be conducted as a white paper / modeling and simulation (M&S) feasibility study. The proposed concept and feasibility study should provide the technical foundation necessary to warrant progression to the Phase II demonstration of low and a high energy outputs, e.g. 50% and 100%.

PHASE II: Develop and demonstrate a prototype explosively loaded item, meant to simulate a hypothetical warhead, that produces a minimum of two levels of response from a single explosive charge. The demonstration must include a minimum of two separate tests, with the same explosive charge. The two separate test must result in low and a high energy outputs, respectively, as described through previous Phase I efforts. The resultant level of response should be ultimately dependent upon a user selectable input criteria. The size of the prototype is not constrained to a particular system as the technology may be applicable / restricted to specific sizes / systems, however the demonstrated item should fall within the medium caliber (e.g. 30 mm, or 40 mm) to large caliber (e.g. 105 mm, 120 mm or 155 mm) range of gun systems.

PHASE III: The technology developed under this submission has the potential to be appropriate within a wide range of US Army systems including medium caliber (e.g. 30 mm, or 40 mm) and / or large caliber (e.g. 105 mm, 120 mm

or 155 mm) gun systems. Potential commercial applications of the demonstrated technology would include demolitions, explosive forming, mining, or explosive drilling. In each of these applications, different levels of response are required for different operations / conditions.

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KEYWORDS: Variable Yield, Scalable, Warheads, Munitions, Explosives, Detonation, Blast, Fragmentation

A09-053            TITLE: Disruptive fibers and textiles for flexible protection

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

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 program is to develop novel fiber materials that will enable significant performance increases in flexible protection for the individual soldier. Research may include synthesis, processing, and physical/mechanical characterization of new fibers or innovative textile architectures as well as the associated manufacturing science necessary to provide confidence in scale-up of promising candidate materials. Although the long-term goal is for fibers and textiles for flexible armor systems, armor design and testing is not part of this topic but promising materials may be evaluated by the Army in notional armor concepts.

DESCRIPTION: High-performance textiles enable current body armor designs. Yet existing materials cannot achieve the performance requirements necessary for future personnel protection needs. A recent ARL/ARO workshop identified essential research needs for flexible protection. Research that developed new high-strength fibers was identified as critical research area. Also, research that advances fiber technology will also benefit new concepts for vehicle armor and composite materials for lightweight structures. The focus of this topic will be to design new fiber-forming materials and explore novel processing techniques to generate a revolutionary class of environmentally stable, high-strength fibers that will be relevant to flexible armor and other fiber applications of interest to the Army and DoD.

PHASE I: Phase I efforts should focus on the development of new fiber systems with significant property enhancements compared to existing aramid, polyethylene, and PBO baselines. Phase I efforts may include approaches such as the molecular design of new fiber chemistry and/or the utilization of novel nanoscale building blocks to create new fibers or hybrid fiber systems. The use of modeling and simulation to more rapidly identify and downselect promising chemistries, morphologies, and processing routes is encouraged. A review of the associated manufacturing processes, scalability, and limitations should be performed in preparation for potential Phase II research. At the conclusion of Phase I, the performers should identify potential fiber systems that will produce improved performance; demonstrate ability to synthesize and process lab-scale quantities of materials (tens of grams), and present data on relevant mechanical and physical properties of interest.

PHASE II: Phase II efforts will utilize findings from phase I results and address scale-up challenges in order to develop pilot-scale quantities of the fiber materials. Phase II research will perform rigorous materials characterization and testing to further refine structure, processing, property relationships necessary to assess performance of fiber system by the Army in relevant protection concepts. Likewise, manufacturing processes, equipment, and infrastructure will be identified, analyzed, and designed that enable the scale-up of building block chemicals, fiber precursors, and the fibers themselves. Pilot-scale production of the fibers will be demonstrated and kilogram quantities of fibers will be delivered to the Army for characterization and evaluation.

PHASE III: Once fiber systems have been developed with associated processes and validated materials data, this research can produce fibers for large-scale evaluation in notional armor systems for individual warfighters and/or ground/air vehicles. These materials can be directly inserted into one or more of the several DOD armor development initiatives or indirectly through DOD OEMs or their materials suppliers. Since there is an everpresent need for high-performance fibers in numerous defense and non-defense sectors there is tremendous dual use opportunity. In addition to their obvious use in protective garments for police/homeland security applications, one can easily see the use of these materials in case-containment technologies for advanced turbine engines used by the commercial air industry; reinforcement for elastomers used in tires; and lightweight composite materials used in the sporting goods, energy, and industrial/automotive sectors.

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KEYWORDS: advanced fibers; composites; personnel protection; body armor; nanotechnology

A09-054            TITLE: Full Field, Out-of-Plane Digital Image Correlation (DIC) from Ultra-High Speed Digital Cameras

TECHNOLOGY AREAS: Information Systems, Materials/Processes

OBJECTIVE: Design and develop a full field digital image correlation (DIC) system by designing software to integrate with ultra-high speed (equal or exceeding 1,000,000 frames per second) digital cameras to observe and quantify the deformation and failure process of armor and threats during impact and blast loading.

DESCRIPTION: For the past several years, commercially available digital image correlation (DIC) systems have proven to be a reliable technique to acquire the surface displacement/strain measurements of a material or structure under deformation. With the use of dual cameras in a stereo setup, full field out-of-plane measurements are achieved [1-4]. This relatively novel method has proved to be very successful in mapping out the strain tensor on a surface. However, this technology is limited by either in spatial or temporal resolution due to the limitations of current high-speed digital camera technology. As to date, this technique is not adequate to offer any usefulness for experiments conducted on the split-Hopkinson pressure bar (SHPB) apparatus, high-rate Brazilian experiments, Taylor impact tests and blast experiments. [5-8]. These high rate experiments are extensively used at the Weapons and Materials Directorate (WMRD) of the Army Research Laboratory (ARL) to characterize the dynamic behavior of materials of interests for the Army's development of material models to provide accurate computer simulations of impact and blast events. For example, such data are essential for validating simulation efforts on events such as IED (improvised explosive device) and mine blasts of vehicles. The desire to verify or calibrate FEM models has been driving the need for full field deformation and strain data. This challenging application will require innovative solutions to address both the simultaneous acquisition of suitable image data at extremely high rates as well as solutions to optimally process the image data to obtain reliable three-dimensional position and deformation maps. This topic addresses the need for accurate non-contact deformation measurement with high spatial and temporal resolution

PHASE I: Develop concepts for a software/hardware camera system to acquire three-dimensional quantitative deformation data from an impact event with image resolutions of at least 300 x 200 pixels at framing rates of 1 MHz or higher. At the end of Phase I, provide a report containing the feasibility study of the proposed system and the design concepts.

PHASE II: During Phase II, the Contractor shall design and integrate the software and hardware concepts from Phase I to build a prototype high-speed digital image correlation system. The software development shall include comprehensive camera interface-control and integrated calibration features. The Contractor shall establish performance parameters of the system through experiments in an impact-testing laboratory at WMRD facilities in Aberdeen Proving Ground (APG), MD to demonstrate the viability of the prototype to measure deformation and failure process in impact studies under these laboratory conditions. Demonstration should include the ability to capture the deformation and failure process of brittle materials in SHPB, Brazilian and Taylor tests. At the end of Phase II, the final prototype with documentation of the design and the user manual shall be delivered to the Army research engineers at APG for evaluation and validation under ballistic impact conditions, at the outdoor gun ranges at APG. Delivery also should include a report containing the laboratory evaluation process.

PHASE III: The transition of this DIC technology into a robust, turnkey "commercially-available" system will provide significant data in greater detail and more importantly the nano to micro seconds time intervals to verify and calibrate the development of high performance FEM models. The success of this SBIR topic will make available a tool for DoD, other Government agencies (i.e. FAA, DHS), National Labs (i.e. Sandia, Los Alamos), Academia, and Defense Contractors to have an immense impact on the work by giving the ability to investigate the dynamic behavior of materials and structures for armor, penetrator, and blast protection. In addition, the Automotive Industries can use this technology to assist in the studies of vehicle structure collisions/damage, and thus will have the ability to improve the designs of automotive systems.

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KEYWORDS: digital image correlation, dynamic deformation

A09-055      TITLE: Versatile Micro/Nano-mechanical Load Frame For In Situ Studies

TECHNOLOGY AREAS: Air Platform, Materials/Processes

**OBJECTIVE:** Design and develop a versatile micro /nano-mechanical load frame for integration with commercially available microscopy systems

**DESCRIPTION:** Development of novel bio-inspired materials technologies, including polymer-based nanocomposites and micro- to nanoscale fibers, requires the ability to characterize complex organic materials over multiple length scales, from macroscopic scales down to the nanometer scale. One aspect of biological materials of importance to the Army involves their protective capabilities regarding the dissipation of mechanical energy. The ability to test materials at larger length scales has been demonstrated for years, including the characterization of the mechanical properties and behavior of polymer composite materials. However, critical energy dissipating mechanisms in biological materials, nanocomposites, fibers and other emerging materials technologies occur at micrometer and nanometer length scales. Characterization of such processes has been demonstrated only on a very limited scale by a few different academic groups, and typically only for inorganic materials (i.e., metals and ceramics). However, with the continued improvements in high resolution microscopy (e.g., electron and scanning probe microscopies) of polymeric and biological materials combined with improvements in force and displacement transducer technologies (low force / small displacement sensitivities / resolutions, signal-to-noise ratios, etc.; for example, those developed for nanoindentation systems), commercial viability appears to exist. In addition, recent efforts in the academic community have started to address some of the important aspects of implementing digital image correlation and related techniques at micrometer and nanometer length scales, including sample preparation, stable random micro/nanoscale pattern generation, and analysis issues. Commercially available systems are thus needed to enable this capability broadly across academic, government and industrial research sectors. Specifically, versatile load frames capable of applying and measuring forces and displacements to small volume samples (i.e., at micrometer and nanometer scales) under a variety of loading conditions (e.g., tension, compression, bending, shear) are required. Such a system must be capable of being used in conjunction with commercially available high resolution imaging systems (e.g., optical microscopy, scanning electron microscopy, atomic force microscopy) to visualize deformation and utilize image correlation techniques for creating strain maps on polymeric and biological materials.

**PHASE I:** Determine issues that are commonly associated with mechanical characterization of polymeric and biological materials at the micro/nano length scales. Describe the approaches for the development of a versatile loading frame or set of frames that can be incorporated into microscopy systems to investigate deformation and failure of polymeric and biological materials under different stress-states, such as tension, compression, bending and shear, by measuring deformation and stress fields in micrometer to nanometer scale regions. Micrometer and nanometer scale regions, for the purposes / scope of this SBIR topic, are defined as regions with lateral dimensions of 0.5-200 micro-m and 1-500 nm, respectively. Microscopy systems of particular interest for integration of such capabilities include a Veeco Dimension 3100 Scanning Probe Microscope, a Zeiss LSM 500 Laser Scanning Confocal Microscope, and FYI Lowvacuum/environmental scanning electron microscopes (e.g., XL30 and Nova 600). Also, define the calibration processes and other procedures for minimizing experimental artifacts and uncertainties. At the end of Phase I, provide a report containing the feasibility study of the concept(s) for the loading frame and related software, including the needed test fixtures and their engineering drawings. The concept(s) should strive to achieve a high degree of modularity regarding use across multiple microscopy platforms, use to assess mechanical behavior over a range of length scales, and ability to test a variety of specimen geometries under different loading conditions / geometries. Such concepts could incorporate, for example, a set of interchangeable transducers with defined force-displacement ranges with a corresponding set of fixtures for particular sample / loading geometries.

**PHASE II:** During Phase II, the Contractor shall design and integrate the software and hardware concepts from Phase I to build a prototype micro/nano-level load frame device. The Contractor shall establish performance parameters of the prototype through experiments on class of microscopy systems identified in Phase I portion to demonstrate the viability of the prototype to measure forces and deformation of samples with sizes commensurate with what would normally be utilized with the microscopy system. Results of these experiments must be compared to results from standard techniques from published literature as well as results supplied by the Army research engineers. At the end of Phase II, documentation of the design of the prototype and a report containing the laboratory evaluation processes with the results shall be delivered.

**PHASE III:** The final prototype with documentation of the design and the user manual shall be delivered to the Army Research Laboratory engineers at APG, MD for further evaluation with experimental set-ups and experiments

relevant to the Army engineers. The success of this SBIR topic will make available a research tool for DoD and other Government agencies (i.e. NIH, Walter Reed Medical), National Laboratories (i.e. Sandia, Los Alamos), Industry and Academia to have an immense impact on studying biological and bioinspired materials as well as other materials having nanoscale and/or multiscale structural features that are important to the material's properties, behavior and function. The ability to characterize materials at these length scales will offer an increased understanding of fundamental structure-property relationships that will enable the design and optimization of next generation protective and multifunctional materials. More importantly, this will enhance the world-wide application of existing microscopy systems for studying the small length scale behavior of polymeric, biological and bio-inspired materials under different types of mechanical loading conditions.

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KEYWORDS: microscopic loading system, bio-inspired materials, micro scale testing, nano scale testing, AFM, SEM, DIC

A09-056 TITLE: Photonics-enabled Radio-Frequency Arbitrary Waveform Generation

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: To develop a robust radio-frequency (RF) arbitrary waveform generator that uses photonics to generate programmable burst arbitrary RF electrical signals at instantaneous bandwidths beyond those offered by pure electronic solutions. Applications include ultrawideband wireless communications, electronic warfare, test and measurement, and impulse radar and ranging.

DESCRIPTION: Limits in digital to analog converter technologies hinder the development of electronic generators for signals with very wide instantaneous bandwidth. Commercial electronic solutions provide a maximum of 5 GHz analog bandwidth. Furthermore, such solutions are subject to electromagnetic interference and are not suitable for placement in harsh environments. Recent research has demonstrated a photonic approach for programmable generation of arbitrary burst radio-frequency electrical waveforms with instantaneous bandwidth well beyond the limits of today's electronic solutions [1-11]. This approach is compatible with fiber remoting, such that the photonic control module may be placed at a distance from the electrical generation point and connected via fiber optics. Such very wide instantaneous bandwidth arbitrary waveform generation enables new systems concepts in impulsive RF systems.

For example, the dispersion of RF components, such as antennas, often becomes important when such components are excited by large fractional bandwidth RF impulses. This results in substantial broadening and distortion of impulsive drive waveforms. Electrical arbitrary waveform generation allows realization of waveform families useful for direct time-domain sensing of such dispersion [11] and of predistorted drive waveforms that compensate such dispersive effects. Recent research has demonstrated that such waveform precompensation allows substantially shorter pulses to be delivered through a broadband, dispersive antenna link [8, 10]. In essence, chirped input signals are compressed by the dispersive antenna pair. Moreover, similar to chirped radar, received voltage levels normalized to peak drive voltage level are significantly increased. This leads to prospects for simultaneous enhancement in detectability and range resolution in impulse radar. Similar pulse compression concepts may be helpful in overcoming peak power limitations in RF transmitters to increase peak radiated power for electronic warfare applications. Additional applications of photonics-enabled radio frequency arbitrary waveform generation include synthesizing signals with desired spectral content, e.g., to optimally fill an allocated frequency band [7], new approaches to testing of travelling wave tube amplifiers, and code generation for realization of ultrawideband, code-division multiple-access wireless networking.

In order to pursue such opportunities, further development of photonics-enabled radio-frequency (RF) arbitrary waveform generators is desired. This technology should be realized in a robust optical package that is immune to polarization fluctuations common in systems involving fiber optics. The ability to scale the instantaneous bandwidth from approximately 10 GHz to approximately 40 GHz while maintaining arbitrary programmability and time-bandwidth products on the order of 50 or more should be demonstrated. Peak voltage levels, limited to several hundred millivolts in published research, should be increased. Additionally, because photodetectors respond to optical intensity, current photonics-enabled radio-frequency (RF) arbitrary waveform generators provide only a unipolar output, with a large baseband peak in the RF spectrum. Innovative approaches are desired to realize bipolar waveform generation capability and elimination of the baseband RF spectral peak.

PHASE I: Phase 1 of the program should demonstrate proof-of-concept of increased voltage levels from the photonics-enabled radio frequency arbitrary waveform generator. Options for a polarization-insensitive realization should be determined, and at least one means to eliminate polarization-sensitivity should be assessed theoretically, and experimentally demonstrated if possible.

PHASE II: Phase 2 of the program will demonstrate methodologies to realize bipolar voltage waveform capability and to scale operation bandwidth in the range 10 to 40 GHz. In addition, demonstrations are required for simultaneous polarization insensitive operation, bipolar waveform generation, and increased peak voltage levels, with arbitrary programmability and time-bandwidth product exceeding fifty.

PHASE III: The proposed research and development is expected to lead to advanced photonics-enabled radio frequency arbitrary waveform generators in the form of packaged modules that are sufficiently robust for realizing laboratory and industrial applications. Therefore, this new technology will lead to practical testing in one or more military-relevant applications areas that spans subjects such as: impulse radar, electronic warfare, test and measurement and/or battlefield wireless communications. This technology will also afford private-sector commercialization opportunities such as: wireless local area network (LANs), cellular communications, and remote spectral sensing, just to name a few.

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KEYWORDS: radio-frequency arbitrary waveform generation, photonics

A09-057 TITLE: Ultraviolet photodetectors based on wide-bandgap oxide semiconductors

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop ZnO based UV photodetectors for the solar-blind detection window of 265-280 nm for various military applications.

DESCRIPTION: The photoresponse of current solar blind detectors (SBDs) is not sufficient for many applications where UV light needs to be sensed. Solar blind photodetectors are specified to the 265-280 nm region of the ultraviolet spectrum and require greater than several hundred milliamps per watt of photoresponse to replace photomultiplier tubes (PMTs) or other semiconductor based SBDs. ZnO (zinc oxide) and its alloys, e.g. (Be, Mg)ZnO, are sought for application to high responsivity photodetectors. (Be,Mg)ZnO alloys have been reported by some groups for application in this regime [1]. Current DARPA programs on SBDs include silicon carbide based APDs (avalanche photodiodes) and GaN based alloy SBDs which have not met the requirements for replacing PMTs. As a highly efficient photoluminescent material, ZnO holds promise for these requirements based on recent development of BeZnO and MgZnO alloys.

PHASE I: Demonstrate (Be,Mg)ZnO semiconductor alloys of high optical quality with optical bandgap of approximately 280 nm for solar blind detection regime with wavelength cutoff  $> 100$  nm for solar blind window region. Also, demonstrate doping and contact formation needed for the complete UV photodetector. Absorption data, contact resistance data, and p-doping should be measured and included in reports.

PHASE II: Develop high responsivity solar-blind photodetectors (265-280 nm) for military applications. Performance goals should be those to surpass current SBDs with approximate photoresponse of 200 mA/W. Approaches to be investigated could include standard p-n junction photodetectors or avalanche photodetectors. Solar blind photodetectors should be delivered to ARL for evaluation (after evaluation the photodetector(s) - one or more - may be returned if desired). Also, if photodetectors were developed in bands outside the 265-280 nm window they should be delivered for comparison - one in each cutoff wavelength band -  $< 265$  nm,  $< 280$  nm,  $< 300$  nm, etc. to 385 nm, every 20 nm interval.

PHASE III: Military applications include UV non-line of sight (NLOS) optical communications, bio-warfare agent detection, missile detection from plume signatures, and other spectroscopic UV signatures. Dual-use (civilian) applications include biosensing and bio-agent detection, flame detection, determination of engine combustion efficiency, atmospheric ozone studies, and astronomical studies.

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KEYWORDS: Zinc Oxide, photodetectors, solar blind, ultraviolet

A09-058 TITLE: ZnO alloy based LEDs and laser diodes

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: To develop ZnO alloy based light emitting diodes and semiconductor lasers for sensing, lighting and displays.

DESCRIPTION: The ZnO semiconductor presents opportunities to develop new blue/UV lasers and light emitters which could surpass the performance of currently available LEDs and lasers based on GaN. The bandgap of ZnO is 3.4 eV (365 nm) and its related alloys cover a large bandgap range: in green/blue/UV with Cd (CdO – 2.4 eV) and Mg (MgO – 7.8 eV). High crystalline quality ZnO with very low defect densities can be demonstrated. Other advantages of ZnO include: low growth temperatures, availability of high-quality lattice matched substrates [1], and possibility of self-assembled nano-structures. Its high exciton binding energy of 60 meV leads to strong excitonic recombination at room temperature. This greatly enhances efficiency of radiative recombination and thus the optical gain. Under optical pumping, ZnO and related materials have demonstrated strong photoluminescence. Optically excited UV laser arrays have been demonstrated in self-organized ZnO-nanowires [2]. However, the development of ZnO based electroluminescence device was hampered due to the lack of p-type material. Recent advances in p-type doping ability [3] and Cd and Mg alloy growth [4] of ZnO semiconductors are indications that p-n junction LEDs are ready to be attempted.

PHASE I: Develop stable, high concentration ( $>1e18\text{ cm}^{-3}$ ) p-type doping of ZnO semiconductor epilayers and demonstrate electroluminescence of p-n junction light emitting diode. P-type doped samples should be delivered to ARL for evaluation (samples may be returned upon request) - one or more samples with the highest achieved p-doping (within a factor of approximately 2) and an area at least equal to 5 mm x 5 mm. The stability, repeatability and uniformity of doping should be examined and reported.

PHASE II: Develop p-n junction LEDs and lasers based on ZnO alloys at and around 3.4 eV. Develop alloys and heterojunction LEDs using Mg, Cd ternary semiconductors for emission in the visible (~400-550 nm) and UV (<260-400 nm) regime for military and commercial applications which include solid state lighting, UV non-line-of-sight communications, bio-agent detection and water purification. LEDs and lasers should be delivered to ARL for evaluation (and may be returned if requested after evaluation). One or more LEDs and lasers at each wavelength band - green, blue, UV >300 nm and UV < 300 nm should be sent. (damage may occur during testing due to electrostatic discharge, other natural device burnout, or accident).

PHASE III: Dual Use Applications: Manufacture blue and UV LEDs and Lasers (possibly white light LEDs) for application to several defense and civilian industries. Military applications include covert (non-line-of-sight) optical communications and bio-agent detection. Civilian applications include solid-state lighting and optical data storage. Another area of large impact is displays.

#### REFERENCES:

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2. P. D. Yang, "From nanowire lasers to quantum wire lasers", Proceedings of the SPIE - The International Society for Optical Engineering, v 5349, n 1, 2004, 18-23
3. J. L. Liu, F. X. Xiu, L. J. Mandalapu, Z. Wang, "P-type ZnO by Sb doping for PN-junction photodetectors", Proceedings of the SPIE - The International Society for Optical Engineering, v 6122, 9 Feb. 2006, p 61220H-1-7.

4. A. V. Osinsky, et. al. "ZnCdO/ZnMgO and ZnO/AlGaIn heterostructures for UV and visible light emitters", Progress in Semiconductor Materials V-Novel Materials and Electronic and Optoelectronic Applications (Materials Research Society Symposium Proceedings Vol.891), 2006, p 371-9.

KEYWORDS: ZnO, LEDs, blue semiconductor lasers, UV semiconductor lasers

A09-059      TITLE: The Energetics of Cognitive Performance: Regulation of Neuronal Adenosine Triphosphate Production

TECHNOLOGY AREAS: Biomedical, Human Systems

ACQUISITION PROGRAM: NA

OBJECTIVE: To optimize neuronal adenosine triphosphate production capacity.

DESCRIPTION: The modern Army is constrained by mitochondria. Mitochondria are the batteries of eukaryotic cells, and mitochondrially produced ATP is the energy that enables cognitive and physical performance in multicellular organisms. Mitochondrial insufficiency due to aging is directly correlated with reduced ATP production which in turn reduces physical and cognitive performance capabilities in humans. Highly qualified and very experienced soldiers regularly leave the Army because their physical and/or cognitive performance capabilities are significantly less than that of a 20 year old. Although people older than 42 are not eligible to join the Army, little has been done to reduce the effect of old mitochondria on DoD capabilities. At present, individuals attempt to counter their mitochondrial decline with frequent exercise and antioxidants, both of which are crude methods with limited effectiveness. A more precise methodology to stimulate mitochondrial energy production when needed would improve soldier cognitive and performance capabilities, and extend the time that soldiers remain fit for duty.

The past twenty years have seen a revolutionary breakthrough in understanding how mitochondria function. Human mitochondria are a network of approximately 2,000 proteins, exquisitely integrated into a larger network of approximately 100,000 cellular proteins, and again functionally integrated into a larger network of 3 billion cells. Sequence data is available for both the human nuclear and the mitochondrial genome. The biochemical basis of oxidative phosphorylation is well understood and genetic polymorphisms leading to altered energetics and performance capabilities are well documented. The scientific understanding and the technology to develop high throughput screening to identify and characterize compounds that improve neuronal adenosine triphosphate production is now feasible.

PHASE I: Design, construct, develop, and demonstrate the feasibility a high throughput system to identify compounds that increase adenosine triphosphate production in neurons.

PHASE II: Identify compounds that have stimulatory effects on neuronal adenosine triphosphate production and are capable of crossing the blood brain barrier. Identify and characterize the mechanism of action for lead compounds using genetics, genomics, bioinformatics, and/or biochemical approaches. Select one prototype compound for pharmaceutical production and FDA approval.

PHASE III: The "vision" is a warfighter force with improved energetic capabilities; this is analogous to replacing zinc carbon batteries with silver oxide batteries – more energy production capacity will enable the warfighter to sustain demanding cognitive or physical activities longer. The expectation is that the product coming out of this phase II research would transition directly to a small or large biotechnology or pharmaceutical company that would sell the product to warfighters. As vast numbers of civilians are old, substantial civilian interest is also anticipated.

#### REFERENCES:

1. Balaban, R.S. Nemoto, S., and Finkel, T. 2005. Mitochondria, oxidants, and aging. Cell 120(4):483-95.
2. Beal, M.F. 2005. Mitochondria take center stage in aging and neurodegeneration. Ann Neurol 58(4):495-505.

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9. Navarro, A., and Boveris, A. 2004. Rat brain and liver mitochondria develop oxidative stress and lose enzymatic activities on aging. *Am J Physiol Regul Integr Comp Physiol* 287(5):1244-9. Keywords: mitochondria, oxidative phosphorylation, adenosine triphosphate, neurons, ATP.

KEYWORDS: mitochondria, oxidative phosphorylation, adenosine triphosphate, neurons, ATP, HTS

A09-060            TITLE: Virtual RF Environment

TECHNOLOGY AREAS: Sensors, Electronics

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

OBJECTIVE: Develop a Virtual Radio Frequency (RF) Environment for testing Command, Control, Communications (C3) systems. Testing the large tactical C3 systems requires fielding hundreds of nodes and providing thousands of signals/messages to meet the operational requirements. This is very expensive and often the large numbers of systems are not available. This virtual environment would allow a few representative C3 systems to be immersed in an environment of hundreds of virtual emitters and exercised through various scenarios of operation. This virtual environment must interact with real radios/communications systems to stress them as they would be in the real world.

DESCRIPTION: Testing mobile ad hoc networks requires a creative and innovative approach to interfacing tactical communications systems with hundreds of modeled systems in a virtual environment. This virtual environment will be a controlled and isolated domain to play out various scenarios and "what if" contingencies with a limited number of real assets. The received signal levels will be based upon RF propagation calculations.

Existing RF propagation models (0 Hz to 100GHz) will be used to determine the proper signal level to be presented from each transmitter to each receiver on its network for each unique propagation path. These calculations will be based upon distance, frequency, modulation, terrain, multi-path urban canyons and weather. Real-time adjustments will be needed to replicate the effects of movement,. The goal of this project is to interface a number of real communications systems with the virtual environment and provide what if scenarios to improve testing and test planning.

The development effort is primarily in the interface of the virtual world with a complex scenario played out to a small number of real communications systems such that they perceive it as reality. The development effort is to create a method of distributing a signal from a transmitter to each receiver in its network at a unique calculated level and perform this for many transmitters simultaneously without interfering or affecting the proper signal level and reception at the other receivers. The overwhelming complexity is in each "real" system receiving signals at the appropriate levels from the real systems and multitude of virtual ones. An additional benefit is the ability to expose the real systems to signals or scenarios that could not be allowed in the public domain due to classification or frequency authorization limitations.

The solution product will need to be able to compare attributes, accuracy, validation, and the sensitivity of output to changes in variables used in calculations. The solution will need to simulate antenna arrays - transmit or receive antennas may be on ground, in the air, on water or under water. As well, characteristic features of the host platforms will need to be modeled since these platforms could be constructed of metal, composites or other materials. The solution must also address how it will be validated to ensure the results will be accepted in Government test programs.

PHASE I: Develop and present a methodology for developing the virtual RF environment and interfaces to tactical C3 systems. The contractor shall develop a phased technical and programmatic approach identifying time, schedule and resources to produce this interactive virtual RF environment.

PHASE II: Implement the plan from Phase I and develop, demonstrate, and validate the modeling/simulation environment with control of and interaction with typical C3 systems, and delivery of a functional prototype system that can be scaled up to provide 100 virtual systems and interface to 7 real systems.

PHASE III: This system could be used with a broad range of military and civilian communications systems to provide testing in a controlled and isolated environment. This prediction capability would provide more robust and accurate transmission and reception planning for military or civilian activities.

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2. NTIA Report TR-07-449; Propagation Loss Prediction Considerations for Close-In Distances and Low-Antenna Height Applications; July 2007; Nicholas DeMinco
3. NTIA Report TR-04-407; Relative Propagation Impairments Between 430 MHz and 5750 MHz for Mobile Communication Systems in Urban Environments; December 2003 Peter Papazian, Michael Cotton
4. NTIA Report TR-00-371; Radio Link Performance Prediction via Software Simulation; October 1999; Edmund A. Quincy, Robert J. Achatz, Michael G. Cotton, Michael P. Roadifer, and Jeanne M. Ratzloff
5. Patent number: 5886626; Filing date: Oct 1, 1997; Issue date: Mar 23, 1999. Inventors: Mark W. Hynes, James L. Cole, Barry C. Miller, Scott A. Morris, Robert E. Reiner; Assignee: The United States of America as represented by the Secretary of the Army.

KEYWORDS: RF propagation, modeling and simulation, antenna and host platform, networks, virtual

A09-061            TITLE: Compact, Robust, Real Time, High Capacity Data Storage for test Instrumentation

TECHNOLOGY AREAS: Information Systems, 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 and demonstrate a ruggedized and miniaturized real time data storage device with increased storage capacity utilizing Holographic Memory Cube (HMC) technology that is capable of operating reliably within a multitude of testing environments ranging from Laboratory to Operational Testing.

**DESCRIPTION:** In recent years Holographic data storage devices have become commercially available and Nintendo has even used this technology in some versions of their video games. Although they do offer many advantages these devices have limitations that prohibit their use in field data recording applications. Current devices use spinning disc, similar to CD/DVD, media which requires mechanical methods to position the media and focus the lasers. Also the storage capacity is limited at 1 Terabytes which is too low for many data intensive applications.

Holographic Memory Cube (HMC) technology promises all of the advantages of the currently available Holographic storage devices and resolves the limitations. Since HMC devices will use electronically steered laser, there are no moving parts and an HMC device will be less susceptible to vibration. HMC devices will have capacities approaching 10 Terabytes on a media about the size of a sugar cube. There are currently no HMC devices available commercially.

The current generations of test instrumentation devices use solid state, optical or magnetic data storage technologies all of which have capacity limitations that can seriously impact data collection. The amount of data generated during testing is ever increasing and the test community is in need of innovative methods to capture and store larger amounts of data. HMC storage offers the advantages of high storage capacity and quick data access all within a potentially small footprint.

The Test Resource Management Center (TRMC) Test & Evaluation/Science & Technology (T&E/S&T) programs recently concluded an effort to research and demonstrate HMC technology. The HMC was successfully demonstrated in a laboratory environment with a storage capacity in excess of 1 Terabytes on a brassboard measuring 9”X7”X5”. A non-erasable photorefractive crystal was used as the storage media and the data writing transfer rate exceeded 1.5 Gigabits/sec. Power consumption for the brassboard prototype was 25 Watts. Although the T&E/S&T effort demonstrated the potential for HMC technology, significant research and development needs to be accomplished in order to ruggedize an HMC device and it’s components, miniaturize an HMC device to a practical and useful size, and to increase the storage capacity beyond what has currently been demonstrated.

The current state of HMC storage technology does not support use in Test and Evaluation field data recording applications. Research and development will need to be conducted to reduce the volume of the storage device, the power consumption and the vibration sensitivity. Research and development will need to be conducted to develop or identify a high frame rate CMOS sensor array to further increase storage capacity. To satisfy security requirements the storage media needs to be erasable so research will have to be conducted into alternative storage media(s). Development efforts are needed to interface the HMC storage device to current instrumentation.

This SBIR effort will include research and development work to reduce the footprint, ruggedize and increase the storage capacity of the HMC technology beyond what is currently available in holographic data storage. This will enable HMC’s practical for use in test instrumentation. The design shall be capable of operating on 12/24 VDC power and interfacing to existing instrumentation through IEEE 1394 (Firewire) and Serial Advanced Technology Attachment (SATA) II connections. The proposed solution shall be capable of meeting the requirements for storing classified data. The desired characteristics of the proposed solution are 8 Terabytes of storage capacity, less than 10 Watts power consumption and maximum volume of 25 Cubic inches or less.

This topic primarily supports the Information Systems Technology technical area. Although ATECs interest is focused on Test and Evaluation instrumentation, the goal of this topic is to produce a high capacity data storage device that utilizes common, standard interfaces. The device will be compatible with Instrumentation systems and virtually all IT systems, both military and commercial, such as computer systems and digital video recording systems.

This topic will also support the Electronics Technical Area. The research done for the CMOS sensors could benefit and support current or future research in optical sensors. Potential applications could be improved guidance systems

and target recognition systems. The research into crystal storage media could benefit current or future efforts into electro-optics and optical materials.

**PHASE I:** This phase will consist of an investigation and feasibility study of HMC technology to determine the effort required to develop a ruggedized, miniaturized, and increased capacity storage device that can be integrated into test instrumentation. The study will include an analysis of the performance characteristics that can be achieved with ruggedization and miniaturization. The storage capability must be able to perform within an Operational Testing environment and must be suitable for storage of classified data. Deliverables for this phase will be a report detailing the results of feasibility study for developing a ruggedized, miniaturized device that has an increased storage capacity beyond what has been previously demonstrated using HMC technology.

**PHASE II:** Phase II will consist of developing and demonstrating a ruggedized, miniaturized, increased capacity prototype storage device capable of operating in a realistic testing environment. The prototype device shall be capable of interfacing to the current inventory of test instrumentation systems as well as data reduction systems. Deliverables for this phase will include a prototype storage device and comprehensive report detailing the results of prototype testing and the device capabilities and limitations.

**PHASE III:** Potential applications include any commercial or military systems that need to store large quantities of data in extreme environments such as flight data recorders and land or sea vehicles systems. The high capacity and quick access time will also benefit vehicle systems that require access to extremely large databases such as GPS mapping systems and terrain databases.

Two references are included for this topic. The first is an article from the ITEA Journal of Test and Evaluation which details the early research done by the Jet Propulsion Laboratory into Holographic Memory. The second reference is the final report for the TRMC T&E/S&T R&D effort to expand on previous research into HMC technology.

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1. The ITEA Journal of Test and Evaluation, Volume 24, Number 2; High-Density High-Speed Holographic Memory for T&E of Next-Generation Embedded instrumentation Weapon Systems; June/July 2003; Dr. Tien-Hsin Chao, Dr. Robert Stirbl, Dr. Hanyin Zhou, George Reyes and Dr. Jan Hanan, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California.
2. Final Project Report, Holographic Memory Cube Upgrade Task, 28 February 2008, Tien-Hsin Choa, Jet Propulsion Laboratory and Jim Cutler, White sands Missile Range.

**KEYWORDS:** Holographic, DataStorage, Instrumentation, Memory Cube

A09-062      **TITLE:** Causality & Prediction of Radio Frequency Encroachment on Test & Training Ranges

**TECHNOLOGY AREAS:** Sensors, Electronics, Weapons

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

**OBJECTIVE:** The model and methodology developed will be used to predict the RF environment or ambient in three dimensions as it changes over time across the RF frequency spectrum. Current RF predictive tools and methodologies are single dimensional in nature (point to point propagation loss prediction) from a single source (transmitter) to a single destination (receiver). When multiple sources are involved with a single receiver, additional single dimension propagation loss calculations are made.

Unlike the single dimensional nature of current models and methodologies, the product of this SBIR will address the three dimensional composite effect of human caused deliberate and unintentionally produced RF (to include secondary radiators such as power lines, fences, and metal towers). The impact of multiple variables such as, but not limited to: transmitter power, vehicular/machine noise, multi-path, grounding, bonding, signal phase addition and subtraction, building construction techniques (commercial, industrial, private home) and physical terrain will be considered.

The methodology and model will be used to predict the impact of urban, suburban, rural, aviation, harbor encroachment on the RF environment at any location on Earth. Models external to this effort will use the products of this SBIR to determine the impact of the RF environment produced by human activity on the ability of the military to operate, train and test anywhere in the world, on or above ground. The model/methodology will be validated using empirical data collected in an environment with low existing RF and low density of signals.

This topic will result in a new and innovative methodology and model for determining the adverse effects of human development, in the military, industrial and private sectors on testing and operations. It will permit the Army and DOD to better prepare for testing and operations involving the electromagnetic spectrum world wide. A successful solution to this problem will provide the ability to analyze, understand causality, and predict the intensity of background RF noise across the entire electromagnetic spectrum so one can determine its adverse effects on testing and operations in said electromagnetic environment.

**DESCRIPTION:** The methodology/model produced by this effort will permit the prediction of RF noise at any location on or above the ground across the RF spectrum at any given time. The methodology will be able to predict the RF noise generated from human development ranging from cities such as New York, Bagdad, or Jakarta, suburban development around such cities, and rural environments such as Southwestern United States, Afghanistan, or the Amazon interior. This effort will initially support open air testing of C4ISR systems on a Major Range Test Facility Base (MRTFB) by predicting the background noise received and the causality for that RF background noise. Understanding the causality, attenuation, and spectrum density of that noise at any three dimensional location over time, will permit the prediction of radio performance across the globe based upon testing in a quiet electromagnetic environment. This same methodology can be used to predict the impact of encroachment on a quiet RF environment. Due to the nature of RF propagation, the predictions produced by this model/methodology are expected to be statistical in nature with a narrow range of standard deviations for each three dimensional point and frequency rather than discrete numerical prediction.

Single sources of RF are relatively easy to predict and locate using existing technology to collect empirically and propagation models to predict. This is the result of extensive research over the years designed to predict propagation loss, single source interference and signal levels for use in the design of communication systems and links. The methodology and modeling of the cumulative effects of multiple deliberate and unintentional RF sources caused by human development is significantly different. Unlike the single focused RF communication link over profiled terrain, the RF noise generated by human activity occurs in a variety of settings, from a variety of directions with a cumulative effect. These settings include urban, suburban, rural human habitats intermixed with commercial and industrial environments on the RF environment has yet to be accomplished. Currently the empirical measurement of the RF environment will show that increased RF background noise can be correlated with the density of human development. The causality of the increased RF noise is not understood nor is it understood as to what the impact or sensitivity of variables associated with development have on the increase in RF background noise. Variables that are known to impact the RF environment are intentional RF sources such as television and radios, as well as the operation of electronics and machinery, building construction materials and methods – to include the grounding and bonding of metal objects/wiring/cables used in construction or to provide electricity or signals, antennas, electrical power generation, computer systems and networks, vehicle operation, and road construction to name only a few.

**PHASE I:** The successful offeror will develop the methodology and associated mathematics to predict the three dimensional RF background noise over time. A sensitivity analysis of mathematical variables used in the calculations will be conducted. Using the mathematical methodology, a computer model of the RF environment from 200 MHz thru 30 GHz will be created capable of predicting the RF ambient as influence by human development. Using a quiet and controlled RF environment, which is surrounded by a low density of human development, the model's predictions of RF noise and the causality of that noise will be demonstrated and validated

using empirical data collected at 5 randomly selected points, across 10 randomly selected frequencies. The software will operate on a state-of-the-art desktop computer.

PHASE II: Based upon inputting the density of human development in the form of housing, businesses, and industry, the model will be evolved to predict the RF noise environment that encapsulates an area of 100 square miles over a spectrum from 2 MHz thru 50 GHz. 50 points will be randomly selected (each environment) on a military range, a rural, suburban, urban development setting within the United States. Spectrum density and intensity will be predicted and validated as well as its causality using empirical measurement. Easy to understand graphical output will be produced.

PHASE III: Should the effort prove successful, phase three product is expected to require a non-engineer to input details regarding density of human development in the form of housing, businesses, and industry, with the model predicting the RF noise environment. Depending upon the requirements of phase three, the methodology could expand to include additional frequencies, geographical area or a combination of both. User friendly software, manuals, user training, and detailed documentation is expected to be produced in this phase (if approved/funded) that will permit an electrical engineer working in a commercial or military environment with limited background in electromagnetics to effectively operate the product to predict the background noise and the minimal signal detectable at a given point world wide.

#### REFERENCES:

1. The Arizona Military Regional Compatibility Project, Fort Huachuca Joint Land Use Study (JLUS)

Can be found at:

[http://www.azcommerce.com/doclib/commasst/ft%20huachuca/ft%20\\_huachuca\\_jlus\\_final\\_report.pdf](http://www.azcommerce.com/doclib/commasst/ft%20huachuca/ft%20_huachuca_jlus_final_report.pdf)

The land use study is provided to describe typical issues related to the occurrence of electromagnetic interference that frequently occur in testing as areas become more developed AND to indicate the issues that can arise when an item is taken from a test range to an area where there is a higher concentration of emitters, NOT as a call to develop a baseline. Good experimental design requires only ONE variable to be changed at a time, and the encroachment of developed areas closer to test ranges can force testing to be relocated in order to have suitable test conditions. There is the need for adequate standoff in testing to ensure that the number of confounding variables are minimized, and preferably eliminated. Standoff distance will vary with the concentration and power of RF devices employed, and the Army needs the capability to be able to calculate this distance, to support test planning and ensure operational reliability.

KEYWORDS: EMI, electromagnetic sources, commercial environment, business development, commercial development, encroachment

A09-063            TITLE: Chaotic Modulation for Satellite Communications (SATCOM) Communications Systems

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: To develop a chaotic signal modulator and demodulator suitable for use in satellite communications (SATCOM) systems. To adapt chaos modulation methods such as Chaos Shift Keying (CSK), Differential Chaos Shift Keying (DCSK), Additive Chaos Modulation (ACM), and Multiplicative Chaos Modulation (MCM) to SATCOM systems. To compare bandwidth and waveform efficiency of chaotic signal systems with current standard modulation methods.

DESCRIPTION: While Army and DoD communication waveform technology has been evolving, SATCOM modulation techniques have been fairly stable with little improvements in effective number of bits via utilizing new variations of standard modulation techniques. Chaotic modulation techniques represent a new paradigm for communication systems. Chaotic modulation functions within or even below the noise floor of standard communications systems, thus greatly improving the ability to avoid signal detection. Also, since the signal is extracted via correlation of a broad band, signal jamming avoidance is near perfect. Recent research has yielded a variety of chaotic modulation techniques. Some of these techniques have analogs within the standard modulation schemes. However, exploitation of chaos theory yields unique modulation models that greatly improve data

throughput over standard modulation models. The development of a chaotic modulator and demodulator for SATCOM communication systems will allow the Warfighter with the capability of increased Beyond Line of Sight (BLOS) bandwidth as well as a greatly reduced chance of unfriendly signal detection and interception.

PHASE I: Phase I will consist of a feasibility study of applying chaotic modulation techniques to transponded SATCOM signals operating at X, Ku, and Ka frequency bands. The study effort will concentrate on showing how chaotic modulation will improve bandwidth efficiency, increase anti-jam capabilities, and improve the Low Probability of Interception and Detection (LPI/LPD) of transponded SATCOM signals. It is expected that waveform modeling and simulation with a tool such as MATLAB or Octave will be part of the Phase I effort.

PHASE II: Phase II will consist of applying the results from Phase I to design and build a prototype SATCOM modulator and demodulator for implementing chaotic modulation and demodulation schemes. The transmit and receive intermediate frequency (IF) interfaces of the SATCOM modulator and demodulator should be compatible with standard commercial L-band (950-1950 MHz) IF interfaces. Completion of Phase II will yield demonstration and delivery of the developed prototype.

PHASE III: Phase III may consist of incorporating chaotic modulation schemes into a complete Engineering Development Model (EDM). Future goals include incorporating chaotic modulation schemes into a complete On The Move (OTM) or manpack terminal architecture. All commercial communication platforms, i.e. wireless, fiber optic, and ethernet will benefit from the higher bandwidth and lower power requirements gained from developing chaotic modulation / demodulation techniques.

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1. Chaotic Communications, their applications and advantages over traditional methods of communication Riaz, A.; Ali, M.; Communication Systems, Networks and Digital Signal Processing, 2008. CNSDSP 2008. 6th International Symposium on 25-25 July 2008 Page(s):21 - 24.
2. Hyper chaos synchronization shift keying (HCSSK) modulation and demodulation in wireless communications Di He; Chuan-jiang Yan; Fang-ming Zhao; Neural Networks and Signal Processing, 2008 International Conference on 7-11 June 2008 Page(s):250 - 254
3. Applications of chaotic time series analysis to signal processing Downes, P.T.; Signals, Systems and Computers, 1992. 1992 Conference Record of The Twenty-Sixth Asilomar Conference on 26-28 Oct. 1992 Page(s):98 - 104 vol.

KEYWORDS: Keywords: chaos, chaotic, waveform, wideband, modulation, demodulation, modulator, demodulator, modem, satcom, satellite, terminal, communication, satellite communication, noise, signal, detection, jamming, jammer, jam

A09-064            TITLE: Micro Cryocooler for Low Temperature Superconductor Electronics Systems

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: To design a small form factor, high efficiency, low power consumption cryogenic cooler capable of reaching and sustaining 3.5 degrees Kelvin. To canvas current micro cryogenic cooler technology such as staged MicroElectroMechanical Systems (MEMS) and other staged cooler technology for applications in developing a micro cryocooler for low temperature superconductor electronics systems.

Niobium superconductor microelectronics have been used successfully in developing a satellite receiver that is capable of directly digitizing at least 125 Megahertz (MHz) at X-Band Radio Frequency. This capability will allow the use of multi-modem processors capable of processing hundreds of communication channels simultaneously. The net effect of such capability on the implementation of the Global Information Grid (GIG) will be greatly increased communications through a significantly smaller terminal with a smaller antenna than is currently needed for the same data rate. The development of a micro cryocooler will enable the use of Niobium superconductor circuits in

low Size Weight and Power (SWaP) environments, such as On The Move (OTM) terminals thereby supporting AMC Mission & Vision 2015 Strategic Goal 1 and greatly enhancing the Warfighter's OTM WIN-T capability.

DESCRIPTION: Currently room temperature semiconductor electronics, i.e. Gallium Arsenide (GaAs) and recently Gallium Nitride (GaN) are used in complex communication systems such as a Satellite Communications (SATCOM) modem. The Communications-Electronics Research, Development and Engineering Center (CERDEC) has funded the development of a new branch of communication systems designed to use superconductor electronics based on Niobium. Niobium (Nb) is a transition metal and presents superconductor characteristics below its critical temperature of 9.3 degrees Kelvin. In order to ensure stability of circuit operation a Niobium based superconductor circuit operates in the range between 3.5 and 4.0 degrees Kelvin. The choice of Niobium is necessary in order to build the complex circuitry necessary for the direct digitization of X and Ka band RF signals. The CERDEC funded superconductor development has been co-funded by the Navy through the funding of several key technology objectives. Both the Navy and CERDEC superconductor systems, All Digital Receivers (ADR), are functional and have demonstrated very wideband (125 Megahertz) signal reception and direct digitization not currently possible with room temperature semiconductor electronics.

Since the circuitry of the ADR is a superconductor operating at 3.5 to 4.0 Kelvin, a cooling mechanism is required. Currently this cooling system is rather bulky and consumes approximately 1600 watts for a net cooling output of 200 milliwatts. The 200 milliwatt cooling requirement is based on the present ADR design. Future ADR designs will require an order of magnitude less in cooling power. The objective of this SBIR is to develop a cooler capable of reaching in a matter of hours and sustaining a temperature of 3.5 Kelvin over an indefinite period of time or as long as is technically feasible. The cooler must consume less than 250 watts of power and provide at least 30 milliwatts of cooling power for a nine (9) cubic inch volume. The nine (9) cubic inch volume will be encased in a vacuum chamber in order to provide thermal isolation with the ambient environment. The cooler itself should occupy less than 64 cubic inches.

PHASE I: During Phase I, a comparison will be conducted of four (4) degree Kelvin cryocoolers including possible systems incorporating MicroElectroMechanical Systems (MEMS). After looking at the trade off options between each system, a suitable cryocooler will be designed. Completion of Phase I will yield a complete micro cryocooler design. Phase I exit criteria will include simulation results and analysis or other suitable data proving the cooler design will meet the requirements listed above. Phase I option 1: delivery of Engineering Development Model of designed cryocooler.

PHASE II: During Phase II, the cryocooler design developed in Phase I will be implemented in hardware. After a review of system specifications and design, the final cryocooler design will be manufactured. Completion of Phase II will yield demonstration, delivery, and training of a completed micro cryocooler. The contractor will perform a demonstration of the final deliverable that shows the actual cooling time as well as sustained temperature (4.0 Kelvin) for at least several hours. Phase II exit criteria will include test data and analysis or other suitable data showing that the cooler meets the requirements listed above. Phase II option 1: delivery of more than one copy for a nominal cost.

PHASE III: Phase III may consist of incorporating the micro cryocooler into the Communications-Electronics Research, Development and Engineering Center (CERDEC) owned All Digital Radio (ADR) or other suitable superconductor electronics systems architecture. The development of a micro cryocooler will bring superconductor based computing within reach of the professional and business class arenas. Overcoming the size, maintainability, and expense of the cryocooler is a major hurdle for the widespread use of superconductors within commercial products.

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KEYWORDS: cryocooler, superconductor, electronics, microelectronics, microelectromechanical systems, MEMS, all digital, low temperature, cryogenic, compressor, compression, helium, coolant, fluid dynamics, heat flow, tactical, size weight and power, SWAP, SATCOM

A09-065            TITLE: Free Space Optical Connections for Airborne On-the-Move Nodes at High Data Rates Over Extended Distances

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: Develop a Free Space Optical (FSO) communication system suitable for the airborne layer operational environment. System requirements include reliable high-bandwidth long distance (minimum of 50 kilometers terrestrial footprint) optical connectivity with continuous On-The-Move (OTM) communications in a wide variety of weather conditions in a relevant military environment.

DESCRIPTION: The tactical communications environment currently hosts a wide variety of space, air, and terrestrial based systems. Most of the communications links are accomplished via Radio Frequency (RF) channels. While RF is suitable for many applications, there is an increasing need for very short bursts of extremely high bandwidth for bidirectional transmission of high resolution imagery or high quality video streams. The typical RF system employed in an OTM operational environment has neither the system power nor the antenna gain necessary to allow the very high bandwidth communication channels increasingly required for tactical imagery and video Situational Awareness (SA).

The state of the art in commercially available FSO solutions consists of stationary nodes placed in highly visible locations mainly for the purpose of building to building or fixed site to fixed site communications. This SBIR will focus on developing OTM FSO solutions suitable for use enabling high bandwidth communications between airborne and terrestrial platforms. This SBIR intends to directly address the air – ground tactical communications segment. All proposed solutions must include at least a single air-ground link.

PHASE I: During Phase I the requirements, challenges, and risks of deploying a tactical optical communication system will be examined closely. The feasibility of tactical free space optical communications will be examined and a small scale experiment or simulation of the proposed solution will be required as a deliverable of this phase. The project will concentrate on the issues related to use of this equipment in a military environment, where such issues as mobility with attendant stresses including vibration, shock and other effects of variable and rough terrain environments will pose specially difficult conditions for maintaining FSO links.

Some of the requirements, challenges, and risks that will be addressed in Phase I are:

1. Describe and define the feasibility of an FSO system for communication range extension in a rigorous military environment, with particular emphasis on an OTM ground component with an airborne connection. Define the capability with respect to required pointing accuracy, beam width and the likelihood/risk of system development to meet the requirements. What are the performance capabilities/issues in air to air, air to ground, or ground to ground network connections in on-the move configurations? What are some of the maximum achievable performance parameters, including speed of platform, maximum data rate, link distance? What are the likely scalability issues, as minimizing size, weight and power (SWaP) is important as user needs will require that payloads will be installed in varying airborne platforms some capable of carrying only a few pounds with low power availability. Scalability of the solutions is important for satisfying versatile applications. Appropriate modeling and simulation will be used to explore and verify the viability of the expected approach.

2. Present an evaluation of weather effects, appropriate operational wavelengths and other factors that affect system performance and expected operational constraints expected with a military optempo. What are the performance losses as a function of weather conditions? What are the availability metrics? Which wavelengths from below are appropriate to mitigate weather considerations? Sample bands are indicated below. Note that any feasible FSO band(s) will be considered.

O band Original 1260–1360 nm

E band Extended 1360–1460 nm

S band Short wavelength 1460–1530 nm

C band Conventional 1530–1565 nm

L band Long wavelength 1565–1625 nm

U band Ultralong wavelength 1625–1675 nm

3. Regulatory considerations. What impediments are imposed by licensing/frequency regulation in appropriate ranges? What are the geographic considerations, such as operating in CONUS vs. OCONUS?

PHASE II: The results of the feasibility phase will be analyzed and optimized to create a realistic experiment that proves the viability of the selected approach. The proposed solution developed in Phase I will be fully exercised in a working prototype system. The demonstration will be performed in relevant military environment, to concentrate on connections between a ground mobile and airborne platform, and consider the environmental conditions unique to this application. The experiment will stress the system to its logical limits, addressing the metrics developed in the feasibility phase and taken into this demonstration phase. The demonstration and test report delivered with the prototype will detail the requirements developed in Phase I, and compare the modeling and simulation results with the experimental results obtained from the demonstration event. The report will include such performance characteristics as maximum link distance, data rate, quantification of the impacts of environmental and military vehicular usage effects. The successful completion of Phase II will yield a free space optical communication system suitable for the airborne layer operational environment. This demonstration must provide an evaluation of the working solution to an applicable military real-world environment and that identifies a practical solution that could enter a further system design and development phase.

Expected TRL: 5

PHASE III: During Phase III, the system developed in Phase II will be integrated into the wider tactical communications environment. Operation of the equipment will be assessed in a relevant, complex and stressed communication environment with multiple data links with competing RF networks. This will provide for data exchange primarily in an air to ground environment. This will support airborne network initiatives that are paramount to Army operations and represent ongoing user requirements as indicated in TRADOC documents, including AERIAL LAYER NETWORK TRANSPORT ICD, dated 29 May 2008. This capability is of interest to such PM's as WIN-T or ACS. Commercial capability has been demonstrated, but in a fixed and lower data rate environment.

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KEYWORDS: Lasercom, long distance, on-the-move, regulatory, airborne

TECHNOLOGY AREAS: Information Systems, Sensors, Space Platforms

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To develop a distributed, scalable aperture that supports Satellite Communications On-The-Move.

An innovative approach to support SATCOM OTM communications with a distributed aperture is required that could be integrated into available spaces on a tactical vehicle. The separate pieces would fit within available space and work together to provide required connectivity.

DESCRIPTION: There are current efforts underway to develop terminals supporting satellite communications on-the-move for different frequency bands and DoD systems (e.g. WIN-T and FCS). Size, weight, and power are design drivers. These efforts are struggling with integration issues for different tactical vehicles. A flexible approach that could be distributed and also scale to space available would ease integration issues and allow for optimal connectivity for vehicle space available.

An innovative solution is required to support SATCOM OTM communications with a distributed aperture that could be integrated into available spaces on a tactical vehicle. The separate pieces would fit within available space and work together to provide required connectivity.

- Supports adding SATCOM OTM to over-subscribed vehicles with limited top side space
- Flexible and scalable to support different vehicles
- Potential benefit for "soft" blockages and increased blockage mitigation
- Increased robustness and less likelihood for comms outage with the allowance for soft failures.
- Potential benefit to reduce profile

The intent is to develop innovative solutions to aperture distribution in order to support an objective system that can be used over the Department of Defense Wideband Global System satellite, which utilizes X and Ka bands.

#### Objective System Definition

- The objective system will consist of antenna apertures and radio frequency components, cabling, any required Inertial Navigation Unit and/or GPS, and any required controllers to achieve specified performance. INU and controller/processors may be internal to vehicle. Modem interface will be L band. Power to be supplied by the vehicle at 28 VDC.

#### Performance Parameters

- The antenna/RF system being developed is intended to operate over the Wideband Global System (WGS) satellites at X and Ka/K bands. X band frequencies are 7.9 to 8.4 GHz transmit and 7.25 to 7.75 GHz receive. Ka/K band frequencies are 29.5 to 31 GHz transmit and 19.7 to 21.2 GHz receive.
- Polarization will be circular and switchable between right hand and left hand for both X and Ka/K.
- The antenna/RF system being developed shall be flexible and modular to support distributed and scalable operation on a variety of tactical vehicles. Overall EIRPs to be achieved are 40 dBW at X band and 49 dBW at Ka band. Overall G/Ts to be achieved are 6 dB/K at X band and 12 dB/K at K band. This performance is to be achieved within an undistributed area of 30" x 30" at a height of 6" and when distributed in up to 8 locations around the vehicle, each location up to 30 ft from any central controller. Distributed locations may not be on the same physical plane and the contractor shall provide analysis on performance at height/tilt/distance limitations. Performance is desired for full azimuth operation and for elevation angles from 20 to 90 degrees relative to the vehicle.
- The system will support pointing requirements in a tactical environment, to include maximum velocity of 200 deg/sec in azimuth and elevation and maximum acceleration of 500 deg/sec/sec in azimuth and elevation. Maximum loss due to pointing shall be 1 dB.
- The system will operate in a Radio Frequency and blockage environment typical of a tactical vehicle. The system design shall be flexible to accommodate these limitations. The contractor shall provide analysis describing system operation under tactical operations, to include but not be limited to blockage, RF interference, or the physical loss of one or more distributed apertures.
- Beamwidths will be characterized for all cases and compared with Mil-Std-188-164/165 requirements.

PHASE I: - Identify issues and design drivers as well as a trade-off of approaches for the objective system  
- Design an X band distributed aperture based on the optimal approach  
- Design a Ka band distributed aperture based on the optimal approach  
- Define the technical challenges associated with each design and identify an approach for a Phase II prototype

PHASE II: - Develop, fabricate, and integrate a distributed aperture prototype. Demonstrate the basic combined performance of distributed apertures (not the entire objective system).

PHASE III: - Build and demonstrate entire tactical distributed aperture system to include meeting antenna pointing requirements and environmental. This objective system will consist of antenna apertures and radio frequency components, cabling, any required Inertial Navigation Unit and/or GPS, and any required controllers to achieve specified performance.

For Phase III military application of this SBIR, Future Combat System (FCS) Manned Ground Vehicles (MGV) and WIN-T Points of Presence (POP) and Tactical Communication Nodes (TCN) would directly utilize this technology in order to achieve additional satellite communications on these vehicles that would not have been possible previously. The SBIR output technology would be transitioned to the respective program of record to accomplish this. For Phase III commercial application of this SBIR, commercial satellite communications applications such as the news media would utilize this technology in order to achieve satellite communications on vehicles not previously able to accommodate it, increase effectiveness by being able to transmit and receive on-the-move, and reduce current setup times. This technology is also commercially viable for other specialized commercial applications such as African expeditions where satellite communications on-the-move would be applicable

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KEYWORDS: Satellite Communications, SATCOM, On-The-Move, OTM, phased array, aperture, distributed, scalable, integration

A09-067 TITLE: Content Dependent Bandwidth (BW) Enhancement

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To determine the benefit of bandwidth reduction and performance enhancement when the predictive elements of common speech are used to anticipate the infinitesimal changes in the speech. Using this technique the effective BW available to the Warfighter will increase allowing more information to be exchanged with less resources, less time on the the air, and better connectivity in both quality and quantity.

DESCRIPTION: Communication systems rely upon extensive processing power in the area of speech compression to produce a digital representation of the compressed speech, then digitally encode the information with interleaving and correction codes in order to get the information to the destination intact. This technique is optimized for the best bit error rate but is not optimal in communicating using the current channel or content of the speech. The result is a generic solution that is not optimized for any specific channel or spoken intent, resulting in poorer intelligence communications than is necessary.

If the uncompressed signal could be transmitted from the source then all the information in the received signal could be capitalized upon to determine its original intent, in this way the equivalent of an optimal compressing, coding and interleaving could be employed at the receiver allowing better speech quality, fewer retransmissions and ultimately more available Bandwidth for other purposes.

Existing digital techniques deliberately obscure the relationship between successive bits of information by making each bit transmitted independent. Because of this independence multiple transmissions on the channel can not be correlated back to the source from which they came and result in the aggregate signal being interpreted as noise. By receiving the entire signal, and not just an ignorant one size fits all interpretation of each signal then a specific technique can be utilized to determine what contribution each signal had to the whole. Ultimately allowing multiple signals to be received simultaneously within the existing bandwidth, allowing more and better quality communications.

PHASE I: During this phase the relative performance enhancement of the extended predictive technique will be compared to the bandwidth enhancement achieved when the information is coded using state of the art compression algorithms and the excess bandwidth used for error correction coding and interleaving.

Techniques that optimize the time varying relationships within a single signal as it relates to channel conditions will be developed and then extended to include the independent relationship between multiple signals. These techniques will be simulated and explained as related to how they will enhance performance in a noisy environment, improve on existing digital transmitted signals and permit increased bandwidth available to the war fighter.

A computer based simulation of the understanding of the technique should be demonstrated to show the feasibility of the concept.

PHASE II: Hardware will be developed where the aggregated information using this technique will be evaluated to multiple signals using conventional compression techniques. It is anticipated that a crossover in performance will be shown where more information is communicated using the analog technique as opposed to the boilerplate digital approach.

PHASE III: In critical circumstances, such as search and rescue it will be more beneficial for the receiving system to process and extract all aspects of the information rather than relying on the common impression that only perfect signals with complete content have value. In emergency situations, where the communication link cannot be previously categorized it is virtually impossible that any compression could optimally compress all valuable information, and valuable relationships of seemingly useless information. In the product intended, if the channel is "cleared" for emergency purposes then the entire transmitted information can be used to determine the information content. Existing communication systems could operate on a normal business digital mode and a emergency analog mode to offer the best solution.

Military use would similarly take advantage of the detailed relationship between apparently unrelated pieces of information to allow the most critical communications to continue. The ability to extract information in the most hostile environments, those caused by degraded channel conditions will result in communications capabilities for WIN-T and FCS where none previously existed. Being able in essence to optimally choose the coding technique will vastly improve communications used in FCS and WIN-T.

Phase III Dual Use: In the rush to exploit the advantages of digital technology, specifically digital encoding of analog signals the advantages of the intact analog version of these signals has been neglected. In a digital signal it is the responsibility of the coding/decoding pair to either give a perfect representation of the transmitted signal or nothing at all. Unfortunately during the coding process and limited processing power available to the user, the coding technique takes a statistical approach to how the information will be encoded and evaluates the effort in additional encoded information to the recovery of the signal within an equally statistically significant time window. When these limitations are combined the result is no received information even if a single bit, or an additional millisecond of processing time would make a two minute transmission understandable. As an example of this consider literally a plea for help from a disadvantaged user, it can be shown that normal codecs used to digitize the voice and the error correction coding of that five second transmission could unfortunately result in sufficient errors in the transmitted signal to cause either synchronization to be lost, which incidentally has no relationship to the cry for help, or for small portions of each packet of data to be uncodable resulting in no received signal. If a different algorithm were used though it might have been possible to get the data through, but use of this different algorithm would have similar problems causing other packet errors resulting in other portions of the message being in error yielding the same problem; no received signal. An analog representation of this signal, with processing done at the receiver, which is the intent of this SBIR would not be restricted with making this decision and would allow a transmission to be successfully received. The fundamental attributes of this concept are: post reception signal correction, application of human intelligence to conduct decoding, and arbitrary history periods to extract correct content. Specific dual use applications would be: Personal communication devices in stores or construction sites, where this feature would be used primarily as an analog override to reset the conversation. It is also anticipated for use as an emergency broadcast service for civil defense where the indication of an emergency is sufficient to entice the recipients or the corrupted message to either seek out more detail or take necessary fundamental precautions regardless of the exact emergency. Use in Fire or emergency rescue situations where the urgent intent of the overall message is more important than the specific instructions, in these situations it would indicate to the recipient the critical nature of the communications and to either obtain a better connection or retreat. Rural areas with low population densities where some signal quality is more advantageous than perfect signal. Fundamentally this proposal will allow communications to occur in areas where it was previously impossible, the dual use applications are limitless since this SBIR provides the communications where none existed previously. To put it most concisely: this SBIR will allow the intent of a "scream" to be communicated even if the entire duration of the "scream" could not.

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KEYWORDS: Bandwidth, speech, predictive elements, non-lossy compression

A09-068      TITLE: Conformal, Printable Antennas for VHF and UHF Applications

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To study the concept/feasibility of developing printable, three dimensional, highly conductive metallization patterns on various substrate/dielectric mediums, e.g. metamaterials, flexible substrates, for advanced VHF/UHF antenna applications including ground and aerial vehicles. The technology should demonstrate low cost prototype/production capability, e.g. ink jet, while maintaining low conductor loss for high performance antennas. This effort should also investigate reduced size VHF/UHF antenna concepts using this printable technology.

DESCRIPTION: Advanced conformal printable antennas operating down to VHF frequencies for airborne and ground platforms are extremely desirable. Some of the major benefits include low cost, rapid prototyping, light weight, low profile, three dimensional antenna patterning, and broadband performance.

Many of these antennas must exhibit omni-directional or directional coverage and must minimize aerodynamic effects on vehicles. Current vehicle antennas typically rely on a monopole blade or whip antenna which is undesirable due to aerodynamic and visual signature concerns. This problem is compounded when many antennas are required to cover multiple bands creating a large array of antennas. This results in higher cost, complex mechanical issues, and possible interference.

The use of planar and/or embedded antennas can replace these standard monopoles thus reducing the number of antennas, providing wider bandwidth, and eliminating the visual signature.

Advances in materials, conductive ink technology, and antenna design can translate into novel and high performance antennas. This effort will investigate these technologies and how they can possibly be combined to realize high performance conformal, planar antennas. The use of these conformal, planar, and/or embedded antennas will have applications in a variety of platforms including ground and aerial vehicles, satellites, helmets and jackets and even munitions. Advances in antenna technology based on this SBIR program could enable new levels of prototyping and advanced antenna structures providing wideband/multi-band operation or that could be printed on very complicated shapes and bodies.

PHASE I: Investigate, model, and analyze conformal antennas that can be realized in a printable format, are small size, and operate at VHF/UHF frequencies. The antenna conductor losses should be minimal to reduce attenuation and therefore provide a high efficiency antenna. Also, several host substrate materials, e.g. dielectrics, metamaterials, should be investigated to produce and optimize small and novel antennas. Omni-directional and directional patterns are both desirable. Additionally, RF power capability of analyzed antennas will be identified for transmitting as well as for receiving. Finally, embedded antennas should be investigated to produce wideband performance hence reducing the number of antennas currently employed on existing systems.

Phase I deliverables are the monthly status reports and the final report, describing the findings of phase I and design recommendations for phase II.

PHASE II: Develop, test, and demonstrate prototype antennas that meet the requirements derived in Phase 1, i.e. printable format, small size, VHF/UHF coverage, minimal conductor losses, and with directional and omni-directional patterns. The deliverable prototypes shall include one conformal planar and one embedded antenna for each of the following applications: a HMMWV; a midsize Unmanned Aerial Vehicle (UAV) such as the Shadow 200; and soldier jacket/helmet. The prototype antennas can initially be fabricated in a brass-board format for demonstration purposes, but must ultimately be adaptable to production fabrication. Demonstrate the antennas' performance in a stand alone configuration and mounted on the aforementioned platforms as well. These prototype antennas will be tested at the contractor facility to demonstrate their capabilities prior to delivery to the Government. Based on the results, identify and recommend a final architecture that addresses performance, SWAP, and manufacturing concerns.

PHASE III: Based on phase 2 results, prototype antennas will be improved upon and optimized for commercialization. These antennas will be used to demonstrate manufacturability and to validate the fabrication process and electrical performance. A specific antenna will be identified and productized for a selected application. A series of demonstration tests shall be conducted on the selected platform. Several specific military/commercial programs that can benefit from this technology include electronic warfare (EW) WARLOCK system, high power jammers, the Tactical signal-intelligence (SIGINT) Payload (TSP) program, Counter Radio-controlled-improvised-explosive Electronic Warfare (CREW), and wireless base stations.

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KEYWORDS: Antenna, ink jet, conformal, printable, embedded, dielectric, metamaterials.

A09-069            TITLE: High Output and Multi-Band Laser for Electro-Optical/Infra Red Counter Measure (EO/IRCM)

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop a compact and highly efficient multi-band laser for infrared countermeasures

DESCRIPTION: Many ground and air-based vehicles operating in hostile environments depend on countermeasure systems that use a laser to disrupt the guidance of an approaching missile. Excessive size and weight, limited duty cycle, low output power and the need for an operational "warm up" time are a few deficiencies present in current laser source systems. The cooling system used in these laser systems increases their cost, weight, and complexity making it difficult to incorporate them on space-limited combat aircraft. Next-generation countermeasure systems are required to focus on compact laser sources that can operate with high electrical efficiency at an elevated temperature; high brightness with extensive wavelength tunability; or simultaneous ultra broad band operation extending into the far-infrared wavelengths. Solid state lasers of traditional bulk format sources provide a limited choice of the wavelength tunability. Originally observed in crystals and glasses, supercontinuum generation can be used as a broadband source to counter an attack by next generation missiles. With the introduction of low loss optical fibers, permitting extended non-linear interaction lengths and small confinement areas, supercontinuum generation was achieved for modest pulsed pump power levels in the fiber. Advances in high power fiber lasers and amplifiers in novel non-linear fibers that can be readily integrated with such pumps have led to a family of high power supercontinuum sources that extend throughout the infrared window. A supercontinuum laser which operates at room temperature is the key to low cost, light weight infrared counter measure systems. Fiber-based supercontinuum sources offer a simple stable design, potential low cost, a compact package, and high reliability.

The technical objective of this proposal is to develop a supercontinuum laser with high output and multi-band capability for use in infrared countermeasure systems. The laser should provide output power of 10-15 watts in the 1-5 micron wavelength region with an electrical efficiency of greater than 50%. The system should have growth capability to defeat future electro-optical, imaging seekers, laser guided and unguided surface to air missiles, rockets, and small arms.

PHASE I: Develop a design for a room-temperature supercontinuum laser with high output power 10-15 Watts in the 1-5 micron wavelength that operates with high electrical efficiency.

Predicted Performance: Total Average power of several tens of Watts in the 1-5 micron at nominal duty cycle, Electrical efficiency greater than 10% with high reliability and lower maintenance cost, size of 0.7 cubic feet, weight less than 30 lbs and OME cost of less than \$50K.

PHASE II: Develop, test and demonstrate a prototype laser that can be integrated with an existing countermeasure system. Required Phase II deliverables will include prototype, test report and OME cost for manufacture.

PHASE III: Based on phase-2 results, a minimum of two laser systems should be fabricated and characterized. These laser systems will be used to demonstrate manufacturability and to validate the fabrication process and performance. A series of demonstration tests shall be conducted to verify performances.

Dual Uses: This technology can be used to detect and detonate improvised explosive devices. This technology can be directly marketed to federal, state, and local law enforcement agencies for the same purposes of IED detection.

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KEYWORDS: Infrared countermeasure, Mid-Infrared Laser, High Power, Laser, Tactical , IR Jamming, Missile Tracking , nonlinear optics, optical fibers, supercontinuum, nonlinear fibers; fiber lasers.

A09-070            TITLE: Detection and Neutralization of Explosive Hazards

TECHNOLOGY AREAS: Chemical/Bio Defense, Electronics

OBJECTIVE: Develop and evaluate an innovative concept for a soldier-borne Counter-Improvised Explosive Device (IED) system. This system shall be able to detect and defeat IED hazards. Small unit maneuver forces and small arms fire can be utilized operationally to deal/avoid IED emplacements and therefore are of critical concerns to PM Soldier and a manpacked system.

DESCRIPTION: The researcher shall develop an innovative concept for a soldier-borne IED detection and defeat system. Current and future operations require an IED system that is more portable and man-packable. Current systems deployed or in development are required to be mounted on air or ground platforms and are not amenable to being carried on the dismounted soldier.

The investigator shall develop a multi-spectral approach to detection and defeat of IED hazards. The multi-spectral approach shall include Signals Intelligence (SIGINT), Measurement and Signature Intelligence (MASINT) and Imagery Intelligence (IMINT) , and Chemical detection signatures. The multi-spectral approach shall be able to be packaged in a 20 pound or less configuration and be able to detect spectral emissions out to 150 meters (required), 300 meters desired. The detections from the multi-spectral information shall be combined to determine the presence

(or not) of an Improvised Explosive Device (IED). It is desired that the approach also address adaptability of the design or theory to changes in the threat.

While past work has been done in IED detection dealing with certain spectral emissions there is no one package nor theoretical approach to look at the cross range of spectral emissions from IEDs within one sensor package that is also man portable.

The packaged approach shall be technically tailorable (for both the detection and defeat capabilities) to maximize the exploitation of different IED spectral emissions depending upon the known pre-mission information and the general topography and geology of the area of operation. Consideration should be given to the method of implementation so that a tailored multi-spectral approach is achievable.

Other previous/existing approaches in the detection field concentrated on one or two spectral emissions; i.e. RF, Hyper-spectral, Imagery. This approach presents a package that can incorporate the optimum multi-sensor spectral emission intercept while also containing the capability to defeat such IEDs based on the most susceptible spectral emission present.

PHASE I: The researcher shall explore different technologies that could be used to detect and defeat of explosive devices. The investigator shall determine performance bounds and perform a feasibility analysis of the design and demonstrate its validity through analysis, simulation, or other means. This analysis shall include as a minimum: size, weight, power, sensors, cost, and operational considerations.

PHASE II: The investigator shall build a software model to predict and analyze the detailed performance of the system. The investigator shall develop a hardware prototype and demonstrate the concept that was developed in Phase I. The contractor shall test the system and compare the measured sensor performance against expected sensor performance values resulting from the modeling effort.

PHASE III: Technologies for detection and neutralization of explosive devices have a wide variety of applications in the military and commercial markets. This technology could be useful for law enforcement, homeland security, and emergency response applications such as firefighting and EMT situations. Military applications of the man-portable IED defeat system would be for the dismounted warfighter during unconventional warfare operations. The technology would be developed further and tested by the CERDEC's I2WD Directorate for potential transfer to PM Soldier.

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KEYWORDS: Counter-IED, neutralization, detection, mitigation, prediction, prevention.

A09-071            TITLE: Window Mounted UHF Antenna System

TECHNOLOGY AREAS: Materials/Processes, Sensors

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

OBJECTIVE: Develop an innovative window mounted UHF antenna system that can be easily installed and removed on both Rotary and Fixed Wing Aircraft without modification to the airframe.

DESCRIPTION: The contractor shall develop an innovative window mounted UHF antenna system that can be easily installed and removed on both Rotary and Fixed Wing Aircraft without modification to the airframe. The antenna will be mounted on the inside of the window and used with the Miniaturized RF Tag (MRFT) program for tagging, tracking, and location. MRFT is an RDECOM Intelligence & Information Warfare Directorate (I2WD) effort. Safety constraints must be addressed since the radiated power will be up to 100 watts. The following are some of the design parameters:

Gain: 6 dBi

Azimuth Beam: 60 degrees

Elevation Beam: 60 degrees

Frequency Range: 400 MHz – 450 MHz.

Antenna Impedance: 50 ohms

Installation Time: less than 20 minutes

Safety: 99% of the energy applied to the antenna shall be radiated into the half-space in front of the antenna.

The contractor shall explore different techniques and materials including using a Frequency Selective Surface and if possible exceed 90 degree coverage while maintaining 6 dBi gain. The contractor shall perform an analysis that will form the basis for any design proposals, and ultimately be validated through the development of prototype hardware. Size, weight, and power parameters will be optimized to required performance. Performance will be contingent upon the successful implementation of design innovations related to establishing a reliable and adequate ground plane on a glass surface for effectively radiating the requisite radio frequency energy away from the airframe. Flexible electronics should be considered to overcome mounting challenges presented by irregularly shaped and variable configurations of glass surfaces for installations intended to be rapid, temporary and reproducible. Performance will also require utilization of materials and fabrication processes and methods yielding a durable device; and in achieving sufficient antenna gain and beam width pattern and shape with a limited and minimal antenna aperture size.

PHASE I: The contractor shall perform a feasibility analysis of the design for an innovative window mounted UHF antenna system and demonstrate its efficacy through analysis, simulation, or other means. This analysis shall include, but not be limited to: size, weight, power, cost, duty cycle limits, damage to the window due to extreme temperature difference between outside temps and hot antenna and safety concerns of high RF levels.

The Phase I deliverables will include monthly reports detailing the progress of the feasibility study and a final report on the analysis conducted and recommendations for design with performance predictions.

PHASE II: The contractor shall develop a hardware prototype and demonstrate the concept that was developed in Phase I. The contractor shall test the system and compare the measured performance against predicted performance values. The contractor shall deliver monthly reports, test reports and a final report. The contractor shall make one prototype unit available to be used for further evaluation. This unit is not considered a deliverable and will remain the property of the contractor.

PHASE III: A window mounted UHF antenna has wide application for military and commercial markets such as for law enforcement, homeland security, and emergency response applications to include: firefighting and EMT situations. Military applications would be for a special customer and other military customers. If Phase II is

successful, the technology would be developed further and tested by the Communications Electronics Research, Development and Engineering Center (CERDEC) Intelligence and Information Warfare (I2WD) Directorate.

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KEYWORDS: Tagging, Tracking and Locating (TTL); Combat Identification, UHF Antenna, window mounted antenna

A09-072            TITLE: Network Fault Management and Self Healing

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Investigate and validate self-healing techniques for the conditions of a tactical ad hoc network and develop an engine that implements the most efficient technique.

DESCRIPTION: The goal of this effort is to investigate and validate the numerous self-healing techniques that are appropriate for a tactical ad hoc network. The goal also is to rank the identified techniques and develop the most efficient mechanism.

Today's networks are typically infrastructure backed networks. These networks are richly connected, reliable, and have a high bandwidth backbone with a stable topology. The problem of fault management and self-healing in this type of traditional network is complex and challenging. A tactical mobile ad hoc network, on the other hand, has very different characteristics. This network is much more complex than an infrastructure backed network. It is intermittently connected, very low bandwidth, and has a highly dynamic network topology. Due to these characteristics, the problem of fault management and self-healing is far more complex and challenging in this type of network.

Existing fault management methodologies and self-healing mechanisms are focused on handling "hard" failures. While such mechanisms prove to be valuable in the context of a traditional network, they are not applicable to tactical mobile ad hoc networks due to the fact that the failures in the battlefield are mainly "soft" failures.

A number of techniques for identifying new faults that occur in tactical ad hoc networks have been identified using a hybrid approach that combines abductive reasoning and probabilistic inferencing techniques. Methodologies must be developed for healing the identified faults. Another issue in this network is resolving a fault may require the fault information to be sent to higher level managers. The system must be scalable so that it can work in a relevant military environment.

Once the mechanisms for the self-healing process have been ranked and the most efficient one chosen, an engine must be developed to perform self-healing tasks. By having such a tool the user gains a better insight into what is happening in their network and can increase network reliability by correcting faults quickly and efficiently. The payoff from this technology will be a new design which resolves the current gaps in the proper way to perform fault management and self-healing for tactical ad hoc networks.

PHASE I: Define and determine the potential network faults along with self-healing mechanisms to fix the problems. The SBIR will develop approaches to address the complex ad hoc network fault management issue and

rank the self-healing mechanisms in order of efficiency. Identify concepts and methods for handling faults, their causes, and techniques to resolve problems. Design/develop an innovative concept along with the limited testing of fault management application. Define the proposed concept and develop key component technological milestones for potential future phases of the SBIR.

PHASE II: Using results from Phase I, fabricate and validate a prototype fault management correlation application that performs self-healing. Test and demonstrate the prototype in actual or emulated tactical mobile ad hoc networks. Required Phase II deliverables will include prototype, software description document and final design documentation.

PHASE III: Further develop prototype to a transitional product with necessary documentation for a Program of record such as Warfighter Information Network - Tactical (WIN-T), Joint Tactical Radio System (JTRS), or PM Future Combat Systems (FCS) to integrate the product into their suite of software. This capability could be incorporated into commercial network management applications such as HP Openview, Tivoli, and Solorwinds products to enhance the usability and improve commercial network reliability by reducing down time.

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KEYWORDS: Network Management, Fault Management, Fault Correlation, Self Healing, Self-optimizing networks, Automated management

A09-073      TITLE: Clutter Mitigation Techniques for Ground-Based, Ground Moving Target Radars

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Investigate and validate innovative clutter mitigation techniques for clutter as seen from a radar sensor located near the Earth's surface. The enhancement of the detection, classification and location of enemy combatants from either unmanned ground vehicles or from stationary positions will provide improved situational awareness to the warfighter.

DESCRIPTION: The objective is to improve the warfighters ability to detect dismounted enemy combatants and discriminate out as clutter terrain features, wildlife, infrastructure features, weather effects such as rain, wind, blown sand and low flying air vehicles. The contractor shall develop innovative techniques for the mitigation of clutter as seen from a radar sensor located as low as 0.1 meters and no more than 2 meters from the earth's surface. From early work done in clutter mitigation, it has been revealed that low-angle land clutter was a highly non-Gaussian (i.e. non-noise like), multifaceted, relatively intractable, statistical random process of which the most salient attribute was variability. This has made the elimination of ground clutter a difficult process. Most surface-cited Pulse Doppler radars partially suppress land clutter interference by filtering out trees and bushes. However, Zero (0) velocity

Doppler filtering is never a complete solution. Nearly all vegetation can take on an apparent velocity due to wind. Thus to filter out the vegetation the filter blind speed is raised causing other slow moving targets to go undetected. Previous research on low angle clutter has been focused primarily on sea clutter. The land environment differs from the maritime one in the depression angle of the radar to the terrain, the amount of vertical reflectors in the area of interest, and in the apparent velocity of the clutter due to wind. Micro Doppler techniques can offer an alternative solution to filtering out low velocity returns while adding the ability to classify targets. Micro Doppler signature recognition has for the most part centered on identifying air and ground vehicles by their mechanical vibrations. The detection and classification of dismounted combatants has remained difficult. More research needs to be conducted so that enemy combatants can be detected and classified from an environment rich in clutter from vegetation, wildlife, and terrain features. In particular the analysis of non-uniform motion and bipedal gaits needs to be studied further. The techniques and algorithms sought would be used to improve the detection, classification and location of enemy combatants in clutter over the entire azimuthally coverage of any given light weight ground surveillance radar with a minimum range of 200 meters and maximum range of 3 km. A minimum of three separate terrains should be considered by contractor: (1) Urban area scenario. (2) A suburban area and (3) A roadway tunnel. Natural terrains (fields, deserts, etc.) may be considered in addition to those three mentioned above.

PHASE I: The contractor shall investigate innovative techniques for clutter mitigation concerning light weight ground surveillance radars operating near the Earth's surface. The contractor shall perform a feasibility analysis of the techniques that can be used to enhance radar detection, classification and location of enemy combatants moving at ranges of between 200 meters to 3 km from broadside of the radar antenna. The contractor shall deliver a detailed report on the analysis, results and recommendation.

PHASE II: The contractor shall demonstrate through a prototype demonstration, innovative clutter mitigation techniques developed in Phase I. Verification and validation in the prototype demonstration shall be achieved through analysis, simulations, and/or other quantitative means. This analysis shall include, but not to be limited to: the probability of detection and probability of false alarm over surfaces varying in roughness, moisture content and vegetation cover for both mounted and dismounted enemy combatants. The contractor shall deliver a detailed report of this effort and its results.

PHASE III: The contractor shall integrate and validate innovative clutter mitigation techniques developed and demonstrated in earlier phases of this SBIR with a relevant system such as the army research lab (ARL) Compact Radar Advanced Technology Objective (ATO), the AN/PPS-5D combat surveillance radar, or other suitable system. The contractor shall deliver a final report describing the enhanced performance offered by the clutter mitigation techniques as well as descriptions of techniques. These descriptions shall include any software algorithms, specification sheets for hardware components, and all Tactics, Techniques, and Procedures (TTP) that are created for and/or modified in order to implement the innovative clutter mitigation techniques on the fore mentioned systems. The Military and Commercial opportunities for integration are numerous. Innovative clutter mitigation techniques could be applied to Weapon Locating Radars, Battlefield Surveillance Radars, and Force Protection Radars. The civilian use would include infrastructure protection, homeland security, automobile collision avoidance systems, water fowl tracking near airports, livestock monitoring and maritime navigation radars.

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KEYWORDS: Force Protection, Situational Awareness, Radar Clutter

A09-074

TITLE: High Efficiency, Highly Linear, Solid-State Power Amplifier for Wide Band Applications

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Determine the feasibility of developing novel high power RF/microwave amplifier circuits using wide bandgap devices that will result in unprecedented efficiency, linearity, output power, reliability, and reduction of non-linear signal components, e.g. harmonics and third order products. The frequency range of interest ranges from VHF to c-band. Instantaneous wideband operation is also desirable.

DESCRIPTION: High power solid-state amplifiers are used extensively in many military applications, e.g. jammers. Current amplifiers are limited in efficiency, output power, operating temperature range, and reliability due to the use of conventional Gallium Arsenide (GaAs) technology. Improving these factors will result in reducing battery requirements, improved range, increased reliability, and the availability of a wide operational temperature range. There are extensive efforts underway to develop high efficiency, wideband, power MMIC chips using wide bandgap devices at power levels of 10 W and 30 W covering bands from HF to C-band. The chips can be used as building blocks to develop mounted and dismounted power amplifier modules with power levels of 20 W and 150 W respectively. Novel circuit topologies and/or combining techniques can be developed that would result in lower nonlinear signal content without the need for additional filtering while simultaneously providing exceptional output power and efficiency. The advantages of these developed power amplifiers could result in smaller size, low cost, high RF power, low power consumption, low intermodulation products, inherently suppressed second harmonics, and a wide bandwidth.

PHASE I: Investigate, model, and analyze novel circuit topologies that can incorporate wide bandgap devices to produce high power amplifiers capable of high performance, e.g. minimum efficiency of 40 % at the one dB compression point, minimum output power of 100 watts, and second harmonic 40 dB minimum below the fundamental. Various conventional and unconventional circuit topologies should also be investigated. Various amplifier classes of operation should also be investigated to maximize performance. Attention to thermal concerns, e.g. device junction temperature, should be evaluated to allow maximized performance and reliability. Since the amplifier duty cycle can vary, e.g. from 5% to 100%, fast turn on and turn off capability should be investigated to allow operation only when an RF signal is present and hence manage thermal concerns. A prediction of amplifier performance at elevated ambient temperatures associated with field conditions will be identified. Phase I deliverables will include a technical report.

PHASE II: Develop, test, and demonstrate a prototype amplifier that meets the requirements derived in Phase 1. The prototype amplifier can initially be fabricated in a brass board format for demonstration purposes, but should be adaptable to conventional production fabrication and assembly techniques. Demonstrate the amplifier performance in a stand alone configuration over a select operational temperature range. Based on the results, identify and recommend a final architecture that addresses performance, SWAP, and manufacturing concerns.

PHASE III: Based on phase 2 results, a minimum of six amplifiers should be fabricated and characterized. These amplifiers will be used to demonstrate manufacturability and to validate the fabrication process and electrical performance. A series of demonstration tests shall be conducted to verify performance.

Dual Uses: Several specific military/commercial programs that can benefit from this technology include electronic warfare (EW) WARLOCK system, high power jammers, CREW, commercial satellite transponders, terrestrial microwave links, and cellular base stations.

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KEYWORDS: amplifier, wide bandgap, linearity, third order intermodulation, GaN, SiC

A09-075

TITLE: Advanced Algorithms and Architecture for Multimodal Biometrics Fusion (A3MBF)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Enterprise Information Systems

OBJECTIVE: Establish a framework capable of linking identities through biometric and contextual information across repositories to track a Person of Interest (POI). Lack of an accurate and quick responding biometric collection store places a burden in relying on a single modal biometrics system. This research is to result in proposed improvements and methods to find and track POIs based on biometric and contextual information.

DESCRIPTION: In the Global War on Terrorism (GWOT), biometric-enabling capabilities have been extensively leveraged for identifying and tracking adversaries of interest. An identity management (IdM) system based on the heterogeneous data/information of a subject is required for use by Counter Intelligence / Human Intelligence (CI/HUMINT), Military police (MP) and Stability, Security, Transition, and Reconstruction (SSTR) operations for identification and tracking of POIs in a crowd and/or as they approach secured areas or become Enemy Prisoners of War (EPW). The relatively high false match and false non-match rates in current biometric systems have renewed attention for the development and refinement of multimodal biometric fusion algorithms using data from multiple sources. There are several reasons for these significant false match and non-match statistics. One of the more probable rationales for this is due to the large amount of information being collected in reports from multiple down-range sources. Simply managing this large volume of data becomes cumbersome, so it follows that the subsequent analysis becomes even more involved for even those experienced individuals. Presently, intelligence analysts, or end-users, must manually link data using a combination of their training and experience for IdM. Thus, it becomes clear that the rate-limiting step occurs at the analyst's level where the sheer volume of information must be meticulously filtered in a timely, orderly manner.

End-users can query databases by using parameters such as name, date, event type, etc. Commercial software exists for these users to perform drawn out analyses for connecting dates, events, people etc. to confidently identify individuals, however, this is limited by the amount of analyses the user can perform. Automation of part of this process can alleviate and hasten the output for the user. In the area of Biometrics Enabled Intelligence (BEI), NGIC (National Ground Intelligence Center) has developed a reporting system based off of the biometric and associated contextual information found with specific repositories such as the BAT (Biometrics Automated Toolset) and BISA (Biometrics Identification System for Access). Here the biometric and associated contextual information is fused together from such repositories to establish reports. Note, that in the repositories where this information is stored, the data mapping and information being relayed has been done so in a standard manner, such as EBTS (Electronic Biometric Transmission Specification). However, the issue that arises is one of the biometrics enterprise level where information of the same type may and does exist in other repositories but is not necessarily being utilized in the same manner. Therefore, the objective of this endeavor is to develop architecture and algorithms to fuse biometrics with associated information across databases in a net centric environment. Though this capability exists, it is limited in capacity as mentioned earlier by the use of only certain repositories. This effort is to extend this capability beyond those aforementioned repositories to those with diverse data structures to offer an enterprise solution. The data structures will not display many commonalities which were more obvious in other repositories previously mapped and thus will require more extensive algorithms. Due to the large scope of this proposal, the actual effort will only

require data mapping across a few databases (preferably at least 2 or 3). The architecture will operate in such a manner that searches by name, date, or any other relevant option will result in corresponding biometric and contextual information of the search criteria where duplicative or mismatched information is resolved automatically. Such automation will most likely require algorithms focused on a select few ontology schema as well as data mapping between databases should their elements be non-equivalent. Because this is a small scale proposal of the larger biometrics enterprise, there is the risk that the architecture and algorithms may not work as quickly or effectively when scaled up. The ontology schema and data mapping will thus only work for this proposal but will still provide much needed research and development in this area for future cases. Also, the data being provided (most likely face, iris, fingerprint, contextual information) will be fictionalized which will undoubtedly raise the risk as opposed to analyzing empirical data.

Notably, this technology will aid in disrupting those operatives or situations where multiple identities of a single individual are discovered which is a form of spoofing. By having various search methods available to the operator, such as Boolean operators or multiple tiers of filtering, the results become more robust in being able to increase the confidence of identifying an individual. According to "Discovering Identity Problems: A Case Study" by Wang et al, a person's identity is defined by his attributed identity (name, DOB, ID#, address, phone #...), his biometric identity (fingerprints, iris, face, DNA...) and his biographical information (personal/familial relationships, upbringing, education...). The study based on criminals outlined attributed identity errors prompted by deceptive practices and unintentional entries. It notes that deceptive or erroneous counterparts are greater than 55%. Intentional falsely reported identity is about 30% and unintentional error occurring at about 42%. Biometric identity offers the intrinsic traits of a person, however, due to privacy issues, access, and incomplete collection its use cases are limited to mostly verification within closed systems. Assuming authoritative sources for biometrics samples are available, the fusion of these potentially available modes with related contextual data in other repositories should facilitate establishing an unambiguous identity of a POI. This is not to be confused with matching biometrics which is the highest possible confidence attainable on identifying an individual. This is rather to determine the confidence of linking and fusion between repositories of related contextual information to a biometric (if it is available) in identifying a POI. Also, this effort is not focused on biometric sensing, but a framework and methods to construct a POI profile consisting of biometric and contextual information. By automating such tasks as data fusion and identity linking, the Army will undoubtedly curtail major costs related to developing experience and training new analysts and the time necessary for actual execution of these skills. Whether linking and fusion takes place in theater or CONUS, it is a manual, lengthy process which does not always provide information in a timely manner. Thus, the proposed method will be to automate a component of this process to increase rate of production and efficiency.

**PHASE I:** Determine the most significant and relevant data elements of contextual information necessary to be mapped for identifying POIs. Provide a feasibility study on identifying POIs based off of the fusion of multimodal biometrics (face, iris, fingerprint) and associated contextual information in a net centric environment.

**PHASE II:** Develop a framework and methods for improving profile information of a POI for identification and tracking. Propose scenarios, evaluation methods, and use of test samples. Determine the measure of effectiveness and performance parameters to be tested. Construct a prototype and establish proof of concept. Complete spiral development refinement of framework and algorithms. Deliver software products for government evaluation, documentation and demonstration improving state-of-the-art technology.

**PHASE III:** The technologies developed in Phase II that have commercial potential will be transitioned in Phase III. Military applications will include a transition to DCGS-A to ensure interoperability with other military ground systems and will also be interoperable with other DoD agencies whose information may be fused into biometrics intelligence reporting. Developed products will have wide use in commercial markets. Market segments include fraud, identity theft, criminal deceit, personnel security, biometrics management, and safekeeping, improvements in multi-modal biometrics, information integrity, and protection. Commercial uses will include transitions to federal law enforcement, such as the FBI, DEA, USMS, and ATF, state and local law enforcement.

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KEYWORDS: IdM – Identity Management EPW - Enemy Prisoner of War, POI – Person Of Interest, CI/HUMINT – Counter Intelligence / Human Intelligence, MP – Military Police SSTR - Stability, Security, Transition, and Reconstruction

A09-076            TITLE: Forward HUMINT (Human Intelligence) Automatic Collection

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Develop a miniaturized (credit card size) physical device and associated software to convert voice to digital, provide embedded communications capability (two-way), and provide automated HUMINT (Human Intelligence) collection to the forward HUMINT elements.

DESCRIPTION: Technological advancements are required to automate the sending and receiving of digital information from forward HUMINT collectors to ground based SINCGARS receivers located at Brigade level within 15 Km of the forward Human Intelligent Collection units. For purposes of this SBIR, the receiver at the CHARCS brigade location can be either the SINCGARS (present configuration, or another receiver being developed under this SBIR). Credit card sized devices that take analog (voice) input and digitize it, forward it in real time to intelligence processing elements are desperately needed on the fluid modern battlefield. The availability of data from remote data bases i.e. Distributed Common Ground Station-Army (DCGS-A) would enhance the ability of the forward HUMINT elements to receive reference data when entering, interrogating, and exiting areas of interest/operations. On-site digitized information at the forward HUMINT level does not currently exist. The addition of this capability would reduce the information flow time for forward HUMINT information down to minutes from several weeks. The technological challenges for this approach include; miniaturization, power supply, antenna, processing, storage, throughput, and the Radio Frequency (RF) communications range. Technical Performance ranges are 15 Kilometers for communications, encryption is not required, however modern spread spectrum communication methodologies will apply to the communication waveform techniques employed. The voice-to-data translation rate shall be 96.5 Kbs. This is expected to require development by the successful offeror of the waveform, packaging advances, and algorithms for processing free-text data handling.

PHASE I: Perform a feasibility study of the hardware architecture, size, weight, and power for alternative approaches and present the most logical approach with supporting rationale. Perform studies of RF communications links (for purposes of this SBIR, the receiver at the CHARCS brigade location can be either the SINCGARS, present configuration, or another receiver being developed under this SBIR), interface for free-text data handling, software capacity for algorithms, processing, and data base capabilities. The technical challenge on speech recognition is to take verbal input and convert it to a digital free text format and from that to a DCGS-A format prior to transmission to higher levels (note: DCGS-A ICD can be obtained by registering with the site in reference 5 below); the lack of this capability has been identified by the User TRADOC System Manager at Ft. Huachuca as a critical enabling technology requirement. The technology challenge for wireless communications is twofold a) create the

communications capability in a small package that has the needed processing and analog to digital converter to support the free text to DCGS-A formatting and b)to enable the implementation of numerous waveforms in a small hardware package. The performance of the system receiver and waveforms are bounded by the requirement to transmit and receive over a 15 km distance in an urban hand-held application environment. The expected output of the transmitter is estimated to be 2 Watts and the receiver sensitivity is expected to be in the area of -95 dBm. The outcome of the Phase I study will determine the trade-off between SWAP (size, weight, and power) and performance (transmit and receive distances) for this hand held (ground based application) device and associated software. Size is expected to be that comparable in surface area to a standard credit card. The weight is limited to 5 lbs or less including power supply. The power supply is expected to be standard batteries or other alternative batteries commercially available that can support a mission of 7 days with 100 transmissions during that 7 day period. Commercial cell phone technology can be employed to satisfy this requirement but it is not the necessary solution to the required performance parameters specified herein.

PHASE II: Develop a prototype device that is compatible with both the Counterintelligence and Human Intelligence Tactical Reporting and Collection System (CHARCS) and DCSG-A. Perform demonstrations of achieved capability and baseline the prototype design in contractor format. Deliver one (1) complete prototype to the government with all necessary software and operating instructions.

PHASE III: This technology has a wide range of applications in personnel and corporate security areas to include homeland defense and local law enforcement agencies which would also benefit. The current plan is to incorporate this capability into the HUMINT Tool Kit, CHARCS, and other Army applications including the SEQUOYAH language translation system.

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KEYWORDS: Credit Card Size, Digitization, Miniature RF Communications Link, High Density Storage, High Processing capacity

A09-077

TITLE: Domain Name Server (DNS) Protection Techniques

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: Develop a successful Domain Name Server Protection Technique for the Army

DESCRIPTION: In July 2008, at the Black Hat Conference held in Las Vegas, the Kaminsky DNS vulnerability was announced. The Domain Name Server or DNS is a critical and integral part of the internet. Successful poisoning of this system can result in catastrophic consequences for the military should any military network domains be targeted by an enemy. Currently, there is only one way to mitigate this vulnerability, patching the DNS server. While this patch reduces the risk of DNS poisoning by an attacker, the patch by itself does not eliminate the threat from a formidable enemy. It has also been suggested that the only way to fully protect against DNS poisoning is to adopt the DNS Security Extensions (DNSSEC). In fact, the US Government has started to transition to DNSSEC, however, as with any new protocol there are always risks involved in rolling it out. This is especially true with a complex protocol like DNSSEC. The complexity of DNSSEC can delay or prolong the transition of DOD networks to the protocol, thus leaving a window of opportunity for a formidable enemy to successfully attack DNS servers. Additionally, DNSSEC may not be suitable for all network environments, in particular tactical environments. DNSSEC uses signed encryption keys that require a public key infrastructure to be in place. This type of infrastructure may not exist or may be in the process of being implemented in a tactical environment. For this reason, the Army is seeking innovative ideas from the small business community in protection techniques that can be used in addition to "patching", and in the interim of transitioning to DNSSEC to prevent an attacker from successfully launching DNS poisoning attacks against DOD networks. In addition, the techniques developed during this effort can complement DOD's defense in Depth strategy by adding another layer an adversary has to overcome in order to attack a DOD network.

PHASE I: The contractor shall perform a study to determine the various approaches toward attacking the problem. Towards the end of the study, the contractor shall present to the government the recommended approach along with the other options to pursue in Phase 2. The government will decide on the best option to pursue in Phase 2.

PHASE II: The contractor shall pursue to approach selected from the Phase 1 study. Approximately a two year effort will be undertaken to develop a prototype working model. At the end of Phase 2, a demonstration of the Phase 2 prototype shall be presented by the contractor to the government.

PHASE III: In Phase 3, the actual commercialization of the contractor product will take place. Possible uses for the product, in addition to the government, include any commercial areas, such as airports, electric utilities, banking, etc where dnssec is not feasible or a defense in depth strategy is required. These commercial applications are in addition to the various government applications, such as the Warfighter Information Network- Tactical (WIN-T) and the Joint Tactical Radio System (JTRS).

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KEYWORDS: DNS, Cache poisoning, BIND, DNSSEC

A09-078      TITLE: A Dynamic and Knowledge Driven Architecture for Airborne Minefield Detection

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics, Weapons

OBJECTIVE: Develop a dynamic and knowledge driven architecture for airborne minefield detection.

DESCRIPTION: Lessons learned from airborne minefield detection research and development in the past years has suggested that no single algorithm or static detection architecture is able to closely meet the minefield detection performance requirements under all operating conditions. This is true not only because of the highly varied environmental and operational conditions under which an airborne sensor is expected to perform but also due to the highly data dependent nature of sensors and algorithms employed for detection. Attempts to make the algorithms themselves robust to varying operating conditions have not been successful.

The dynamic and knowledge-driven architecture will provide more robust minefield detection for a highly multi-modal operating environment. The acquisition of the knowledge for this system is predominantly data driven, incorporating not only the analysis of historical airborne mine and minefield imagery data collection, but also other source information that may be available such as terrain, time of day, weather, pixel resolution, and minefield types. This source information is extremely important and embodies causal information that drives the detection performance. This information is not being used by current detection architectures. Moreover, the dynamic and knowledge-driven architecture supports the decision of the warfighter in the near real-time that improves greatly the minefield detection performance in unknown environments.

S. Agarwal et al have published the knowledge-based architecture at the SPIE conference in 2004. There are several drawbacks of their effort. The minefield detection algorithm was not used during the evaluation and the user in the loop was not used for the minefield decision. These are two important factors that make the performance better. Also, not all sources of information were used during the performance evaluation. Finally, different data sets had not been used to validate their architecture. In short, their effort began a good introduction of the knowledge-based architecture; only a complete work with extensive real airborne data testing will attest to the useful and powerful knowledge-based architecture that will greatly improve the minefield detection performance in all operating conditions.

The Countermine (CM) Division of the Night Vision and Electronic Sensors Directorate will provide the multi-spectral (visual and IR) mine and minefield data.

PHASE I: This proof of feasibility phase will focus on the development of a dynamic and knowledge driven architecture for airborne minefield detection. As a minimum, the architecture must include the following:

1. More than one anomaly/mine detectors
2. More than one false alarm techniques if used
3. Patterned and unpatterned minefield detection algorithms
4. Warfighter-in-the-loop decision
5. Autonomous, continual adaptation and selection of algorithms and parameters for better performance in the varying operating environment
6. Ability to support and act upon varied source information
7. Each algorithm or each processing technique must be confined in the module

Phase I will include a feasibility analysis supporting the approaches, and a demonstration to experimentally confirm the results. The decision of the warfighter will not be tested in this phase. Small data sets with source information will be provided for this effort. In this phase, the algorithms could be implemented in a suitable high-level language such as Matlab.

PHASE II: The task in Phase II is to further develop and refine the algorithms and the architecture on large quantities of real airborne data collected both in desert and tropical environments to maximize and quantify the robustness of the architecture. Automated and warfighter-in-the-loop's decision in the near real time will be fully explored and tested. Evaluation of the architecture based on the combined sensor data and each individual sensor data is also required. This effort will be subjected to a blind test. In this phase, each algorithm must be confined in the module, and the algorithms and software must be implemented in C/C++. Other software languages, if used, must be pre-approved by the Government. The delivered product would be a thoroughly documented software and algorithms prototype with a report or journal paper documenting the rationale and method by which the developed efforts are intended to operate.

PHASE III: This technology has numerous applications in the Army, Navy, the humanitarian de-mining area, and counter terrorism. A system with this technology could efficiently determine clear areas for safe convoy passing and land-use surveys. In this phase, software and algorithms source code and their detailed documentations must be included in the deliverable product.

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KEYWORDS: minefield detection, knowledge based architecture, warfighter-in-the-loop

A09-079            TITLE: Transition Metal Oxide Optical Switch

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: To test the ability of transition metal thin film oxides for use as a thermochromic optical switch with high absorption in the mid-wave (3-5um) infrared band but with excellent transmission in the long-wave (8-12um) infrared band in the semiconductor, or insulator, phase while having a several-orders-of-magnitude decrease in electrical resistance and optical transmission in both the mid-wave infrared (MWIR) and long-wave infrared (LWIR) in the metal phase.

DESCRIPTION: An optical switch works in much the same way as a light switch in a typical home. In this case, the optical switch activation occurs under the right physical conditions. In the past, oxides of Vanadium have been used, and these typically have a characteristic temperature of 68 C at which the switch "turns on." Once the switching material cools down, it effectively "turns off." The "off" stage exhibits a higher electrical resistance and optical transmission in the LWIR as well as a higher absorption in the MWIR. However, the "on" stage shows a several order of magnitude change in both electrical resistance and optical transmission in the MWIR and LWIR. These stages "off" and "on" are separated by a physical material phase change from a semiconductor, or insulator, stage to a metallic stage. Historically, optical switches have been used as laser modulators for optical communications both in free space and in the telecom industries, thus this study will include laser induced thermochromic optical switching. Recently, Vanadium Oxide optical switches were fabricated and tested electrically to show a thermal induced memory such that the switch hysteresis and switching characteristics changed after thermal cycling. This change in switching characteristics may make this switching material unacceptable for use as an optical or electrical switch; therefore, it is necessary to verify whether transition metal oxides exhibit these characteristics to determine the reliability of these materials within systems.

PHASE I: Test the feasibility of growing the optical switch on various substrates that have a high transmission in the MWIR and LWIR. Specific areas to be addressed are: intermediate-layer deposition, so that the optical switch will

adhere to the substrate, and how these layers affect optical switch performance; deposition temperature and its effects on layers and optical switch performance; Dopants and their effects on optical switch performance; and film thickness and its effect on switching performance. Deliverables: (1) Monthly reports, which will eventually be compiled and used for a final investigation report; (2) 1-inch diameter prototypes on various substrates for evaluation that can be delivered on an on going basis during development.

PHASE II: Using materials tested from Phase I, concentrate on optimization of at least 2-3 different prototype materials. Materials should have very narrow hysteresis with switching on and off speeds faster than 1 nanosecond, a high optical transmission change in the MWIR and LWIR from “off” to “on” and vice versa, and exhibit the ability to be thermally cycled by laser or conventional heating at least 50 times while exhibiting no thermally induced memory.

PHASE III: Focus on insertion of optimized filter from Phase II into a small footprint commercial thermal imaging system such as an Indigo Omega, BAE Systems HHC 100, or Scott Safety and Healthy Eagle Imager 160 or Eagle X. The use of this filter will concentrate primarily on protecting the focal plane array from damage induced by extremely high temperature scenes in fires or any number of scenarios where very high emittance of thermal radiation may cause damage to the commercial camera focal plane array. Use of a heater to bring the material near the switching temperature will be investigated and its effect on performance of the material, camera system, and battery life will be determined.

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KEYWORDS: Vanadium Oxide, Infrared, Optical Switch, Thermochromic, Transition Metal,

A09-080      TITLE: Array Processing Techniques for III-V Material, Strained Layer Superlattice, Mid and Long Wavelength, High Sensitivity Infrared (IR) Sensors

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: To demonstrate a durable process for fabricating high performance mid-wave infrared and long-wave infrared focal plane arrays from III-V material based Strained Layer Superlattice devices.

DESCRIPTION: The closely lattice-matched material system of InAs, GaSb, and AlSb, has attracted increasing interest for the development of new optoelectronic devices due to their unique band alignment and physical properties. The flexibility of the system in simultaneously permitting type-I, type-II staggered, and type-II broken-gap band alignments has been the basis for many novel, high-performance heterostructure devices in recent years, including the GaInSb/InAs type-II strained layer superlattice (SLS) infrared detectors. The effective bandgap of these SLS structures can be tailored to detect mid and long wavelength infrared by varying the thickness of the superlattice layers or by changing the composition of the materials. Several research groups have reported promising results by demonstrating detectors and arrays with mid and long wavelength cutoffs.

Most infrared detectors, specifically long-wave infrared sensing, require passivation of etched surfaces to achieve higher sensitivity, and the strained layer superlattice detectors are no exception. The lifetime of such detectors or

arrays greatly relies on the long-term stability of the passivated surfaces. This topic solicits innovative ideas for high performance SLS detector arrays that could avoid or minimize the open etched surfaces, i.e. eliminating volatility associated with passivation. Proposed technology should have an achievable goal of producing high performance long-wave infrared focal plane arrays with high yield and long-term stability.

PHASE I: Show feasibility of a durable fabrication process or novel device concept that eliminates or minimizes the surface passivation of III-V material based Strained Layer Superlattice detector arrays.

PHASE II: Further optimize the process demonstrated during Phase I and fabricate prototype high performance staring imaging focal plane arrays with a format of at least 640 x 512 x 25 microns. Demonstrate performance, including long-term stability, of this new and innovative technology at the array level through laboratory and/or field tests.

PHASE III: Develop and execute a plan to manufacture the sensor components developed in Phase II, and assist the government in transitioning this technology to the appropriate defense system(s) or prime contractor(s) for the engineering integration and testing.

Successful demonstration of this technology will lead to affordable, very large format long wavelength infrared focal plane arrays (FPAs) with high operability and long-term stability. Such a FPAs are in demand for space-based high altitude wide area persistent surveillance applications as well as systems that are being fielded with 3rd Generation infrared technology. If successful, there would be a high potential for transferring technology developed under this SBIR to the more general IR industry, where the dream of low-cost, high performance, large-format, LWIR arrays has yet to be realized. Funding would expect to come from the programs, such as MANTECH, or missile defense agency's FastFPA which is established to develop industry capabilities to fabricate infrared FPAs that can be tested, and eventually used by various ballistic missile defense systems (BMDS).

Apart from military, there are numerous commercial applications for inexpensive imaging infrared sensors. Commercial applications that may benefit from this SBIR include: i) medical applications such as thermographs; ii) transportation applications such as enhanced vision systems for airplanes, helicopters, sea vehicles, and automobiles; iii) law enforcement applications in drug prevention and criminal tracking; iv) forest industry applications for fighting forest fires; v) and environmental monitoring applications

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KEYWORDS: strained layer superlattice, passivation, long wavelength infrared, focal plane arrays

A09-081      TITLE: Identity Management of Biometric Data (IMBD) across the Global Information Grid (GIG) using a Service Oriented Architecture (SOA) Framework

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: PEO Enterprise Information Systems

OBJECTIVE: Develop a novel approach to address data mining, data compression, and network scheme that renders a reliable communication link to compensate for limited bandwidth at lower echelons. The approach will enable Commanders to securely disseminate and share biometric data, across the Global Information Grid (GIG), in real time, using a Service Oriented Architecture (SOA) framework.

**DESCRIPTION:** The war fighter has an extremely difficult task to perform with regards to the identification of threats. Biometric information gathering is a solution for capturing unique information about an individual. Soldiers continuously collect biometric data in combat areas. However, failure to share data, in real time, across the battlefield and counterterrorism agencies such as Department of Defense (DoD), Department of Homeland Security (DHS), and Federal Bureau of Investigation (FBI) can lead to endangering the lives of soldiers and U.S. citizens. Additionally, the Deputy Secretary of Defense issued a memorandum requiring the department to share unclassified biometric data with other agencies that have counterterrorism missions, as the law allows.

Although the military and counterterrorism agencies handle and process biometric data differently, the biometric data exchanged between these systems should be standardized. By developing procedures for standardized data, interoperability can be improved, thereby increasing the size of the network used to identify potential threats to security. Since the type of data collected is inconsistent among agencies and often not shared, defining a logical data model can create flexibility among users, and serve global operations taking advantage of a SOA implementation.

The goal of this SBIR is to develop a communications architecture that provides the war fighter with the ability to capture, disseminate and exploit biometric data in real time at the lower tactical echelons, as well as the means to notify other war fighters in theater of significant events. The architecture will provide the capability to communicate at the lower tactical level with nearly the same level of reliability as those communications at the strategic level. The architecture shall include a network from the tactical Biometric Automated Toolset (BAT) to the strategic Next Generation Automated Biometric Identification System (NG-ABIS) as well as timely reach back to information across counterterrorism agencies. The approach will provide highly robust signal processing techniques that will increase the reliability of the datalink.

**PHASE I:** The contractor shall analyze and determine the feasibility of sharing biometric data in real time, across the global information grid. The feasibility study will address collecting, storing, matching and sharing biometric data from the lower tactical level through the strategic level, and include defining a logical data model that will create flexibility and openness across the entire global information grid. The communication approach will include a network scheme that makes use of data compression algorithms that allow for transfer of large files and a reduction of consumption of transmission bandwidth at the lower tactical level. The decompression schemes for the compressed data shall not be detrimental to other applications, services or databases on the GIG.

In summary, PHASE I will include a feasibility study and the development of a proof of concept system to show technological progress on standardized biometric data exchange, defined biometric data models, and communication capability of biometric data at lower echelons with similar levels of reliability than strategic level communications, while utilizing data compression schema, and efficiently passing data throughout echelons. As a result of Phase I, the contractor shall prepare and deliver a System Design Specification that documents the approach to be used in Phase II for development of the prototype system, identifying the characteristics and requirements for the design. As an annex to this document the contractor will document the trade studies leading to this approach.

**PHASE II:** The contractor shall demonstrate development of a prototype system that addresses all requirements in phase I. The system shall also undergo preliminary field testing in a relevant environment where both the success of the data mining, data compression and identity management will be demonstrated over tactical radio communications. The contractor shall also demonstrate the integrity of the data, as well as, throughput in sending and receiving biometric data from multiple sources across the GIG. A likely transition path to a DoD Project Management Office (PMO) and/or the Biometric Task Force (BTF) shall be defined.

**PHASE III:** The contractor will deploy the prototype system in an operational environment during a scheduled field exercise. Upon successful completion of the exercise, final testing and evaluations will be conducted and documented to determine if the system is ready for transition to a U.S. Army Project Management Office (PMO). The most likely path for transition would be to PM DoD Biometrics.

The prototype system architecture shall fulfill the PMO urgent need to share biometric information with the specified government agencies and improve as defined in Phases I, II, and III the end to end communications from the tactical Biometric Automated Toolset (BAT) to the strategic Next Generation Automated Biometric Identification System (NG-ABIS).

It is envisioned that Identity Management for Biometric Data (IMBD) would be desired for other applications and agencies such as border control and disaster relief who frequently coordinate with both domestic and foreign nations, militaries and personnel.

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KEYWORDS: Biometrics, Counterterrorism, Data Mining, Data Sharing, Data Compression, Global Information Grid, Service Oriented Architecture, Tactical Communications, Identity Management, Network Scheme, Biometric Automated Toolset, Next Generation Automated Biometric Identification System, Strategic Communications

A09-082            TITLE: High resistivity VOx for Continuous Bias Read-outs

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

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

OBJECTIVE: To demonstrate higher resistivity vanadium oxide for smaller pitch very large focal plane arrays with continuous bias read-out

DESCRIPTION: Current uncooled VOx focal plane arrays use ROICs that incorporate pulsed bias. As arrays become larger and larger, continuous bias may be necessary to ensure good sensitivity with short time constants. This represents a paradigm shift in the uncooled sensor arena. The effort would focus on developing growth methods for higher resistivity vanadium oxide for small pitch (12 micron) very large (1920x1080) focal plane arrays.

PHASE I: Develop and demonstrate feasibility of higher resistivity vanadium oxide wafers with high (greater than 2%) thermal coefficient of resistivity. Deliver sample wafers to the government.

PHASE II: Develop continuous bias read-out circuitry. Deposit vanadium oxide such that 35mK and 10 msec time constants (or less) are obtained. Deliver focal plane array with sufficient electronics to demonstrate good sensitivity and time constant to the government.

PHASE III: Very large uncooled focal plane arrays have utility for fire-fighting and security operations. Military uses include helmet-mounted and distributed aperture systems. Phase III would focus on developing a camera that exhibits good sensitivity at a short time constant.

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KEYWORDS: uncooled, focal plane arrays, vanadium oxide

A09-083      TITLE: Develop High Operating Temperature Infrared Detectors and Systems

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Investigate and validate that the recent advances in III-V material technologies of new device concepts, simplified device processing, improved uniformity, and higher yields can be refined to develop and demonstrate fielded high operating temperature (HOT) thermal imaging camera systems.

DESCRIPTION: There is a high demand for thermal imaging cameras for hand-held and surveillance applications that operate at high temperature, which would reduce power consumption and increase the camera lifetime. Current mid-infrared (3 to 5 micron) imaging focal plane array (FPA) technologies based on indium antimony (InSb) and mercury cadmium telluride (HgCdTe) technologies require cooling to 77 Kelvin, have power requirements of more than 6 Watts and are limited by mean time between repair lifetimes, of less than two years. For example by reducing the cooling power consumption to less than 1 W and increasing the lifetime to greater than 10 years requires using a detector capable of operating at high temperatures, specifically temperatures greater than 170 K. The power necessary to cool such detectors would be under 1 W, and the lifetime of such a cooler can be an order of magnitude longer than a micro-cooler tasked with maintaining a temperature of 77 K.

Therefore, minimizing power consumption and maximizing camera lifetimes are most important to enhance the ability of the war fighter. A camera with low power requirements results in longer battery life and reduced battery weight. The result is soldiers who are more mobile and can be deployed on longer missions. Long camera lifetime reduces the overall equipment cost and increases the number of cameras available for use by soldiers.

PHASE I: The expected result is to show, through analysis and the open literature that it is feasible to fabricate a high operating temperature (HOT) mid-infrared (3 to 5 micron) focal plane array (FPA). HOT implies non-uniformity correction adjusted operating temperature of at least 170 K.

PHASE II: Produce a prototype HOT imaging camera system utilizing less than 1 Watt power consumption that demonstrates an image at 170 K with 99.5 % pixel operability.

PHASE III: Deliver prototype HOT imaging camera system to Night Vision and Electronic Sensors Directorate for in-house characterization and field testing.

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KEYWORDS:

A09-084      TITLE: Small Pitch Flip-Chip Interconnects for Focal Plan Arrays/Readout Integrated Circuit Hybridization

## TECHNOLOGY AREAS: Information Systems, Electronics

**OBJECTIVE:** Develop a new process, or improve upon a current one, that allows for smaller pitch flip-chip interconnects between a focal planar array and a read-out integrated circuit. This goal would be to achieve a pitch of 5um or smaller and should be capable of withstanding stress associated with thermal cycling down to 77°K.

**DESCRIPTION:** Infrared focal planar arrays require read out circuitry that processes the light sensed by the focal planar 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 Read-out integrated circuit is fabricated separately on a silicon substrate and bonded, or hybridized, to the focal planar array. There are several qualities of this bonding material that are critical to the long term operability of a focal planar array. Nearly all HgCdTe/CdZnTe infrared photodetectors require cooling to increase their signal to noise ratio. Additionally, Silicon and CdZnTe have a greatly different thermal coefficient of expansion. Thus, when the two materials are thermally cycled, they will expand and contract by different amounts. The current standard industry process involves a liftoff of thick thermally evaporated indium layer. Because the indium is relatively tall and flexible, it is able comply with the differences in thermal expansion between the read-out integrated circuit and focal planar array. Also, as indium is cooled to 77°K, it maintains this flexibility and does not become brittle. While indium appears to be a suitable interconnect material, it becomes more and more difficult to perform the evaporation and liftoff process as the pitch of interconnects decreases. This results in a sacrifice of the performance of the focal planar array as more and more interconnects fail.

This solicitation seeks an innovative approach to fabricate small pitch, high yield interconnects for flip-chip hybridization of HgCdTe focal planar arrays to Si read-out integrated circuits. The target interconnect pitch should be 5um or below. The interconnect design should ensure that no loss of yield will occur due to stress caused by thermal cycling down to 77°K. Additionally, the solution proposed should minimize changes to current industry equipment, minimize required changes to detector and ROIC design, it should be broadly applicable to different focal plane genre (i.e. HgCdTe, InSb, InGaAs, silicon, etc.) with minimal process variations, and process temperatures should be kept as low as possible, with a 160°C upper limit, though maximum process temperatures of 100°C would be preferred. Highly toxic interconnect materials should not be considered as a solution.

**PHASE I:** Begin to develop the flip-chip interconnect process proposed. Greater importance should be placed on the novel aspects of the process to demonstrate its feasibility by the end of Phase I. The minimum required deliverables for Phase I include a set of monthly technical reports and a final report detailing progress of the program.

**PHASE II:** Complete the development of the flip-chip interconnect process proposed. Once completed, demonstrate the bonding of a dummy HgCdTe/CdZnTe focal planar array to a dummy silicon read-out integrated circuit using the proposed process. The goal for interconnect pitch is 5um or smaller. Testing should be conducted to confirm high bond yield, the ability to withstand stress caused by thermal cycling down to 77°K, and high bond strength. The minimum required deliverables for Phase II include a set of monthly reports and a final report that discuss progress of the program, along with a successfully hybridized dummy HgCdTe/CdZnTe focal planar array to a dummy silicon read-out integrated circuit with the smallest achieved bump bond pitch.

**PHASE III:** This technology could be used in infrared cameras 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 or 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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KEYWORDS: Night Vision, Infrared, Indium, Bump Bond, Flip Chip, Hybridization, Focal Planar Array, CdZnTe, HgCdTe

A09-085            TITLE: Proactive Adaptive Channel Reconfiguration (PACR)

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Existing techniques for performance enhancements to communication systems employ techniques such as coding or interleaving to provide an either perfect or unacceptable connection. The transition region is normally steep resulting in the system working one second and not the next, with no graceful degradation. This concept examines and predicts the environment based upon a learned data base, and problems are avoided entirely by adapting the system's operating parameters to avoid these predicted problems. In this way the user does not experience a fault, or even degradation since the system avoids it.

DESCRIPTION: Existing communication systems rely upon the user interface to the application layer to determine when a connection is no longer viable, resulting in a termination of the connection on all layers of the OSI 7 layer model and the reestablishment of the overall link to continue. The primary cause for the link being terminated is hidden and the fix relies on the reestablishment process to go through the OSI stack and correct the offending layer(s) by the normal process of establishing all 7 layers. The result is additional latency while the connection is being reestablished, and in particularly volatile connections, as seen in forward deployed forces or similar low power unmanned sensors, due to the sensitivity of the connections, is the significant probability that any non-dependent layer connection parameter selection, may become non-usable before the overall layer structure can be determined. As an example: consider a ad-hoc unmanned sensor system that is trying to route between nodes, as the routing tree becomes established it is entirely possible that the RF physical layer connection may make the newly completed route tables invalid. To solve this problem it would be optimal to determine a failure in the physical layer, say due to frequency specific interference and reestablish the physical connection at a new clear RF channel. In this way the upper network layer can proceed in its current routing waiting only for the specific problem in the physical layer to be corrected.

The natural and anticipated extension to this, which is the primarily expectation in this SBIR topic is a proactive approach where cross layer negotiations allow the "weakest link" to be identified and improved before the connections fails, in this way the throughput is not interrupted as the repair to the proper layer is in process. These cross layer negotiations must consider their interrelationship and the reconfiguration capability of each layer.

Existing cross layer manipulations do not add the anticipatory aspect proposed in this program. For example a channel access period parameter may consider a Maximum Transmission Unit (MTU) size to optimize the pair but does not predict that the channel accesses period is decreasing, possibly due to additional users and that a proactive effort should be made to the link layer to decrease the MTU size properly related to the future channel access trend.

Most beneficial applications for this technique will be in volatile networks where optimization of tracked parameters will occur frequently and result in less dropped connections. Similarly, a seldom used network would benefit substantially since the network use profile could be included in the access variability of the network to correlate when changes to the network would be needed based upon its anticipated use or criticalness of the link. For example, a network that consisted of nodes that are emplaced for the long haul can have there initial configurations vary significantly between the time the system is emplaced and it needs to be used. In this case an urgent need to use the network would require extensive layer independent guesses to bring connectivity back up, thus making the entire network unavailable for an extensive time while these independent guesses settle down. If instead a routine maintenance schedule were determined by this SBIR that diagnosed an ailing layer of the model that needed to be corrected then this could be done with minimal system usage, and the changes further optimized as they affect other layers during the next scheduled maintenance period.

To synopsise: periodic maintenance calculated from collected data will result in an optimal working connection when needed, or allow for continued operation that does not adversely wear susceptible parts.

PHASE I: Specific tasks for this SBIR would include: Inter layer relationships, both system dependent and independent techniques to analyze deteriorating or improving layer operational parameters, and interrelated Return On Investment relationships between changes to various layer operating parameters. Initial exploration would be conducted on 802.11 type Wi-Fi systems due to their susceptibility to interference, ubiquity and potential for future commercial activity.

Collective node sharing information and theoretical performance enhancements by adaptive reconfiguration. Here the components which could be used in an operational system will be identified and the system modeled.

PHASE II: Software influenced network configuration algorithm embedded in the applications layer to control lower layers of the network stack. During this phase a demonstration model of the system in operational mode will be provided.

PHASE III: Small network dispersed node automatic reconfiguration offered to ubiquitous networking systems, typical of 802.11 networks in a small office or home. This product would allow items to be disbursed in a random/convenient fashion and the algorithm used to determine not just the proper initial connections but also be able to adapt the possible existing connectivity as changes occur such as the turning on of a microwave or a cordless phone being picked up.

Military applications for this product will allow the devices to continue their intended operations rather than fail when in the midst of operating. For example, a sensor network which is to detect a vehicle may have as its primary path to the soldier through the vehicle it needs to detect. The result is the signal would be blocked just when the critical bit needs to be communicated. In this program the initial disturbance of the vehicle will cause the networked to be reconfigured in anticipation of the channel being destroyed.

With the type, speed, and latency requirements for both WIN-T and FCS information, this topic will need to provide support for the warfighter using automated techniques to enhance the delivery of information. The ability to anticipate the changes to the network and reconfigure to guarantee communications when these changes occur will greatly enhance the overall performance to the war fighter. This topic will react independently to the changing environment and adapt the network connections accordingly.

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KEYWORDS: Adaptive configuration, Learned response, User experience

A09-086            TITLE: Refillable Liquid Fuel Cartridges for Portable Methanol Fuel Cell Systems

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Design, develop, and deliver a safe, cost-effective refillable liquid (i.e. methanol, ethanol, butanol, liquid chemical hydride solution, etc) fuel cartridge adaptable to a minimum of three (3) separate fuel cell systems.

DESCRIPTION: The DoD has a need for high-energy density, lightweight power sources for soldier power applications in the 20W to 100W range. Much of the development focus of the past several years has centered on development of the fuel cell energy conversion module itself rather than the fueling source. The goal of this program is to develop a standardized, rugged, and refillable fuel cartridge for a variety of liquid fuels, caustic and acidic.

The packaged fuel cartridge must be compact, safe, and have sufficient stored energy to operate the hybrid fuel cell demonstrator for the entire duration of the 72-hr mission. There are no restrictions on the fuel cell technology. Ideally, technologies that can show simplified logistics over current fuel cell and battery systems and a path towards reducing commercial energy costs to < \$0.25 / Watt-hour (for a minimum 1000-hour lifetime) will be favored [1]. Hot-environment performance of the demonstrator should be rated for safe operation up to 55 degrees Celsius (131 degrees F) and safe storage up to 71 degrees Celsius (160 degrees F).

PHASE I: Identify three methanol fuel cell technologies and system developers for which the proposed fueling source would be applicable and provide letters of support from each. Design a fueling system that could be scaled to a minimum of three different sizes (for example: 250-milliliter, 500-milliliter, and 1-Liter) with standard quick-disconnect mechanical and electrical interfaces while working with same methanol fuel cell system original equipment manufacturers (OEM's). Design a bulk refilling method so that cartridges can be interfaced with a 55-gallon drum and refilled in safe and efficient manner. Demonstrate the fundamental principles of the specific fuel cell and fueling technology in a lab experiment. Control and thermal management principles should be demonstrated to indicate potential safety and hydrogen delivery issues (where applicable) and show that any undesired effects can be mitigated. Mission energy density (for 25-Watt, 72-hour mission), logistics tail, and commercial energy costs (\$ / Watt-hour) should all be projected and at least one of those metrics should demonstrate a clear ability to be competitive with current packaged fuel solutions (the other two metrics should be acceptably comparable to incumbent technologies).

PHASE II: Fabricate a minimum of nine (9) fuel cartridges and integrate with three (3) fuel cell systems (three cartridges per fuel cell system), at the breadboard level, the fueling system that was developed in Phase I. Demonstrate operation in environments up to 55 degrees C and storage in environments up to 71 degrees C. Demonstrate limited MIL-STD-810F survivability of fuel cartridge (minimum of dust/sand, water immersion, and shock/vibration tests). Develop a business case analysis showing the logistical benefits of the technology. This analysis should contain a commercial energy cost (\$ / Watt-hour) approximation that incorporates cartridge synthesis, production / packaging, recycling / disposal, and transportation cost estimates. Deliver three (3) fuel cartridges to the government for independent evaluation. Monitor and work with DoD agencies to support portable fuel cell system fluid connector standardization activities.

PHASE III: Dual Use Applications: Developments in safe, high-energy liquid fuel cartridges for portable fuel cell power systems will have immediate impact on a wide range of military uses as well as commercial power sources such as computer power, emergency medical power supplies, recreational power, as well as other applications. Products developed under this SBIR topic will be transitioned into CERDEC's Mounted / Dismounted Soldier Power Army Technology Objective and eventually transitioned into PEO Soldier's Land Warrior, Ground Soldier System, and Future Force Warrior programs of record.

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KEYWORDS: Refillable fuel cartridge, portable fuel cell, methanol, soldier power

A09-087      TITLE: Any-Time Cognition for Network Centric Environments

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Design, develop and demonstrate the algorithms and software components required to enable any-time cognition of the warfighter or team to improve distributed collaboration and decision making in network centric operations.

DESCRIPTION: Current Networks can deliver vast amounts of information to commanders and teams. The volume of information and pace of action made possible by network centric operations (NCO), threatens to overwhelm human decision makers negating NCO's potential for offering more accurate information, shared situation

awareness, better decisions or improved mission performance. For NCO to succeed, technologies must be developed for managing the attention and cognitive resources of the decision maker. The obstacles are many and varied: abundant information has the risk of overloading warfighters; it is difficult to understand the information needs of individuals and teams; current technology is not capable of capturing the context of the warfighter or team to determine what information is needed now and what can be delayed.

In complex automated systems the decision maker's attention is often the most limited resource. Some actions, such as recognition of tactically meaningful patterns, can best be performed by a human. When the human decision maker is attending to competing tasks, however, some decisions may not be taken or tasks may be left undone. Adjustable autonomy where automation responds to evidence of decision maker overload by performing or delaying the task is part of the solution. In cases where human judgment is crucial, however, preventing or delaying a decision may not be an option. Any-time cognition is needed to make sure these crucial decisions get made. Unlike anytime algorithms that can compute progressively refined solutions, the level of refinement and corresponding delay of human decision making are strongly dependent on the information being provided. Research is needed to identify and test automation strategies that can manage the cognitive resources of a decision maker to produce any-time cognition.

This SBIR aims at developing agent-based any-time cognition technology to address these shortcomings. Any-time cognition is defined as an agent supported ability to monitor the evolving warfighter's environment and situation, understand warfighter's current needs and future intent, and adaptively provide information tailored to the time available for its utilization in decision making. The agent(s) determine how much information, at what granularity and specificity, when and what mode of presentation to use to allow the most effective utilization of the information in decision making. If the agent estimates that the human has more time available, it will present information in more detail to facilitate decision that takes more factors into consideration. On the other hand, if the agent determines that the decision is time stressed, it will provide information at a higher granularity and only the most important factors to allow a timely decision. The result is a hybrid human automation system that is cognitively and situationally congruent.

The development of this technology must overcome many challenges: automated detection of warfighter's context, intent and cognitive state. No matter what techniques are used to identify cognitive overload, the most crucial problem lies in determining how to reduce the information to fit the available cognitive capacity of the decision maker, so decisions can be made within appropriate time bounds.

PHASE I: Investigate methods for calculating cognitive load, such as task analytic estimates, self reports etc; investigate intent inference techniques; situation assessment methods; agent technologies; information presentation and dissemination; adjustable autonomy schemes to determine best algorithms and architecture approach to meet the topic requirements. Develop and document the overall software component design and accompanying algorithms.

PHASE II: Develop and demonstrate a prototype capability for insertion into a realistic NCO Command and Control (C2) scenario. One of the key sub-goals of phase two will be to establish performance criteria and metrics for the hybrid human automation system that allows for the assessment of Any-Time Cognition to enable automated detection of 1) warfighter context, 2) warfighter intent and 3) warfighter cognitive state. The prototype will implement best of breed algorithms in the architectural approach investigated in Phase I, using C2 scenario that should support tactically viable timescales for Network Centric Operations. The Phase II deliverables will include a software prototype and documentation describing the potential performance criteria for any-time cognition.

PHASE III: The end-state for Any-time Cognition would be to transition as a software component or service for military decision support/course of action analysis (COAA) software systems such as the Maneuver Control System (MCS) or the emerging Defense Advanced Research Project Agency (DARPA) Deep Green program. This SBIR can also assist Tactical Human Interaction with Networked Knowledge (THINK) Army Technology Objective (ATO) in achieving its objective of increasing information relevance. The capability should create the novel hybrid human automation system that should aid the human by appropriately providing information to the decision-maker and his staff in a collaborative environment where context, intent and cognitive state are all parameters that are used by the any-time cognitive capability. Ideally, this capability will provide the ability to effectively mitigate the information overload challenges in a Network Centric Environment from a more human centric perspective.

There are several civilian applications that could benefit from this type of approach where large volume of complex data has to be dealt with as part of decision making process. Domains that could be impacted by this software capability include: Air traffic control, civilian planning for police and fire activities, and Homeland security & disaster recovery mission planning.

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KEYWORDS: Anytime Algorithm, Knowledge Management, Cognitive Resources,

A09-088            TITLE: Context Based Data Abstraction

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a generalized computer software system that is able to reduce the amount of data required to successfully perform a given task by producing an abstract model of the data, populating the model with real world data, and then using the model to perform the task.

DESCRIPTION: Human information processing capacity is often a key factor in the success or failure of military operations. Humans require information to understand the situation, recognize risks and opportunities, and to make informed decisions. Insufficient information can lead to mission failure but, perhaps counter intuitively, too much information can result in information overload which can also have a deleterious effect on mission success. In order to reduce cognitive burdens, engineers have developed abstract models which are less complex than the real world. Users can then interact with the simpler model yet still obtain useful results. The obstacles facing such models are numerous and include the possibility of incorrect predictions being made which lead to incorrect information and modeling or the omission of datum which may skew the model. Terrain elevation information is a good example of building an abstract model well: Elevation samples are taken at regular intervals. By doing this a vast amount of information is discarded, yet the resulting abstraction is useful for maneuver planning.

In general an abstraction is a model that differs from the real world in that it ignores some data. Hopefully the data is not relevant to the problem the model is being used to solve. What data is germane to the model is determined by the context the model is used in. In other words some abstractions are appropriate and useful for some tasks while others are not. Such abstractions could be useful in tasks which involve modeling cognitive burden or social networks where infinite amounts of data can be considered in the model. While some of it could be safely ignored when building the abstraction deciding what this includes is difficult.

For this Small Business Innovation Research, the contractor will study the general technique of abstraction as a mechanism for reducing the amount of data required to produce useful models. The usefulness of a model is judged relative to the given context or use to which the model will be put. This means that the contractor will be required to explore general mechanisms for describing contexts and the demands that those contexts place on data. Further the contractor will devise a way of describing data that will be used to feed the models. The Small Business Innovation Research result will be to produce a collection of software tools to define data, define contexts, and to provide

continuous data abstraction models. These tools should enable users to more easily develop abstractions that reduce human cognitive burdens yet do not negatively impact mission success.

PHASE I: Develop a design for a tool set to produce abstract models based on descriptions of the context the models will be used in and descriptions of the input and output data. The Phase I deliverables will be a report describing the state of the art and the design.

PHASE II: Build and demonstrate a generalized abstraction system based on the Phase I design. The demonstration must show how contexts and data are defined and how the tools use these definitions to generate abstract models that reduce the amount of data required to achieve mission success.

PHASE III: Integrate the capability developed in Phase II into an appropriate Battle Command application. During this phase, the capability needs to clearly demonstrate an ability to meaningfully and quantitatively reduce the cognitive demands on a decision maker or a collaborative team of decision makers operating within the confines of the context-based data abstraction model. The end-state of such a capability would be a Network Centric Warfare (NCW) software service or application that reduces a commander and/or his staff's cognitive burden during mission planning or execution. Also, the ability to easily design abstract models has non military application to many forms of situation management including emergency management. The topic will be linked to ATO R.ARL.2009.05 THINK

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KEYWORDS: information processing, data, abstraction, cognitive, model, human

A09-089 TITLE: Innovative Silicon Imager for Head-Mounted Night Vision

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: Develop and implement innovative techniques and designs for optimizing silicon as a photo-detector for use in head-mounted night vision sensors. To receive consideration for award, the proposed approaches must be fundamentally novel and potentially ground-breaking, not merely refinements or extrapolations of existing approaches for signal collection, signal gain, and/or signal readout. These techniques and designs shall be incorporated in prototype imaging sensors whose measured data satisfies no-moon nighttime requirements for radiant sensitivity, signal amplification, overall noise floor, and power consumption. A critical consideration of proposed approaches will be the potential sensor signal-to-noise ratio over a nighttime spectral power band ranging from the Near-Infrared (700 nanometers) to the Short-Wave Infrared (1300 nanometers). Under no-moon nighttime conditions, the incident radiant power over this band ranges from 1-10 picowatts per square centimeter per nanometer.

DESCRIPTION: Silicon remains the pre-eminent detector material for charge-coupled devices (CCDs) and Complementary Metal Oxide Semiconductor (CMOS) arrays, also known as Active Pixel Sensors (APS). The commercial market for such devices has enabled leap-ahead advances in silicon pixel design, but the thrust of these advancements has been directed towards ever smaller pixel dimensions and formats, with only modest gains for low-light imaging at the shot-noise level. Such low-light applications generally require larger pixel sizes (approx. 10-microns), a thicker photosensitive layer (>15 microns) for sufficient near-infrared sensitivity, unfiltered spectral

response (i.e., monochrome), and larger formats (approx. 16mm diagonal), in conjunction with state-of-the-art levels for thermal dark current and signal readout noise. Most critically, head-mounted night mobility applications also demand high resolution (>1 megapixel) arrays, low total power (<2 watts), and minimal motion-smearing during the normal head-panning required for situational awareness, which has typically mandated a 60 Hertz frame rate.

Recent approaches for achieving the above have met with only limited success. The thicker silicon needed for near-infrared sensitivity results in significant optical crosstalk, thereby imposing an intrinsic tradeoff between high-light Nyquist imaging and low-light, noise-limited resolution. On-chip CCD signal amplification techniques to mitigate readout noise have incurred both high excess noise and prohibitive power consumption (10-20 watts). Optimized silicon design/fabrication techniques have reduced thermal dark current levels to 10 picoamperes or less per square centimeter at room temperature, but such levels still require temperature stabilization for effective sensor operation at high ambient temperatures (>35-deg Centigrade).

Recent innovations in silicon-based photo-detectors for optimized signal collection, signal gain, and low-noise signal amplification have demonstrated the potential to extend useful nighttime spectral sensitivity beyond the conventional silicon cutoff (1100 nm) out into the short-wave infrared spectral band. Such a silicon-based detector holds the potential of enabling leap-ahead night vision capabilities for a low cost, low power, solid-state sensor.

PHASE I: Develop, fabricate, characterize, and deliver a silicon-based photo-detector compatible with conventional silicon CMOS or CCD fabrication techniques, with useful nighttime room temperature (300K) response ranging over 600 to 1300 nanometers. Data provided for this photo-detector should include the following: (1) Detector spectral quantum efficiency measured throughout the 600-1300 nm spectral band that is not less than 0.10 (or 10%); (2) Photo-detector signal response between 600-1100 nm that is measured to be not less than 10 amperes/watt; (3) Detector signal-to-noise ("D-Star" or "D\*") that is measured to be not less than  $5 \times 10^{12}$  cm(Hz<sup>1/2</sup>)/W at some point within each of the following spectral bands: 600-800nm; 800-1000nm; and 1000-1300nm. This detector shall be delivered in industry-standard packaging to enable follow-on Government characterization.

PHASE II: Develop, fabricate, characterize, and deliver a silicon-based photo-detector array compatible with conventional silicon CMOS or CCD fabrication techniques, with useful nighttime room temperature (300K) response ranging over 600 to 1300 nanometers. This photo-detector array shall comprise a minimum of 100 pixels and shall be capable of generating still images and/or image sequences at an effective pixel integration time of 30 milliseconds or less. These images/image sequences shall demonstrate useful imagery when the photo-detector array is illuminated with not greater than one (1) picowatt per square centimeter per nanometer over the 600-1300 nm spectral band. This photo-detector array shall be delivered in industry-standard packaging to enable follow-on Government characterization.

PHASE III: The Phase III effort shall include the development, fabrication, characterization, and delivery of a prototype silicon-based imaging camera based upon conventional silicon CMOS or CCD fabrication techniques, with useful nighttime room temperature (300K) response ranging over 600 to 1300 nanometers. The camera shall provide Nyquist-limited resolution when it is illuminated with not greater than 10 picowatts per square centimeter per nanometer over the 600-1300 nm spectral band. This camera shall comprise a minimum array of 320 x 240 pixels, a maximum array format of 16mm (diagonal), and shall operate at a minimum 30Hz progressive frame rate. The total power consumption shall be not greater than one (1) watt.

In addition to their pervasive role in military nighttime mobility and fire control tactics, low-light sensors have a growing presence in the commercial arena. Industrial security, police surveillance, fire & rescue, and day/night remote tele-presence are among the applications that would benefit from true no-moon nighttime imaging at much lower size, cost, and power consumption than existing low-light solid-state sensor solutions.

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KEYWORDS: Night vision, solid state, silicon detector, CMOS, active pixel sensor, CCD

A09-090 TITLE: Heat Actuated Cooling System

TECHNOLOGY AREAS: Ground/Sea Vehicles

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 heat actuated cooling technology by designing and building a prototype unit capable of providing air-conditioning and heating at high and low ambient temperatures. The energy efficiencies, based on the fuel heating value, will be competitive with or superior to utilizing an existing diesel engine driven generator sets to power fluorocarbon-based vapor compression Environmental Control Units (ECUs). The cooling unit will be capable of converting the heat of combustion of JP8 and DF2 directly into cooling rather than relying on electric power.

DESCRIPTION: The development of key heat actuated cooling components is necessary to allow further development of integrated co-generation and tri-generation systems in the size ranges applicable to military standard families. The results of SBIR Topic 2007.1 OSD07-ES1 – “Portable Cogeneration of Power and Cooling” have demonstrated that current net weight and volume of heat actuated cooling systems exceed that of generator-driven vapor compression systems of similar capacity. A smaller, lighter, more efficient heat actuated cooling system will lead to a smaller power source and increased mobility for tactical users. This will directly enhance the deployability of the Objective Force.

A military standard family of ECUs exists, all of which operate using chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). The Army has 25,000 units fielded ranging from 0.5 to 5 refrigeration ton cooling capacity and the US Air Force has about 10,000 fielded units as well. Most of these units are nearing the end of their useful lives, and will have to be replaced soon. This presents a unique opportunity to “leap ahead” with the introduction of a cheap, efficient, and easily supportable refrigerant and reap the benefits of small size and weight, higher efficiency, and greater heating performance.

Each overall design has its advantages and disadvantages in terms of energy efficiency, capacity, controllability, size, weight, production cost, and maintainability. A successful design will find the optimal balance of the trade-offs given the requirements and constraints of a given application.

The primary target application for this heat actuated cooling system is the Standard Integrated Command Post Shelter (SICPS), which is essentially a large rigid-wall shelter that sits on the back of a HMMWV. Currently, a 10kW auxiliary power unit (APU) is used in combination with a 18,000-BTU-per-hour (or 1.5-ton cooling) split pack ECU. Approximately 3-kW are used for hotel loads within the shelter and ~7-kW is used for the ECU. Information on the SICPS APU is here: <http://www.pm-mep.army.mil/technicaldata/10kwapu.htm>. Current Army systems weigh approx. 290-kg (both 10kW APU and 18kBTU/h ECU) and consume 1-gal-per-hour of fuel. The end goal for this SBIR topic is to demonstrate technology readiness level (TRL) 5 technologies for this application with 205-kg dry weight and 0.7-gal-per-hour fuel consumption.

PHASE I: Significantly advance the state-of-the-art through novel design and development of one or more of the following key components for the heat actuated cooling unit: evaporator, absorber, desorber, control system, or other novel components. Design and model the overall system to demonstrate its feasibility and key features, including performance characteristics over a wide range of operating conditions for cooling and heating.

PHASE II: Design and fabricate full size working prototypes in nominal 1.5-ton cooling capacity as developed in Phase I. Fabricate and test these prototype ECUs to military requirements using laboratory test stands.

PHASE III: The results from the Phase II effort will afford the contractor the capability to provide US Army and the DOD a new family of advanced state-of-the-art scalable heat actuated cooling systems (350 – 35000 W) for use with

small (battalion), medium (brigade), and large (division) applications and in all extreme tactical environments. Resulting key cooling components can transition to upgrade existing commercial cooling systems to optimize performance and reliability. Resulting system designs have potential to transition to automotive applications, commercial cooling and heating market , high-tech applications (Global Positioning System (GPS), composites, etc) and applications which support the Global War on Terror Advanced (emergency mobile hospitals, temporary field police stations and developing nations) .

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KEYWORDS: air-conditioning, cooling, heating, heat exchanger, condenser, evaporator, absorber, desorber, burner

A09-091            TITLE: Rapid Frame Rate Focal Plane Arrays for Active Electro-Optic Applications

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Ammunition

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 a high speed focal plane array and readout for insertion into standoff vibrometers, Laser Radar (LADAR), or other coherent optical detection sensors.

DESCRIPTION: The army seeks two-dimensional focal plane arrays suitable for active electro-optic detection. These transducers are applicable to laser vibrometers and LADAR which in turn shall support multiple needs: maneuver support for detection of Improvised Explosive Device (IED) and landmine detection, battlespace awareness for observation of human activity and infrastructure mapping, and line of sight lethality through target identification.

Emerging focal plane array technologies suggest that read-outs can achieve frame rates of 4 million frames per second for limited size arrays. Insertion of this technology into existing sensor designs has the potential to greatly reduce size and complexity of such systems. The proposal shall discuss the focal plane array design to be performed in phase 1 and how fabrication and laboratory demonstration is achievable in phase 2. The demonstration shall provide at least 3000 pixels in a rectangular format. The focal plane array does not necessarily need to be square but both dimensions shall have 30 elements or more to achieve greater than or equal to 3000 pixels. The read-out shall sample each pixel at a sampling rate greater than 4 mega samples per second. The phase 2 demonstration shall show this functionality in either a vibrometer or LADAR application. Careful attention shall be paid to carrier-to-noise ratios to maintain accuracy of the post-processed data.

PHASE I: Determine technical specifications of a focal plane array with at least 3000 pixels each with 4 mega samples per second or greater. Develop an initial concept design and model key elements of the array and readout. Provide model results that predict performance under received optical intensities as would be observed in field applications. Provide a detailed plan for the fabrication process.

PHASE II: Construct and demonstrate the operation of a prototype array in a laboratory vibrometer or LADAR application. The demonstration shall verify pixel independence, 4 million frames per second, and readouts that will support continuous acquisition. The raw output data will be stored and processed for verification of a calibrated vibration source or target range, real time processing is not required.

PHASE III: The transducer development outlined here could be inserted into a variety of active electro-optic applications. The vibrometer application is currently being pursued for IED and landmine detection at standoff distances and LADAR systems are implemented in a variety of military systems for target identification. Commercially one might envision visual or infrared images combined with range information for interactive virtual environments where objects are viewed in 3d color. This type of application might then be used for battlefield simulations or remote teleoperator applications.

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KEYWORDS: focal plane array, LADAR, LIDAR, readout, frame rate, laser vibrometer

A09-092      TITLE: 50- 100 Watt Wind Energy Harvesting in Light Tactical Applications

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

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

OBJECTIVE: To develop a vehicle mounted energy-conversion efficient, wind turbine system that can be quickly erected and stowed. It must be capable of operation and movement over the range of military environmental and transportation conditions.

DESCRIPTION: Wind as a source of alternative energy is rapidly becoming a viable resource for electrical energy generation. A system capable of efficient conversion of wind to electrical energy is well suited for on-the-move applications. The major challenge is to develop a system that can be quickly deployed and rapidly stowed away in a rigid container for transport in less than 4 minutes. The rigid container will prevent turbine component from physical damage during transport. The system is expected to operate in harsh weather environments including wide daily swings in temperature, sand and snowstorms, hail and rain, and strong winds in excess of 60 mph.

The energy requirement for Army communication, situational awareness and target acquisition systems that are candidates for this system is estimated to be between 60 – 100W. Currently this power is being supplied by either the vehicle or an external generator. The wind turbine will supplement energy supplied by the conventional generator. This may result in savings on engine usage. Depending on the load and wind conditions, between 10-100% and that will lead to savings on fuel and maintenance while reducing air pollution.

The applications for commercial, consumer sectors and Government agencies are substantial. These applications include hybrid vehicles, electrical power for remote locations, backup power for telecommunication devices and computers, and forestry service sensors.

In addition to turbine development the effort must address the efficiency of the system generator coupled with an electronic control to effectively extract wind energy. It is desired that the system provide a minimum of 50 W of power in a 12 mph wind. Output should be a nominal 24 volts DC.

This SBIR seeks to investigate the possibility of development a rapidly deployable wind turbine for mobile applications by employing currently available technology. The development must address ease of use, compactness, resilience and energy conversion efficiency.

PHASE I: The purpose of this phase is to conduct a five month study and experimentation leading to selection of a potential turbine designs that will be easily deployed and stowed. Upon completion of this phase the following criteria is expected to be met:

1. The turbine can be stowed in a container to occupy a minimum of 1/8 of the turbine's deployed volume.
2. The time required to deploy and stow the system should not exceed 4 minutes.
3. Demonstrate that the turbine can provide 50W of electric power at 12 mph wind. The system shall not exceed 45 pounds.
4. Provide a concept study to demonstrate that the device will maintain specified performance when subjected to severe environmental conditions of a continuous exposure to fine dust/sand, salt spray, temperature ( -40 to +120 C), UV and petroleum products (fuel, lube).

PHASE II: The purpose of this phase is to further develop a mobile wind generating system with emphasis on an efficient generator and power conversion electronics for maximum power point tracking. The maximum power point tracking will engage the generator to optimally convert wind energy to electricity. Upon completion of this phase the following criteria are expected to be met:

1. Demonstrate high efficiency power conversion of the generator
2. Demonstrate improved performance of the system over a wide range of wind speeds from 8 to 25 mph by employing maximum power tracking circuitry. Demonstrate the system's ability to self-protect itself in wind speeds above normal operating conditions, up to 60 mph.
3. Demonstrate system packaging and in transport resiliency of the system in adverse weather environments.
4. Demonstrate system's ease of both rapid deployment and stowaway process.
5. Deliver a prototype for evaluation and testing in government laboratories

PHASE III: Based on Phase II results, select the best possible designs for the military and/or commercial markets. This phase focuses on developing a product for mass production and intended for field implementation and for commercial/consumer markets. These applications will include hybrid vehicles, electrical power for remote locations, backup power for telecommunication devices and computers, and forestry service sensors.

1. Develop methodology for high production and cost reduction for both military and commercial markets
2. Deliver prototypes for field evaluation in military environments of operations to evaluate over-all performance.
3. Introduce enhancements into design if cost effective and develop prototype system for field and commercial applications

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**KEYWORDS:** Wind energy, alternate energy, natural resources, operational cost savings, hybrid vehicles, hybrid gas-electric vehicles, power for remote locations, remote sensors, emergency services,

A09-093            **TITLE:** Metadata Databases

**TECHNOLOGY AREAS:** Information Systems

**OBJECTIVE:** Develop a database system that stores and retrieves intelligence information based on the information's meaning rather than on exact data matches. This system should function without the need for users to specifically classify information being stored in the database by requiring users to manually apply predetermined metadata.

**DESCRIPTION:** When planning and executing a mission, operations staff members need to gain access to the intelligence information that supports the tasks they are to perform. The Commander requests information based on his training and experience. For example, when planning a mission with CPOF (Command Post of the Future) if the Commander is trying to find an enemy in an urban setting, he might request information about roads leading out of the area in order to place roadblocks so as to make escape less likely. What the Commander might not think to ask for are similar points of exit from the area such as storm drains, rivers, or footpaths. In the context of blocking escape all of these exit points have the same meaning. Experience teaches Warfighters what information to ask for but Warfighters don't know what they don't know. In general Warfighters only get the information they ask for and without sufficient experience they may not ask for all available relevant information. Often getting the right information involves a dialog between operations and intelligence. In lower echelon tactical units there is no intelligence staff so commanders are largely on their own.

For this SBIR, the contractor will research and develop a database system for storing and retrieving intelligence information based on the information's meaning rather than on predetermined manually assigned categories. The contractor should consider demonstrating methods of querying the intelligence database from within an operations planning system such as CPOF. This might be done, for example, so that when an operator requests all available routes out of a specified city, CPOF will have the ability to retrieve all similar information about the city's exit points. In general, though, because data is meaningless when taken out of context the developed system must also provide a method for defining the context that supports the information's meaning. For example, the concept of a "road" can have different meanings and as a result return different related information depending on the context in which it is used. A search for "blocked" roads should yield much different information than a search for "paved" roads. The developed system must therefore have the ability to introduce new contexts and a method to automatically categorize incoming information based on its meaning within the contexts.

**PHASE I:** Research existing work in this area, perform an analysis of alternatives and document the strengths and weaknesses of the approaches. Select an approach and design the system. The design must specifically address how context-based meaning will be represented, how information will be automatically categorized based on meaning,

how queries will be made for information, and how the system will respond when confronted with new or novel inputs. The Phase I deliverables will be the analysis of alternatives and the system design.

PHASE II: Build and demonstrate the system, capable of storing information and retrieving information from available sources such as C/JMTK databases, based on the retrieved information's meaning rather than on predetermined manually assigned categories. The demonstration must show how the system will work with an Army planning system such as CPOF and be based on real world Army-relevant data. The contractor will propose and implement a realistic Army mission-based use case for the demonstration. The use case must show how mission relevant information can be retrieved from database by the planning system and how the system can suggest additional useful information based on meaning of the request and the associated mission context. The Phase II deliverables will be the functional system integrated with a planning system and available Army intelligence data sources, the use case, and the demonstration. While the approach for this Phase of the SBIR will utilize specific Army systems, the proposed solution should be flexible enough to be modified to support other Battle Command systems and commercial information systems as well.

PHASE III: The ability to store and retrieve information based on meaning within a given context has applicability to Internet searching and any mission-based planning activities such as construction, emergency management, or advertising campaign planning. This is in support of Tactical Battle Command Systems and FCS and the COBRA ATO (D.C4.2009.03).

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KEYWORDS: database, metadata, information retrieval, information storage

A09-094      TITLE: Novel Growth and Processing of an Extremely High Performance, Low Defect FPAs Utilizing HgCdTe on InSb Substrates

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To develop an appropriate and reproducible cleaning process for InSb substrate prior to the MBE heteroepitaxial growth of HgCdTe and/or CdTe and to demonstrate improved material quality for long wavelength infrared (LWIR) HgCdTe-based detectors and focal plane arrays on large-area InSb substrate.

DESCRIPTION: The next generation of infrared sensors will be based on large-format (megapixel) arrays of photovoltaic detectors with multi-spectral capabilities. II-VI compound semiconductor alloys of HgCdTe have been shown to be ideal materials for detecting infrared radiation at wavelengths of tactical and strategic interest. To create useful detector arrays, thin films of crystalline HgCdTe must be deposited on suitable substrate materials. Suitable substrate materials must have similar bonding properties, crystal lattice spacing, and thermal expansion behavior as the deposited HgCdTe films. Properly matched substrate materials will enable the deposition of high-quality HgCdTe layers without propagation of crystalline defects from the substrate interface. Ideal substrate materials will also permit straightforward integration with Si-based detector readout circuits while providing thermal and mechanical stability under cryogenic operating conditions. Current CdZnTe substrates for HgCdTe deposition remain limited by high cost and availability in relatively small areas, (~50 cm<sup>2</sup>). Low-cost alternative substrates, including Si, Ge and GaAs, are limited by large lattice and thermal expansion differences with HgCdTe. The result of this large lattice mismatch is a high dislocation density (~5x10<sup>6</sup> cm<sup>-2</sup>) for the HgCdTe film. These dislocation densities have been shown not to impact the SWIR and MWIR detector performance. However, for LWIR detectors, these defect densities have a significant impact on device performance. The current group of lattice mismatched

substrate alternatives may not be suitable for LWIR device and array fabrication in the near future. Thus, a reduction in dislocation densities is needed for adequate LWIR and VLWIR HgCdTe FPAs.

The physical properties of InSb suggest a nearly ideal, alternative substrate for HgCdTe heteroepitaxy. InSb substrates are nearly matched to HgCdTe in both lattice constant and thermal expansion coefficient, and are commercially available in higher quality than the currently used CdZnTe substrates. InSb substrates have dislocation densities at two orders of magnitude lower than for CdZnTe. In addition, bulk InSb is now available in sizes up to 5 inches in diameter (6 inch substrates under development) at approximately 10X lower price per area than bulk CdZnTe. Thus, InSb offers a unique pathway to lower-cost, larger-format LWIR HgCdTe-based single and dual color detectors without sacrificing detector performance. The main concerns that need to be addressed to succeed in an improved epitaxial growth of HgCdTe on InSb include surface preparation (removal of oxide while maintaining surface structure and stoichiometry) and procedure for avoiding In<sub>2</sub>Te<sub>3</sub> at CdTe or HgCdTe growth initiation.

**PHASE I:** Suggest innovative technique for making InSb suitable for epitaxial growth of HgCdTe and/or CdTe as a buffer layer. The proposed technique should address issues such as the uniform removal of the tenacious oxide from the surface of InSb, interdiffusion of In and Te, compatibility of the InSb substrate with annealing, and concerns associated with the interface, sticking coefficients. The exit criteria of this phase should include a demonstration of etch pit density (EPD) with objective values of below 10<sup>4</sup> cm<sup>-2</sup> to a threshold of below 10<sup>5</sup> cm<sup>-2</sup> range.

**PHASE II:** Show the practicality of large-area growth (threshold = 3" diameter) with reasonable material uniformity. Optimize growth to yield HgCdTe photodiode test structures on the new substrate. Develop an strategy for InSb substrate removal prior to activation anneals along with wafer transfer and bonding to enable subsequent processing. Estimate yield of low defect layers and assess cost effectiveness in comparison to industry standard CdZnTe and Si substrates.

**PHASE III:** Expand on Large-area (greater than 3" diameter) deposition of HgCdTe photodetectors will enable low-cost manufacturing of high-resolution, high performance infrared focal plane arrays for improved targeting and detection. Current work on two-color and hyperspectral infrared staring arrays will benefit from fundamental advances in HgCdTe substrate technology. By reducing total cost per pixel, large-area substrates could enable new commercial applications such as sensor arrays for high-resolution medical imaging, navigation, and fire/rescue aid.

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**KEYWORDS:** HgCdTe, CdZnTe, Molecular Beam epitaxy, heteroepitaxy, substrate, InSb, Si, CdTe.

A09-095

**TITLE:** Integrated Multi-Criteria Decision Analysis and Geographic Information System for Environmental Management

## TECHNOLOGY AREAS: Information Systems

**OBJECTIVE:** Develop a seamless, user-intuitive software platform for integration diverse data sources including, spatial and temporal data, value and judgment criteria and quantitative environmental models output to provide a comprehensive risk management tool.

**DESCRIPTION:** Environmental management of military sites requires decision-makers to integrate heterogeneous technical information with stakeholder values and expert judgment. Currently models exist that specifically address the technical or numerical environmental conditions and separately to provide decision analysis. Numerical models include those that predict environmental fate and transport and risks associated with potentially toxic chemicals and military compounds as well as impacts associated with military and civil works operations. Specific models of interest include, the Adaptive Risk Assessment Modeling System (ARAMS), TrophicTrace and FishRand models for bioaccumulation and food chain transport of chemicals in aquatic environments, and the Spatially Explicit Exposure Model (SEEM) for assessing risk associated with spatially-distributed compounds in terrestrial environments. Some of the quantitative environmental models currently include at least rudimentary geospatial capability, however, none of the programs seamlessly integrate existing GIS data. The output from the quantitative models can be entered into decision analysis models and software, however, no platform for seamless transition and integration has been developed. Environmental managers would significantly benefit from a user-intuitive tool with site-specific and project-specific application of quantitative environmental models integrated with Multi-Criteria Decision Analysis (MCDA) and Geographic Information System (GIS) that would ensure seamless integration of value/judgment, geospatial and numerical data or output.

**PHASE I:** Develop integration methodology and prototype software functional with a typical desktop computing system with Windows operating system. A hypothetical case study should be developed that illustrates integrated quantitative environmental, GIS and MCDA capabilities for risk management or environmental planning. At least two existing quantitative environmental models (ARAMS, TrophicTrace, FishRand, or SEEM) should be integrated into the case study. Phase I should result in prototype software, to be refined and extended in Phase II.

**PHASE II:** Phase II should result in a working software platform with intuitive user interface with flexible application to a range of problems typical to contaminated and disturbed site management. Software design should be automated to allow implementation using libraries of models, GIS tools and decision needs. Multiple MCDA tools (e.g., MAUT, AHP, Outranking) should be implemented as a part of the software. The GIS module should implement kriging and other standard geostatistical analyses.

**PHASE III:** Assessment of the modeling results for various sites (military and civilian) and application needs. Use guidelines must be developed and tools for prioritization and decision support should be finalized. The evaluation of the commercial product would be performed in this phase. This technology has potential commercial applications in the areas of land use management (both military and civilian), remediation of contaminated sites, and restoration planning.

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**KEYWORDS:** Multi-Criteria Decision Analysis (MCDA), Geographic Information System (GIS), Environmental Management

## TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop materials and processes to: (1) facilitate self healing and self diagnosing of composite materials; and (2) to improve bonding between reinforcement fibers and matrix in multifunctional composite materials. These multifunctional composite materials will be used to make novel layered structural protective systems for protection of physical assets and protection of personnel to defeat emerging adaptive threats.

DESCRIPTION: Emerging multifunctional materials will be used in military construction to provide multifunctional capabilities to self diagnose, while providing for layered protective systems that incorporate multiple defeat mechanisms for the mitigation of blast, ballistic, and debris and to provide soldiers and selected/designated civilian personnel with improved protection from the effects of weapons including the kinetic, nonkinetic, chemical, biological, nuclear, explosives, projectiles, and provide for electromagnetic (EM) shielding.

Advanced fiber reinforced polymer (FRP) composite materials have been increasingly used in many applications relevant to the Army's transformation. This is because FRP composites possess properties that give them several advantages over traditional materials. In general, FRP composites offer high stiffness and strength to weight ratios and are durable in harsh environments. However, currently used reinforced polymeric materials are limited by weaknesses in bonding between fiber and matrix due to defects induced by stress and/or chemical interactions introduced during manufacture, as well as inherent weaknesses of the polymeric matrix. There is a need for a new generation of multifunctional materials that have capabilities to strengthen at the interface and to self heal when stressed.

Recent laboratory investigations indicate that additives can be incorporated into FRP composites that contain chemicals that repair damaged areas and prevent further damage from occurring. Past approaches to self-healing materials have taken the form of microcapsules or filaments that rupture and release their contents when damage occurs to the nearby region. However, these additives suffer from the inability to release their contents more than once. A new generation of materials is needed that can self heal especially at damaged areas near the fiber-matrix interface. These materials also need to be capable of reporting the degree of damage by changes in optical and/or electrical properties. The goal of this SBIR would be to develop promising technologies into full scale components and commercialize products for military and civilian use.

PHASE I: Conduct research on the materials and processes required for innovative self-healing and self diagnosing multifunctional materials that can self repair, when damaged by high velocity impacts or high stress. Such multifunctional materials are expected to be able to retain at least 80% of their original shear strength at fiber/reinforcement interfaces and at interfaces between ceramic/FRP materials. Since the microcapsules are distributed throughout the material, it can be expected that the entire area damaged will self-repair.

For example, "smart" microcapsules and filaments may be induced to release their self-repairing compounds when damage is imminent. The self-repair action in the "smart" microcapsules should be initiated by mechanisms that rely on sensing of a decrease in shear strength and/or stiffness, prior to damage, rather than just breaking of the matrix or fiber reinforcement, as is currently done with microcapsules now available. Also, conduct research on the use of electrically or optically additives that can be used to interrogate the multifunctional materials especially at the fiber/matrix interfaces to determine their integrity at any given time. The optical additives are to be integrated into the matrix of the multifunctional composite material, rather than just adhered onto the surface of the composite as is done in conventional sensing. Metrics for success will be: (1) achievement of identifications of 75% of damaged areas, (2) achievement of repair of damaged areas with 80% of original strength/stiffness, and (3) demonstration of multiple releases (at least two) of healing compounds from the same area. Demonstrate the capabilities at the laboratory scale, and down-select the most promising technologies for further development, based on achievement of the metrics listed above.

PHASE II: Design and test high strength high stiffness, self-healing, self diagnosing multifunctional materials, which meet the metrics defined in Phase I, for construction of military critical facilities, such as Command Control Communication, Computer, Intelligence, Surveillance and Reconnaissance (C4ISR) equipment and facilities that

increase service life by at least 30%, beyond a nominal 15 years, based on Standard ASTM life cycle tests that simulate actual service environments. Develop additives and processes that can add these self-healing, self-diagnosing capabilities to FRP composite materials with ceramic blast shields, with the intent of scaling up to full sized multifunctional composite components for commercialization.

PHASE III: DUAL USE: Commercialize self-healing, self-diagnosing multifunctional composite materials for use as components in both military and non-military buildings and structures in industrial and extreme (e.g., highly corrosive) environments. The resulting structural components would have high stiffness, higher strength and toughness for increased service life. These lightweight long-lasting components would also find applications in the ground transportation industry, and particularly in the aerospace industry.

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KEYWORDS: multifunctional composites, polymeric composite, self healing, self diagnosing

A09-097      TITLE: Tension/Extension Test Device for Ultra High Strength Concretes

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design and demonstrate a direct tension and extension device for quantifying the mechanical properties of ultra high performance materials, such as concretes, to better protect army personnel and assets. Develop technologies and demonstrate a direct tension and extension device for quantifying the mechanical properties of ultra high performance materials as well as conventional urban materials to (1) better protect army personnel and assets, and (2) design scalable weapons to defeat hard targets.

DESCRIPTION: Within the Army, there is a strong need to better predict the behavior of structures exposed to dynamic loading events. Past research on the subject has primarily focused on studying targets that were constructed using conventional construction materials. The concrete materials tested, for example, had nominal unconfined strengths of between 20-35 MPa and could be found readily around the world. To evaluate the mechanical behavior of these materials, researchers typically conduct a series of carefully controlled experiments on right-circular cylinder samples. Data collected from these compression and tensile experiments were ultimately used to develop material constitutive properties that were eventually input into computational models. These data have been limited by the fact that testing equipment for measuring the tension/extension properties is stress controlled rather than strain controlled and post-peak strain softening properties necessary to quantify damage to masonry materials has not been obtained.

In the past decade, research has begun to shift more toward ultra-high performance concretes that not only have extremely high compressive strengths but, in some cases, have good tensile properties as well. Researchers have found that due to the improved tensile strength of these materials, more information on the tensile behavior of these materials is needed. Specifically, modelers need to obtain the post-peak tensile properties of ultra-high performance concrete materials and standard conventional urban construction materials to accurately predict damage in numerical simulations.

The machines that were previously used to test brittle geologic and man-made materials do not have the loading or confining capabilities to fail these new materials nor do they have the necessary control to obtain post-peak material property data. To capture the post-peak behavior of these brittle conventional and new ultra high-strength materials, new technologies are required. New, yet-to-be-developed equipment is needed that will be capable of controlling the deformation of the specimen during tensile failure. Clearly, computer-controlled, servo-hydraulic systems will be a viable part of this new technology but it is unclear to what extent and how it will be configured (stress-controlled versus strain-controlled).

Several current Army technical research thrusts are studying these new materials with the intent of either defeating these new materials or using them as protection for their assets. In the protection arena, passive protection systems that are being developed and designed include new high strength materials. In the LOS/BLOS/NLOS lethality area, weapons are being developed to provide lethality over match against conventional urban and hard targets ranging from conventional to ultra high strength. All of these areas have a need for the damage properties made possible by this technology, making this equipment commercially viable. The mechanical properties obtained through this technology/device will be used to develop constitutive relations for use in numerical simulations that predict the material responses from ballistic/blast loads. Without the needed technologies/device, protective material development, new scalable weapons, and specialized urban breaching demolitions will take years and be far more expensive due to the necessity of many required field experiments. The experimental program could be pared down significantly by conducting numerical predictions making use of the tensile and extension properties made available by the proposed technology/device and hence, saving time and money.

**PHASE I:** Complete a conceptual design of a direct tension/extension device capable of testing a 2-inch-diameter, 4.5-inch-long sample at confining pressures up to 200 MPa. Deliverables for the Phase I effort will be an analysis of control requirements and completed mechanical design of a direct tension/ extension device. In a Phase I option, researchers will need to develop an instrumentation architecture that, aided by state-of-the-art servo-hydraulic controllers, will be able to accurately measure the post-peak behavior of ultra-high performance materials in tensile environments. Novel measurement tools are expected in the Option 1 effort that will allow researchers to measure up to 10 percent lateral and axial strains on the specimen as well as hold measurement precision to less than .025 percent. Contractors will be evaluated based upon credibility of design concept(s), functionality, ease of use, expected device precision, and overall cost to build and test.

**PHASE II:** Complete construction of the steel pressure chamber, installation of the instrumentation and fittings, incorporate the servo-hydraulic system for applying tensile stress, perform initial testing of the device, and demonstrate the direct tension and extension device designed in the Phase I/ Phase I option is capable of capturing the post-peak behavior of high-strength concrete, geologic, and man-made materials in a tensile environment.

**PHASE III:** The technologies developed in this program will have direct applicability to the geotechnical and servo-hydraulic communities. In addition to the current technical need for such a system, the maturing of ultra-high strength concrete manufacturing capabilities will open up new technical uses for these materials (as a potential replacement for armor, for example). With these new uses, the need for high-quality tensile properties will be one of the most important material parameters to understand. Manufacturers of ultra high-strength concretes will need to provide reliable tensile data to the customer to demonstrate quality and repeatability. The development of a standardized testing procedure with the Tensile/Extension Test Device shall be determined by ASTM or another certifying agency.

Indirectly, the high-precision instrumentation that will be developed in this program could have direct applicability to the automotive, shock and vibration, and fatigue industries. Additionally, the pressure vessel advancements made in this program will lead to new applications in the space, aircraft, and submarine industries through improved seal designs and/or new seal materials.

From a business standpoint, the commercialization of these technologies is a critical portion of this program. Proposals for this effort should show a clear plan from technical development to marketability.

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KEYWORDS: Confining Pressure, Direct Tension, Extension, Ultra-High Strength Concretes and Materials, Post-Peak Data

A09-098            TITLE: Vehicle Payload Detection at Low Speeds through Weigh-in-Motion

TECHNOLOGY AREAS: Sensors

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

OBJECTIVE: Develop sensor system, in surface-mounted and in-ground configurations, that measures the axle and wheel weights of slow moving (<10 mph) passenger vehicles for stand-off detection of anomalously loaded sedans.

DESCRIPTION:

A. Requirement: To measure the axle and wheel weights of slow moving passenger vehicles for determination of whether a vehicle carries a concealed payload, such as a vehicle-borne improvised explosive device (VBIED). ERDC-CRREL in 2007 demonstrated the feasibility of detecting hidden payloads (>400 lbs) in compact sedans using a commercial weigh-in-motion (WIM) sensor system. [The WIM analytical method devised by ERDC-CRREL does NOT require knowing the unloaded weight of a vehicle.] The WIM sensor system that was tested is representative of current technology in that it is designed to measure axle weights typical of loaded tractor trailers while the vehicles are moving at highway speeds. Although the WIM sensor system was shown to be capable of measuring the axle weight of sedans, a limitation associated with the dynamics of slow moving vehicles could not be overcome. This imposes a lower limit of ~20 mph vehicle speed for detecting anomalously loaded sedans. The commercial WIM technology cannot be used to detect hidden payloads in slow-moving (<10 mph) passenger vehicles, such as sedans approaching an entry control point or a traffic control point. Also, the existing WIM technology cannot be used in/on gravel or packed soil roads, such as might be found at hasty check points.

B. Desired capability / concept of the final product: A sensor system that accurately measures the axle and wheel weights of sedans and light trucks that are moving at speeds of <10 mph to 30 mph (performance range of 5 – 30 mph). The sensor system will have two configurations, one for emplacement in gravel, packed soil or pavement (asphalt or concrete), and one for expedient surface emplacement on pavement, gravel or packed soil. The sensor system's weigh-in-motion capability will be adaptable to road layouts ranging from straight, level travel lanes to serpentine approach lanes. The sensor system will determine the number of axles on a vehicle and, for two-axle vehicles, calculate various vehicle parameters, including gross vehicle weight, the ratio of (front, rear) axle weight to

gross vehicle weight, and the ratio of each wheel weight to other wheel weights, axle weights and gross vehicle weight. Weights will be accurate to within 10 lbs. When a vehicle parameter or weight exceeds (is less than) a user-specified maximum (minimum) value, the sensor system will activate a trigger for the purpose of cuing other equipment. The weight determinations, parameter calculations and triggering will occur in real time.

The current WIM data analysis devised by ERDC-CRREL makes use of the measured gross vehicle weight and the measured front axle weight to detect anomalous weight distribution. In testing to date, with various vehicles, payloads and payload distributions, it has been a reliable discriminator of payloads located in the trunk or rear seat areas of sedans (equivalent locations for trucks and vans). Techniques to detect front-seat payloads are still under development. It is anticipated that the specified capability to measure wheel weights will be important in this effort.

C. Technical risk: There is significant technical risk in providing the desired capability because of the unconventional WIM aspects required of the final product. The primary risk relates to the road conditions under which the final product must provide reliable weight measurements. Current WIM systems are limited to paved roads with straight, flat travel lanes, and impose restrictions on the quality of the pavement (e.g., no heaving, significant cracking or other roughness), its slope from crown to shoulder, and its deflection under vehicle passage. The desired capability removes these limitations by functioning reliably when the sensor is installed in gravel, packed soil or pavement, and when the vehicle lane is serpentine in layout.

- The final product must accurately measure wheel weights of a vehicle traveling rough road surfaces, including the undulations that develop in gravel or packed soil roads, which can bounce some of a vehicle's weight off a tire and result in invalid determinations of load distribution. Its operation cannot require that the road (paved, gravel or soil) be maintained flat at the WIM sensor location.
- When installed in or on gravel or packed soil, the final product must persist in accurately measuring wheel weights despite weather-related variations in the state of the gravel or soil. A factor in system performance might be the dependence of road deflection on, for example, whether gravel is loose or encased in ice, or soil is dry, wet or frozen.
- The final product must incorporate a means of isolating a vehicle's static weight distribution from the dynamic load distribution (lateral weight shifts) associated with a vehicle following a serpentine course. Vehicle weight refers to the loaded weight of a vehicle, i.e., vehicle, occupant(s) and any payload.

The technical risk associated with developing a WIM system that is accurate at low vehicle speeds (<10 mph) is judged to be moderate. Slow moving vehicles present a longer interval for multiple sensing events as the vehicle interacts with the WIM sensor, and they do not bounce as much on rough surfaces. The challenge may be to develop a system that measures wheel weights to an accuracy of 10 lbs in the performance range of 5 – 30 mph vehicle speed.

PHASE I: Phase I focuses on selection and testing of candidate sensor types (piezoelectric, fiber optic, etc.) for measuring the wheel and axle weights of slow-moving, light vehicles (sedans, small trucks) traveling on pavement, gravel or packed soil. Signal processing for weight determination from sensor output is demonstrated (at breadboard level) using vehicles of known weights traveling paved roads, including serpentine layouts. Deliverables are a report on the elimination testing of candidate sensor types, a report on the signal processing trials, and a design concept for the sensor system that supports both fixed/permanent and expedient/temporary installations.

PHASE II: Phase II develops, demonstrates and validates the Phase I sensor system design concept to include operation on/in gravel and packed soil as well as pavement. Signal processing is finalized. A prototype vehicle-weight sensor system is constructed, tested in two configurations (in gravel/soil/pavement and surface mounted) for straight and serpentine traffic lanes, and demonstrated at CRREL or at a location approved by the sponsor. CRREL personnel are instructed on the installation and operation of the sensor system.

One deliverable is a prototype sensor system that accurately measures the wheel and axle weights of sedans and light trucks moving at slow (<5 – 10 mph) to moderate (10-30 mph) speed; calculates, reports and archives vehicle parameters; and activates a trigger according to user-specified threshold values of the vehicle parameters or weights. The other deliverables are a report on the performance testing of the sensor system and an operator's manual that includes installation guidance.

PHASE III: The vehicle-weight sensor system has high commercialization potential. In the public sector, it fills a technology gap for weight monitoring of commercial vehicles moving at low speeds typical of urban settings. Applications would include diverting overweight commercial vehicles from low-weight-limit bridges and, for homeland security, detecting anomalously loaded passenger vehicles in the vicinity of government buildings or critical infrastructure. In military applications, it is a force protection measure for real-time standoff detection of anomalously loaded passenger vehicles as they approach an entry control point or traffic control point. It also supports covert monitoring of road networks for awareness of VBIED vehicles on the move.

REFERENCES. None.

ERDC-CRREL has not yet published on hidden payload detection. The cited 2007 feasibility study led to an intensive data collection in October 2008, which was directed at further testing and refinement of the CRREL weigh-in-motion analytical method that enables payload detection from measured axle weights without requiring that the unloaded weight of a vehicle be known. Open publication of the results will follow. Current summaries of results are designated For Official Use Only.

KEYWORDS: Weigh-in-motion, sensor system, vehicle payload, threat vehicle detection, vehicle weight

A09-099            TITLE: Optimally Designed Wireless Seismic/Acoustic Ordnance Impact Characterization System

TECHNOLOGY AREAS: Information Systems, Electronics, Weapons

OBJECTIVE: Optimal design of wireless sensor array and deployment scheme(s) based on range-specific criteria, including the seismic velocity structure, in order to assess ordnance impacts (high- or low-order and dud) and to record ordnance impact locations within an accuracy of 1-2m.

DESCRIPTION: As military testing and training facilities develop new live-fire ranges to support continued conventional training and future force joint training, there is great need for safe, cost-effective methods to deal with the issue of duds or unexploded ordnance (UXO) on mortar, artillery, helicopter fire, and bombing ranges. A viable approach is to use the seismic/acoustic signatures of impacting ordnance not only to accurately locate the impact but to classify the event in terms of UXO-producing duds, low order detonation, or full detonation. The location and classification information can produce an archival documentation of range usage and status. The archival documentation then supports periodic maintenance of ranges for long term sustainable use and a reduction of future liability under BRAC and FUDS site remediation of UXO. The technical challenges that research and development efforts should address are: (1) optimal design of solid state, low power consuming, remotely powered wireless sensors and wireless sensor arrays for range-specific ordnance impact events; (2) optimal design of wireless sensor/array deployment schemes based on range-specific criteria, including the seismic velocity structure, in order to achieve an impact assessment (high- or low-order and dud) and a location accuracy of 1-2m; (3) development of a wireless network architecture to eliminate the difficulties inherent in installing and maintaining a hard-wired system; (4) development of a near-real time data processing, display, and data storage system (5) validation of system design, concepts, and implementation in a relevant environment. While the sensor array(s) will generally be deployed outside/around the range impact area, sensors within the impact area are potentially feasible.

PHASE I: Provide conceptual designs of a wireless multi-sensor array(s) system that assess and document ordnance impacts (high- or low-order and dud) and geographical location of impacts (within 1-2m) for both mortar and artillery rounds. Provide a remote data processing station capability for receipt of wireless data from all sensor locations. Transmission distance can range from 100m to 5km. Design individual wireless programmable solid state sensors with an internal data storage capability and to operate independently and with remote power (i.e., battery, solar, other). The wireless programmable sensors must also have the capability to be networked to enable smart, flexible communications with the data acquisition/processing system. Design multi-sensor array(s) that will be positioned outside the impact zone and configured for 60- and 81-mm mortar ranges that encompass nominally 50 – 250 acres and for 105-, 120-, and 155-mm artillery ranges that encompass nominally 500 - 5000 acres. The success criteria for the concept impact assessment, location, and data archival system evaluated at active range relevant demonstration site(s) is: 95% detection/identification of ordnance impacts (high- order, low-order or dud)

and 90% geographical location of all impacts (within 1-2m). A technical report will be provided that provides comparison of wireless multi-sensor arrays and design schemes to best meet the technical objectives.

PHASE II: Based upon Phase I concept array design schemes, field and evaluate prototype multi-array systems that accurately assess and document both mortar and artillery impacts at active range relevant demonstration sites (two field evaluation tests). Success criteria for prototype impact assessment, location, and data archival systems evaluated at active range relevant demonstration site(s): 95% detection/identification of ordnance impacts (high-order, low-order or dud) and 90% geographical location of all impacts (within 1-2m) and 2-10m location accuracy for the remaining 10% of ordnance impacts.

PHASE III: Development of commercial systems for installation at active training ranges throughout the Army and DoD, capable of accurate determination and recording of ordnance impact and impact location. The system could be used for reporting of range training activities as well as range management. Other DoD and Homeland Security applications could be the detection/location of tunneling activities. Other commercial applications could be found in the mining industry with improvement to trapped miner location technologies or other geophysics such as rock fall identification and recording systems.

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KEYWORDS: Keywords: Multi-array sensors, seismic, acoustic, unexploded ordnance, sustainable range, wireless programmable solid state sensor

A09-100      TITLE: Point and Stand-off Microwave-Induced Thermal Emission (MITE) of Chemical, Biological, and Explosive Materials

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

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: Assess the feasibility of analyzing thermal infrared (IR) emissions from the thermally desorbed and/or fragmented excited chemical agents, bacteria, viruses, toxins, and explosives deposited on surfaces. Devise and apply detection algorithms to identify chemical species and classify the biological material based on spectrally-resolved thermal emission. Extend the investigations to a short range (about 50 meters) stand-off capability with appropriate emission collection optics.

DESCRIPTION: The Joint Services have a need for a short range, active stand-off system that detects and classifies contaminated surface areas with chemical, biological, and explosive (CBE) substances. Military spectroscopy systems exist that have been applied to the interrogation of CB aerosols and chemical vapor. These systems include frequency agile lidar (FAL), and active differential absorption lidar (DIAL), and passive Fourier Transform IR, in

the Joint Service Lightweight Standoff Chemical Agent Detector (JSLSCAD) for the detection of chemical vapor and bioaerosol clouds. Recently, hyperspectral imaging systems have shown great promise for a real time and temporal display of chemical clouds.

The literature presents flame spectrophotometry, inductively coupled plasma-mass spectrometry, laser-induced breakdown spectroscopy (LIBS), and more recently laser-induced thermal emission (LITE) as high energy deposition methods for a wide variety of samples. Microwaves have also been investigated in this regard. Flames and inductively-coupled plasmas do not lend themselves to stand-off application. In LIBS, spectral signatures arise from plasma-induced atomic emission and for a few small molecules such as CN, C<sub>2</sub>, and PO in the UV-VIS region. However, for thermal signature analysis it would be preferable to deliver energy to the surface at levels below the onset of air breakdown or plasma creation that are typical of LIBS. Relatively large molecular fragments and or thermally-excited molecular species from the original CBE sample could in principle be detected in the IR region vice the generic atomic species observed under LIBS conditions, effecting improved detection and identification reliability. These partial breakdown products and hot molecular species may be a source of much more detailed information for substances in the vicinity of the heating region. A favorable situation exists with high contrast IR signatures from ambient air and surface background.

The thermal emission concept can afford a means for detection and potential identification of CBE materials on surfaces such as concrete, plastic, steel, trucks, buildings, and high value vehicles.

PHASE I: Design and conduct a series of systematic experiments and/or physical models to establish the basis for a demonstration of the thermal emission phenomenology. Investigate the optimal conditions needed to excite CBE particles on surfaces to yield rich near to far IR emission spectra and/or to convert the particles into meaningful products/fragments in the vapor state. Investigate the basis by which IR emission spectra of CBE species may be generated by various energy deposition parameters and under various temporal conditions. Investigate the thermodynamics and kinetics basis by which various distributions of thermal fragment products can yield IR emission spectra as a function of deposited energy. Assess and recommend an energy deposition approach (e.g., laser or microwave) to effect optimal signal generation for this technology.

PHASE II: Perform an engineering performance study for the breadboard design of a thermal emission analysis platform to include the thermal excitation source with variable power output, focusing optics, sample translation stage at various distances from the source, collection optics that are tailored for receiving distances up to 50 meters, and detection spectrometer(s) to capture the 2-12 micron emission from the induced thermal products. Develop a system model of the thermal emission hardware concept and present a baseline performance analysis of the system. Perform limit of detection studies for select CBE materials to demonstrate the feasibility of acquiring useful signatures as a function of distance from the contaminated surface. Investigate possible temporal emission characteristics. Develop a set of preliminary Receiver Operational Characteristic (ROC) curves for the thermal emission concept platform for CBE sample detection.

PHASE III: There are many environmental and military mission applications for a point or stand-off sensor for surface CBE contamination. A rugged, sensitive, and flexible CBE detector/identifier will benefit the environmental monitoring community by providing point and stand-off capabilities for remote CBE surface contamination. In addition, first responders such as civilian support teams, fire departments, and military post-blast reconnaissance teams have a critical need for a rugged and versatile sensor that can be transported to the field to test for possible CBE contamination on many types of surfaces.

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KEYWORDS: Chemical detection, chemical identification, biological detection, biological classification, infrared emission spectrum, microwave induced thermal emission, bacteria, chemical agent, explosives.

A09-101            TITLE: Passive Standoff Detection of Chlorine

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

OBJECTIVE: Develop a passive standoff sensor that is optimized for detecting chlorine vapor.

DESCRIPTION: The U.S. Army in addition to the other DoD Services have the need for a small, lightweight, inexpensive sensor for standoff detection of chlorine vapor releases. Several industrial accidents involving chlorine releases have taken place in the U.S. in recent years. For example, in 2002 in Festus, Missouri, chlorine was being transferred from a railroad car to an industrial plant when a hose burst and released 48,000 pounds of chlorine into the environment. Other accidental releases have occurred in Camas, Washington (1995); Lynchburg, Virginia (2006), and Glendale, Arizona (2003). Within the DoD there is an interest in providing protection to fixed sites that may be vulnerable to an attack using toxic industrial chemicals (TICs).

The goal of this topic is to develop a passive standoff sensor that is optimized for the detection, identification, and tracking of chlorine. It is envisioned that the system will operate passively and interrogate the environment for the strong ultraviolet absorption band from 300 to 450 nm that is indicative of chlorine.

PHASE I: Develop and demonstrate the proof-of-concept for a passive standoff sensor that is optimized for the specific detection, identification, and tracking of chlorine vapor. The system should be able detect and track chlorine vapor clouds from a standoff distance of up to 1 km. The Immediate Danger to Life and Health (IDLH) and Acute Exposure Guideline Levels, AEGL-3 (permanently disabling) concentration level for chlorine is 10 ppmv. A release consisting of one pound of chlorine will produce a 30 meter diameter cloud at AEGL-3. The system produced under this effort should be designed to detect a release of chlorine of one-pound or less at a minimum distance of one kilometer in ten seconds or less.

PHASE II: Design and build a passive standoff sensor that is optimized for the specific detection, identification, and tracking of chlorine vapor. The pre-production prototype system should be built and optimized for field usage. The

final system, including sensor, power supply, and display, should weigh less than 100 pounds and operate on a standard 120 volt, 20 amp power supply. Data acquisition and signal processing of the proposed system should be examined and modeled.

PHASE III: There are environmental applications for a robust, standoff chlorine sensor. A rugged, inexpensive standoff sensor will benefit the manufacturing community by providing inexpensive monitoring of industrial processes. Also, first responders such as the WMD Civil Support Teams (CST) and local Fire Departments have a critical need for a rugged, inexpensive sensor that can be transported to the field to test for possible contamination by toxic industrial chemicals.

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KEYWORDS: Chemical detection, Standoff detection, UV spectrum, Toxic Industrial Chemicals, chlorine

A09-102      TITLE: Application of Finger-Mounted Ultrasound Array Probes

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acquisition

OBJECTIVE: Develop a finger-mounted imaging probe that addresses the imaging, workflow, sterility and usability requirements of line placement and vein location.

DESCRIPTION: Clinicians insert lines (catheters) in patients to deliver life saving drugs and fluids, and to monitor hemodynamics. These lines can be placed in blood vessels in the neck, shoulder, arm, or groin, depending on the clinical requirements. The objective is to insert the line in the right place quickly and to avoid injury or trauma to adjoining areas or vessels. Severe complications can arise, for example, by inadvertently puncturing the carotid artery vs. the jugular vein. Sick or severely injured patients such as those with hypotension or shock due to dehydration or hemorrhage are particularly challenging for line placement. In those situations fast and accurate access is even more critical. Ultrasound is commonly used to aid the clinician in identifying and localizing the intended vessel and placing the line into it. However, traditional ultrasound probes don't adequately address the workflow requirements of these procedures. They require the operator to grip, hold, and manipulate the cylindrical or slab shaped probe. These probe form factors require extensive training and practice to use. Furthermore, for line placement, the unassisted operator is required to use the non-dominant hand solely for imaging leaving only the dominant hand free to perform the line placement. Clearly, there is significant advantage of the fingertip probe to the operator by allowing the use of both hands to perform the procedure; one (non-dominant hand) to image, palpate and immobilize the insertion site, but also assist with the line placement, and the second (dominant hand) to insert the line. In either scenario, an assistant could do the imaging leaving the primary operator to place the line, however this

adds significant cost and logistical complexity. Line placement is often performed in a confined space making utilization of an assistant (if one is available) problematic.

PICC and Central Line placement are sterile procedures. This is a higher standard than high level disinfection or cleaning. This is because the imaging technology is used in the sterile field to guide a catheter that will reside within the body. The tip of the catheter is placed near the heart. Any type of infection would represent a major complication. Therefore it is a requirement that the finger probe support sterile use.

The proposed Finger-Mounted Imaging Probe will address the following requirements for line placement:

- Adequate image quality
- Ergonomic design addressing comfort (subject and operator) and ease of use
- Intuitive design to simplify and accelerate operator training
- Workflow consideration to facilitate unassisted procedures
- Sterility
- Ultrasound, or other applicable safety and regulatory requirements

PHASE I: Understand the clinical and technical requirements to develop a finger-mounted imaging probe for use in central line placement. The probe must be able to generate a high-resolution image to visualize the target vessel and differentiate it from other vessels and structures. The field of view must be able to provide a cross section of the vessel. Develop and demonstrate a prototype. Determine the technical feasibility to support sterility, safety and regulatory requirements. Provide a project plan to support development of the probe including product specifications and technical milestones.

PHASE II: Design, develop and demonstrate a functional prototype. Conduct all regulatory and safety testing to support clinical use. Design and implement a field trial to validate the superiority of the finger probe versus conventional probes in addressing the requirements of central line placement.

PHASE III: Phase III will commercialize the finger probe for end-user sale in both the military and private sector markets for commercially available devices. This effort includes, but is not limited to obtaining FDA and other regulatory clearances, manufacturing, clinical studies, product enhancements to support other clinical applications.

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KEYWORDS: Ultrasound, Imaging, Finger Probe, Vascular Access, Medical Device

A09-103            TITLE: Surgical Debridement Assist Device

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acquisition

OBJECTIVE: Wounds inflicted by modern weaponry, especially Improvised Explosive Devices and other blast effect weapons, are extremely dirty and contain debris from the weapon, the environment, the casualty's equipment and clothing driven into the tissue by the force of the explosion. In addition, much of the wounded tissue is devitalized by direct injury as well as loss of blood supply. A key step in initial management of wounds is the

removal of debris of all kinds as well as the identification and removal of devitalized tissue (1). Present methods for doing this are relatively crude, involving primarily massive irrigation with saline, mechanical identification and removal, and close examination of tissues for color and reactivity.

Various modalities are used to detect foreign bodies embedded in tissues, including ultrasound, fluoroscopy, plain film radiographs, computerized tomography, and magnetic resonance imaging (2,3). Unfortunately, bedside ultrasound has been found to be neither sensitive nor specific for the presence of small soft tissue foreign bodies (wood, metal, plastic, glass) in cadavers, having an overall sensitivity of slightly more than 50% in one study, and to have poor sensitivity and specificity with no individual foreign body (gravel, metal, glass, cactus spine, wood, and plastic) having an ultrasound detection rate of 50% in a second study (4,5). Low-power portable fluoroscopy is as effective as plain film radiography in detecting very small glass foreign bodies in a teaching model (6), but lacks sufficient sensitivity to rule out many foreign bodies which are not radiopaque (7). Similar to the difficulties inherent in consistently detecting foreign bodies, distinguishing vital from nonvital tissues in wounds is challenging. For example, observational determination of muscle viability is based on the four C's (8) which consist of "contraction on being pinched, consistency (not waxy or "stewed"), capillary bleeding when cut, and color (red, not pale or brown)." Alternative methods to distinguish vital from devitalized tissues include laser-induced fluorescence angiography with indocyanine-green dye, which has been shown to be a sensitive diagnostic tool for detecting compromised tissue perfusion in trauma surgery and for evaluating the circulation in surgical flaps (9,10), and nitroblue tetrazolium dye to intraoperatively identify ischemic and necrotic muscle (11). Examples abound in the present conflict of both failure to locate and remove debris and devitalized tissue as well as excessive debridement of tissue that is actually still viable. A better means for finding debris and distinguishing between viable and non-viable tissue would result in better clinical outcomes, both reduced infection and reduced loss of otherwise viable tissue.

**DESCRIPTION:** The primary objective of this topic is to identify and define the feasibility of a technology or technologies to recognize and provide appropriate signals to aid in the location of types of debris as typically found in battlefield wounds such as metals, rock, cloth, and ceramic materials. The device would be hand held or mounted on the head of the surgeon or perhaps both. It would generate some kind of signal, probably visual but not necessarily just that, that would assist the surgeon in locating debris for removal. It is preferred that the signal will not require interaction between the surgeon and a video screen, i.e., the signal (for example light, or an audio tone) should be provided at the locality of the debris. The method used to detect debris could be ultrasonic, fluoroscopic, or any other method capable of detecting debris embedded in tissues. A secondary objective of this topic is the identification of technologies that can distinguish between viable and non-viable tissues, especially muscle, leading to a signal to the surgeon to distinguish between viable and non-viable tissue. Detection of devitalized tissues could be by vital dye or any other method capable of discriminating between viable and non-viable tissues in real time. It is recognized that the secondary objective can only be pursued if a regulatory-approved animal model is available before the Phase I award, and the lack of an appropriate model to explore the secondary objective will not be a deciding factor in funding this topic. Ideally the device would not require an extensive source of electrical power nor tether the surgeon to a large battery or generator. It would also be designed so that surgeons could be easily trained in its use.

**PHASE I:** Demonstrate in an appropriate tissue phantom or tissue model that the system is capable of detecting metal, rock, cloth and ceramic debris. The detection limits of the technology in terms of minimal size and maximum depth of the debris in the model should be documented. If an appropriate animal model is available, demonstrate that areas of viable and non-viable tissue are detected by the technology. Document that the indicated viable and non-viable tissues are accurately classified by histology, metabolic activity, or other methods as appropriate.

**PHASE II:** Construct and demonstrate the operation of a prototype device to detect and indicate the location of metals, rock, cloth, and ceramic materials types of debris, and optionally non-viable tissues, in animal models based on realistic wounding mechanisms. The device must identify and locate the debris, and optionally distinguish between viable and non-viable tissues, at least as well as demonstrated in Phase I. The test animals must be kept alive long enough to show significant clinical improvement in clinical outcomes including post-operative infection. It is preferred that the device be small and light enough to either be worn on the head or held in the hand, but at the maximum the device must weigh no more than 120 pounds if free-standing or 233 pounds if it is attached to the ceiling of a patient care facility such as an International Organization for Standardization Shelter (ISO Shelter). The device should attain a maturity sufficient to prepare a 510K application to the Food and Drug Administration.

PHASE III: Licensure of the device by the FDA for use in practice. Ideally, this approval would not be a "military use only" approval, but as a Threshold parameter, it would be acceptable. The Objective would be FDA licensure for all purposes.

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KEYWORDS: Surgery, Foreign Body, Debridement, Wound Cleansing, Battlefield Injuries, Trauma

A09-104      TITLE: Improved Robot Actuator Motors for Medical Applications

TECHNOLOGY AREAS: Ground/Sea Vehicles, Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acquisition

OBJECTIVE: Design and prototype a scalable enhanced set of high power-to-weight ratio robotic actuator mechanisms for deployment on medical robotic systems to replace 1) hydraulic manipulator arms used in current robotic combat casualty and hospital patient movement and 2) large heavy actuator motors currently used in advanced exoskeletons and robotic prosthetic arm prototypes.

DESCRIPTION: Unmanned robotic systems intended for use in health care support operations such as combat casualty extraction and patient positioning in forward medical treatment facilities must be portable, lightweight, and, above all, safely interact with humans. To avoid excessive weight and bulk and yet be capable of performing

diverse heavy lift missions in combat environments, robotic actuators must meet very demanding requirements on survivability, operational temperature, lubrication, reliability, smoothness and linearity of motion. In addition, these systems are typically mobile and must therefore transport their own source of power. Thus the weight of batteries, compressed air cylinders, pumps, and other energy sources/delivery devices must also be taken into account in maximizing the power-to-weight ratio of the actuator system. For example, the Battlefield Extraction-Assist Robot (BEAR) (Ref 1), built for removing casualties from hostile environments, is limited in payload capacity by the size of its motors which must be driven by a supply of onboard batteries. Many high power density actuators, such as pneumatic muscle actuators, currently lack sufficient bandwidth to be employed in robotic systems, whereas high bandwidth devices, such as electric motors, typically have very low power density (Ref 3). Likewise, robotic manipulator arms for patient monitoring and treatment must be strong enough to support a variety of physiological monitoring, assessment, and instrumented end-effectors as well as being lightweight to minimize maneuver support transport and strategic lift requirements. Wearable robotic devices, such as exoskeletons and prostheses also require actuators with high stiffness, high power density, and self-contained power. Several technologies (Refs 2-10) are potential candidates for this research topic, but pneumatic or electric actuation are preferred. We are looking for new concepts in compact, lightweight actuators which meet the demanding requirements of military operations with a simple but efficient component arrangement. Technology approaches could include pneumatic artificial muscles (PAM) fabricated from high strength materials (Ref 4), wire bundles constructed from shaped memory alloys (SMA), motorized lead-screws (Ref 6), and efficient motors (Ref 10). In addition to the actuation technology employed, research challenges inherent in this topic include energy storage/delivery, mechanical efficiency, miniaturization, ruggedization, local sensing and processing, communication, and packaging. For example, colocated position sensing is required for servocontrol and is highly dependent on the actuators employed. For dc motors, optical encoders are often used, but for shaped memory alloys, the actuator can also be used as a strain sensor to determine position (Ref 7).

**PHASE I:** The overall goal of this phase is to generate a proof of concept to build and demonstrate lightweight, strong, and scalable robotic actuators required for the applications described above. Determine torque, speed, stiffness, bandwidth, and other requirements for the above applications using the cases outlined under Phase II while maximizing the overall mechanical power-to-weight ratio of the overall system. Conduct a market survey of relevant military and potential civilian applications such as manipulator arms for robotic combat casualty and hospital patient movement, advanced exoskeletons, and robotic prosthetic arms, and prepare an initial commercialization plan for the Phase II proposal.

**PHASE II:** Prototype and demonstrate the Phase I actuator motor technological approach which could be used in the military robotic applications described above and is otherwise sufficient to power: 1) a 0.6 m length robotic manipulator arm with at least two links and 5 degrees of freedom with a tool tip speed of up to 1 m/s that can support a 50 N payload at full extension with less than 1 cm deflection; and 2) a 1.8 m length robotic manipulator arm with at least three links and 6 degrees of freedom with a tool tip speed of up to 0.5 m/s that can support a 1500 N payload at full extension with less than 5 cm deflection. Implement the robotic manipulator arms on one or more military type unmanned ground systems (UGV) using the Joint Architecture for Unmanned Systems (JAUS) to control both the robotic manipulators and the UGV. Prepare a more detailed Phase III commercialization plan based on detailed analysis of the Phase I market survey of relevant military acquisition programs and potential civilian applications.

**PHASE III:** Assist the Army in transitioning improved actuator technology to military medical robotics programs. Extend to general military robotics and unmanned systems acquisition programs identified in Phases I and II market surveys. Execute commercialization plan developed in Phase II extending improved actuator technology to civilian robotic systems applications identified in the plan and marketing surveys.

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KEYWORDS: Robot, Actuator Motor, Robotic Manipulator Arm, Unmanned Systems

A09-105            TITLE: Developing a Point-of-Care Diagnostic Assay for Leptospirosis

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acquisition

OBJECTIVE: Adapt state-of-the art technology to develop a highly sensitive diagnostic assay for leptospirosis to be used at Point-of-Care.

DESCRIPTION: Leptospirosis is caused by spirochaetes of the genus *Leptospira*. It is considered to be the most widespread zoonotic disease in the world. Due to its worldwide distribution, US military and civilian personnel deployed overseas are at high risk of being infected. Recent study showed that leptospirosis is prevalent in the Caribbean and Latin American, the Indian subcontinent, Southeast Asia, and Oceania (1). Currently, the Armed Forces Medical Intelligence Center (AFMIC) ranked leptospirosis as the 7th highest global risk-severity index (GRSI) disease among 53 infectious diseases of military significance (2). A seroepidemiological survey of rodents collected at a U.S. military installation in South Korea indicated that more rodents were leptospirosis positive than

scrub typhus and murine typhus (3). Symptoms of leptospirosis are easily confused with a variety of other pathogens (e.g., dengue, malaria, Q fever, etc.) that require different treatment regimens. The acute phase of the disease lasts for approximately one week. Untreated patients may develop kidney and liver damages. Mortality rate in the severe form can be as high as 15% (4). Therefore, timely diagnosis is essential since antibiotic therapy provides greatest benefit when initiated early in the course of illness (5, 6). A rapid Point-of-Care diagnostic assay is urgently needed in order to initiate appropriate treatment and to minimize the impact of the disease on our operational capabilities.

The objective of this topic is to develop rapid assays which can detect the infection of *Leptospira* within one week after the onset of illness with sufficient sensitivity and specificity. Currently, the Microscopic Agglutination Test (MAT) is the standard method for the diagnosis of leptospirosis. It is not only technically complex and also time-consuming (7). Although there are less complicated IFA and ELISA tests for leptospirosis, the sensitivity is very low during the early phase of the infection (8, 9). They are not sufficiently accurate for the diagnosis of acute leptospirosis. Culture takes a long time and is labor intensive. PCR requires instrument and extensive end user training. We envision a FDA-cleared, hand-held diagnostic assay capable of determining whether a sick soldier is infected with *Leptospira*. Assays capable of detecting *Leptospira* specific antigen and/or specific IgM antibody are desired. The principal requirements of a field-capable leptospirosis assay are: 1) rapid (<30 min), 2) easy to use (one or two steps), 3) no need for sample processing, 4) stable (no temperature sensitive reagents will be used), 5) portable, and 6) inexpensive. The performance of the assay should be at least 85% as sensitive and specific at 95% confidence level as current (non-deployable, non-FDA cleared) assays. The test kit should contain all supplies necessary to run the assay. Both positive and negative controls must be included in the test kit.

**PHASE I:** Selected contractor determines the feasibility of the concept by developing a prototype diagnostic assay that has the potential to meet the broad needs discussed in this topic. The assay must detect and differentiate leptospirosis from other febrile diseases within one week after the onset of illness. Currently there are no FDA-cleared, field-capable assays that can be used to diagnose leptospirosis in febrile soldiers. Development of an assay for the detection of leptospira infection is therefore a high priority. We envision a rapid detection assay capable of determining whether a sick soldier is infected with leptospira. The assay must be rapid (<30 min), soldier-friendly (i.e., easy to operate), inexpensive, portable, and stable (no requirement of refrigeration). The assay should be at least 85% as sensitive and specific as current (non-deployable, non-FDA cleared) assays and sera, plasma, whole blood, or other types of specimen can be used without sample processing. Selected contractor should coordinate with the Contracting Officer Representative (COR) for access to required reagents and positive control materials from the Walter Reed Army Institute of Research (WRAIR) or the Naval Medical Research Center (NMRC) or other Institutes. The contractor may have to obtain additional reagents from a source other than WRAIR/NMRC. The selected contractor provides a single lot of 100 prototype assays to the COR to be evaluated in a government laboratory. Data from this independent evaluation will be used in the determination of the Phase II awardees.

**PHASE II:** Based on the results from Phase I, the selected contractor provides up to 3 initial lots of 250 prototype assays each to the COR. These initial lots will be evaluated at government laboratories for sensitivity and specificity. Feedback regarding the sensitivity/specificity of each lot of prototype assays will be provided to the contractor. This data will then be used to optimize each subsequent lot of assays. The goal in Phase II is the development of a prototype assay that provides 85% sensitivity and 85% specificity when compared to current standard assays for leptospirosis. Once sensitivity and specificity requirements have been met, the selected contractor will confirm the performance characteristics of the assay (sensitivity, specificity, positive and negative predictive value, accuracy and reliability) under both laboratory and field conditions using clinical specimens. The contractor may be required to coordinate with WRAIR/NMRC to set up field testing sites. The regulatory strategy for using different types of clinical specimen should be clearly described in the Phase II proposal. Human use protocols for using clinical specimen should be approved by Institutional Review Board (IRB) of all participating institutes. The selected contractor will require a Federal-Wide Assurance of Compliance before government funds can be provided for any effort that requires human testing or uses of clinical samples. The selected contractor will also conduct stability testing of the prototype device in Phase II. Stability testing will follow both real-time and accelerated (attempt to force the product to fail under a broad range of temperature and humidity conditions and extremes) testing in accordance with FDA requirements. The data package required for 510(k) application to the U.S. Food and Drug Administration will be prepared at the end of phase II.

PHASE III: During this phase the performance of the assay should be evaluated in a variety of field studies that will conclusively demonstrate that the assay meets the requirements of this topic. The selected contractor shall make this product available to potential military and non-military users throughout the world.

Military applications: Leptospirosis is a worldwide zoonotic disease. It occurs through direct or indirect transmission from a mammalian host. Indirect transmission via contact with leptospira contaminated water or soil, is thought to be responsible for most cases. The Armed Forces Medical Intelligence Center (AFMIC) last year ranked leptospirosis as the 7th highest global risk-severity index (GRSI) disease among 53 infectious diseases of military significance. US military and civilian personnel deployed overseas are at high risk of being infected. The diagnosis of these cases is often delayed, because the currently available tests of leptospirosis are not field-capable and the serological results vary considerably among different laboratories even when using the same kit. With the availability of an easy and rapid assay developed under this topic, sick soldiers can be treated in a timely manner in any military medical organization (such as a Battalion Aid Station, a Combat Support Hospital, Forward operation base, or a fixed medical facility). Once a National Stock Number (NSN) has been assigned to the assay, it will be incorporated into appropriate "Sets, Kits and Outfits" that are used by deployed medical forces.

Civilian applications: Leptospirosis is considered to be the most widespread zoonotic disease in the world. Anyone who works in rice fields, sugar cane plantations, mines, sewer systems, slaughterhouses; animal caretakers, veterinarians; and travelers to tropical parts of the world involved in recreational activities in fresh water are at high risk. We envision that the contractor that develops the leptospirosis assay will be able to sell and/or market this assay to a variety of civilian medical organizations, and that this market will be adequate to sustain the continued production of this device.

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KEYWORDS: Leptospirosis, Leptospira, Point-of-Care, Diagnosis, Rapid assay, Hand-held

A09-106

TITLE: Biocompatible Materials for Repair of Bony Defects in Craniofacial Reconstruction

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acquisition

OBJECTIVE: Develop new materials or improvements to existing materials for use in bone replacement and reconstruction of craniofacial bony defects.

DESCRIPTION: While improved medical care and personal protection of the twenty-first century warfighter has significantly decreased combat related mortality and morbidity, the use of improvised explosive devices in Operation Iraqi Freedom and Operation Enduring Freedom has led to an increase in blast-related injury to the exposed regions of the warfighter, especially to the head and neck.; Bone replacement and reconstruction in the craniofacial region presents unique challenges due to the irregular shape of the facial skeleton and the pull of the craniofacial muscles which produce variable loading in different regions. While autogenous bone grafting remains the gold standard for craniofacial repair, the utility is limited to small, optimized defects. The disadvantages of autogenous bone grafting are significant, including high rate of resorption, donor site morbidity, limited supply, and difficult and time consuming shaping of the graft to fit the defect. A variety of allo-, xeno- and synthetic grafting materials exist, however none of these grafts meet all of the characteristics of an ideal grafting material that would be quick and easy to use, and resembles the original uninjured bone in form and function once healing is complete.

This solicitation elicits proposals for the development of a biocompatible material(s) for use in bone replacement and reconstruction of craniofacial defects. The ideal bone replacement biocompatible material(s) should be readily available, cost effective, non-toxic, non-antigenic, non-carcinogenic and inert in physiological fluids, be easily and quickly shaped and fitted on the operating table, and maintain its desired form and function in situ indefinitely.

PHASE I: Design and synthesize a new or improved biocompatible material(s) for use in bone replacement and reconstruction of craniofacial bony defects that meets or exceeds the ideal characteristics listed above. The methodology and rationale should be clearly elaborated in the proposal. Use of human cells and tissues and/or vertebrate animals requires approval by the appropriate US Army Medical Research and Materiel Command regulatory office. Phase I should include approval of appropriate regulatory documents necessary to execute Phase II.

PHASE II: The objective of Phase II is to test and refine the prototype new or improved material(s) developed in Phase I, both in vitro and in vivo testing is required in Phase II. The material(s) must be fully characterized to show that it meets or exceeds the ideal characteristics listed above and in comparison to existing materials, i.e. methylmethacrylate and titanium. A clear research plan including the use of appropriate in vitro and in vivo models to be used must be described.

PHASE III: During Phase III, the offeror is expected to perform any additional experiments necessary to prepare for FDA review, receipt of an IND/IDE, and initiation of human clinical trials using the new or improved material for bone replacement and reconstruction of craniofacial bony defects developed in Phase I and refined in Phase II. The commercialization potential of the resultant product is expected to be high. Development of such an FDA approved material would significantly impact the outcome of treatment modalities available to injured warfighter and civilian trauma casualties and likely minimize residual bony and soft tissue disfigurement and improve self esteem following the repair of the injury.

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KEYWORDS: Biomaterial, Biocompatible, Bone, Defect, Healing, Inflammation, Injury, Reconstruction

A09-107      TITLE: Malarial Vaccines Utilizing Antigen/Adjuvant Display on Viral-Like Particles

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acquisition

OBJECTIVE: Create a viral-like particle (VLP) system for use in malarial vaccine development that can display different antigens and / or adjuvants on the particle surface and that can induce long-lived, sterile protection against challenge in naïve-individuals.

DESCRIPTION: Development of an effective malarial vaccine has been slowed by several factors - a relatively attenuated protective response elicited by antigen, the presence of natural variants of candidate malarial antigens used for vaccination, and the lack of good immune correlates of protection or predictive models of immune efficacy (1,2). Recent success in vaccine development has been achieved by using the *Plasmodium falciparum* circumsporozoite surface protein (CSP)- hepatitis B surface antigen fusion proteins (3), in conjunction with hepatitis B particles (the RTS, S formulation); this has suggested that efficacy of immune response might be improved through use of a viral-like particle (VLP)-linked immunogen. The protective response to the pre-erythrocytic stage CSP antigen, although at approximately 50% efficacy against homologous challenge, represents an important step; however, it is possible that better vaccine formulations can be generated by empirically testing other VLP structures that display CSP in conjunction with biological adjuvants. Furthermore, vaccination against the blood-stage of malarial infection remains an important goal, as this would limit the extent of the disease in affected individuals. Thus inclusion of other malarial antigens in conjunction with CSP – eg., merozoite surface protein 1 (MSP1), liver stage antigen (LSA), apical membrane antigen 1 (AMA1) – may make it possible to sustain the immune response and / or minimize disease development in those that are only partially protected by immunization with CSP.

The goal of this solicitation is to evaluate the potential of recombinant VLP systems, other than hepatitis B, that are capable of displaying malarial antigens while retaining the capacity to form self-assembling structures. Capsid proteins from several other genera of virus are known to assemble into VLPs when expressed as recombinant proteins, including those from adenovirus, papillomavirus, and norovirus (4,5). Some of these recombinant VLP induce immunity against the vector itself, which can carry both, advantages and disadvantages. To date, effective expression of these has required a eukaryotic cell system (cultured cells, baculovirus, and yeast). It is not known if particles will form properly when a heterologous protein domain is introduced into the capsid protein, therefore the selected contractor will need to create capsid protein-antigen constructions, express them as recombinant fusion proteins and characterize the structure of viral-like particles that are produced. The ideal VLP antigen display system would be one that is versatile enough to allow for incorporation of different antigens and /or adjuvant elements to stimulate cellular and humoral responses, thus enabling a “plug and play” platform technology. Moreover, such vectors should have low seroprevalence in the target population to avoid failure of vaccination due to pre-existing immunity. Moreover, the vector alone should not be immunodominant in order to allow repeated immunizations with the constructs.

The selected contractor should have extensive experience in the construction and expression of recombinant proteins, particularly in baculovirus and yeast, and should have the resources needed for biophysical characterization

of VLPs. The successful applicant for this work would also need to consider all relevant manufacturing issues that are important in vaccine development – these include the adherence to GMP guidelines, the historical requirements for FDA approval of materials in human vaccines and the economic feasibility of production.

PHASE I: Demonstrate the capability to produce VLPs that display a specific malarial antigen and secondarily, can display a heterologous adjuvant moiety on their surface. Preferably, the malarial antigen is a pre-erythrocytic stage antigen and expression can be demonstrated by using transfection of eukaryotic cells and western blotting.

PHASE II: Test VLPs for safety, immunogenicity and for ability to protect against parasite challenge in a mouse model of infection. For this reason, it is anticipated that the successful phase I demonstration will include a VLP for at least one pre-erythrocytic stage antigen, ie., CSP, LSA1, LSA3, CeITOS.

PHASE III: Carry out scale-up procedures for the VLP-antigen preparation(s) of highest interest. It may also be necessary to test combinations of different VLP-displayed antigens to determine formulations with the highest potential for immunogenicity and economic feasibility.

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KEYWORDS: Virus like particles, Vaccine, Cellular, Humoral, Immunity

A09-108            TITLE: Development and Commercialization of Analyte Specific Reagents (ASRs) for the Diagnosis of Selected Arthropod-Borne Viruses on FDA-Cleared Real-time PCR Platforms

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acquisition

OBJECTIVE: Develop, evaluate and commercialize Analyte Specific Reagents (ASRs) for the detection of Dengue (DEN), Rift Valley fever (RVF), Sand Fly fever-Toscana (SFF), Crimean-Congo fever (CCHF), Tick-borne encephalitis-Central European (TBE) and Chikungunya (CHIK) viruses in blood/sera from clinically ill patients. ASRs that are developed must meet all FDA requirements (21 CFR 809.10(e), 809.30, and 864.4020) pertaining to ASRs and should be designed for use on commercially-available Real-Time PCR equipment, with priority going to the development of ASRs that can be used on the military-specific Joint Biological Agent Identification and Diagnostic System (JBAIDS) platform. Each ASR should serve as the foundation for a pathogen-specific assay that is at least as sensitive and specific as current "gold-standard" assays and that has a Limit of Detection (LOD) low enough to reliably detect and diagnose the pathogen in clinically ill service members.

**DESCRIPTION:** Background: Infectious diseases, to include DEN, RVF, CHIK, CCHF, SFF, and TBE viruses, pose a significant threat to deployed military forces (Burnette et al. 2008). In order to minimize the impact of infectious diseases on military operations, the rapid identification of the pathogen causing illness in military troops is required. Although the Department of Defense (DoD) desires FDA-cleared diagnostic assays for all of the more than 40 infectious diseases that threaten our deployed forces, the time and cost to develop these FDA-cleared assays (estimated at >\$100 million over a 20 year period) is prohibitive. When combined with the relative rarity of each disease along with the limited commercial market, it is difficult to develop a business model that justifies the development of all of these FDA-cleared assays. The DoD is therefore interested in evaluating alternative strategies that can rapidly and cost-effectively deliver diagnostic capabilities for militarily-relevant infectious diseases. Key requirements for any alternative strategy include the following: i) must be acceptable to the FDA, ii) must provide commercially available solutions that can yield diagnostic assays, iii) should allow for the rapid (<1-year) development of assays at a modest cost (<\$100,000 per assay), and iv) should provide flexibility to both the commercial company and to the DoD so that specific assays can be rapidly provided on an "as-needed" basis. ASRs provide a potential solution to this problem. The goals of this SBIR topic are to i) evaluate ASRs as a mechanism by which diagnostic capabilities can be provided to the DoD, and ii) develop and commercialize ASRs for six specific arthropod-borne viruses.

**Desired Capability:** The goal of this SBIR is to successfully develop and commercialize a total of six ASRs that can be used to develop molecular assays for the detection and identification of DEN, RVF, CHIK, CCHF, SFF and TBE viruses. Each ASR should meet all current FDA requirements (21 CFR 809.10(e), 809.30, 864.4020 at the time this document was prepared) for ASRs, should be produced under current GMP conditions, should be commercially available, and should be capable of being used on a variety of Real-time PCR platforms, with priority going to the development of ASRs that can be used on the military-specific Joint Biological Agent Identification and Diagnostic System (JBAIDS) platform. Although the manufacturer of a specific ASR can make no claims about the performance of the product, laboratories that purchase the ASR will have to establish and validate the assays. Therefore, diagnostic assays developed using the specific ASRs should be at least as sensitive and specific as current accepted diagnostic assays and should not cross-react with other infectious agents. Although not absolutely required, each individual ASR should be lyophilized if possible. As part of this SBIR effort, positive and negative control material shall also be provided as separate products.

**PHASE I:** The selected contractor determines the feasibility of the concept by developing prototype ASRs (to include positive and negative control material) for at least one of the six pathogens listed above. By the conclusion of Phase I, the selected contractor must provide the Contracting Officer Representative (COR) with sufficient prototype ASR material to establish the assay in a government laboratory and to carry out 100 tests. The degree to which the prototype ASR material meets the desired capability outlined above will be evaluated at the government laboratory. Data from this independent evaluation will be used in the determination of the Phase II awardee.

**PHASE II:** The goal in Phase II is the successful development and commercialization of ASRs for each of the six pathogens listed above. Specific goals for each ASR include demonstration i) that the LOD of each assay developed using the ASRs will be low enough to detect and identify the pathogen causing illness in a clinically ill service member, ii) that each assay developed using the ASRs is as specific as current "gold-standard" assays when evaluated using a panel of "near" and "far" neighbor nucleic acid preparations, and iii) that assays developed using the ASRs are as sensitive and specific for the pathogen of interest as current "gold-standard" assays when evaluated using a panel of clinical samples. Once these objectives have been met, each ASR (to include positive and negative control material) should be made available commercially in accordance with FDA guidelines pertaining to ASRs.

The U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) and/or the Walter Reed Army Institute of Research may potentially be able to provide support to Phase II efforts. Support could include access to technology (i.e., information on primers and probes used by WRAIR or USAMRIID for the detection of each specific pathogen) as well as testing and evaluation of candidate ASRs. All requests for support should be coordinated thru the topic author and/or COR well in advance of the date that the support is required.

**PHASE III:** ASRs developed under this SBIR topic will be suitable for use in a variety of military medical units, to include both deployable units and non-deployable units with a Real-time PCR platform. ASRs will also be available for non-military medical purposes, such as use by regional medical clinics or non-governmental organizations

(NGOs) in areas of the world where the specific pathogens are present. We envision that the commercial company that develops the ASRs for these selected pathogens will be able to sell and/or market these products to a variety of commercial medical organizations, and that this market will be adequate to sustain the continued production of these products.

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KEYWORDS: Analyte Specific Reagents, Diagnostic Assays, Infectious Diseases, Virus Detection

A09-109            TITLE: Personnel High Rate Data Recorder

TECHNOLOGY AREAS: Biomedical, Sensors

OBJECTIVE: Develop a small, lightweight, robust, modular, and wearable electronic data recording device or system for recording sensor data at sample speeds at least 1MHz per channel, capable of expansion or linking for multiple channels of data, and post-event download.

DESCRIPTION: To improve protection provided to Warriors, potentially injurious exposures need to be recorded. Typically such exposures occur during realistic training and operations in harsh environments that create unique challenges to the collection of high-quality exposure data. Currently, almost all high-quality exposure data recording is accomplished with reliable power, lengthy wiring, weighty equipment, and/or close-range wireless transmission, which require prediction or control of Warrior activities. All of these requirements interfere with training and missions, which mean exposure data can only be recorded infrequently, with a limited number of volunteers, in a controlled setting. Currently, no data recorder exists that can record high-quality data from an entire exposure event that occurs at an unpredicted time and location during training or operational missions. An example of a system that is currently experiencing these challenges is Generation I of helmet sensors being used on Army and Marine helmets in combat. To meet size, weight, battery life and immediate fielding needs, these Generation I systems are unable to record a complete exposure event. The data recording portion of the systems must turn on after the event begins, thereby losing the exposure onset and initial portion of the exposure data. With today's deployed Warriors often exposed to blast during the conduct of operations, injuries result from high-rate exposure, which magnifying the critical need to record the exposure onset and initial portion of the exposure data. Because blast-related injuries may be due to high-rate blast pressure wave exposure and/or high rate local body/equipment accelerations, higher frequency sampling is needed in data recording devices. Only a few quality, portable (weight in pounds), high speed recording systems (greater than 500 kHz) exist today that can handle multiple channels (collectively or modularly) in controlled, but hazardous experimental environments. The ideal system or device would employ innovative technology to record sensor responses at high frequency rates in potentially harsh environments without harming the Warrior or jeopardizing the mission.

System or device requirements include: (1) a high sampling rate of at least 1MHz per data channel; (2) sufficient memory capacity to record a full second of time-history exposure data per channel for each event; (3) detection and recording of at least 10 entire time-series events prior to reset or download; (4) self-contained power that ensures the detailed performance requirements, particularly the ability capture an entire event; (5) small size (less than 1in x 2in x 2in); (6) light-weight (less than 6 ounces) including power; (7) low-power requirements; (8) ability to record time series data from multiple sensor input ranges (+/- 100 mV to +/- 10 V); (9) ability to record time series data from a single-ended and a dual-ended sensor; (10) user friendly technology and operating software; (11) rugged enough to withstand use in military training and operational environments; and (12) does not interfere with safety of the Warrior. The proposed data recording device must have adjustable input ranges to accommodate a variety of single-ended or double-ended sensors with varying signal amplitudes. The recorder device can supply sensor power, but this is not a requirement as sensor power requirements may vary. User software should allow the data to be quickly downloaded onto a Windows based-PC, clear the device memory, set required parameters on the recorder, and reset the device for another series of exposures. Consideration should be given to including a wireless capability in the data recorder, so that the data recorder can interface wirelessly with a PC or a longer term storage unit. Consideration should also be given to developing a modular design to increase the number of data channels being collected at the desired sample rates, or provide the ability to time synchronize multiple data channels. The intent of this effort is to produce a device suitable for wear by a Warrior during training activities when exposures to blast or impulse noise environments are likely (i.e., Breacher and artillery training). Outside of the military, the data recorder could be worn by law enforcement, bomb squads, homeland security personnel, astronauts, race car drivers, construction workers, or miners.

PHASE I: The contractor will develop innovative concepts and determine the design of a prototype data recording device that will demonstrate the desired data recording capabilities. Work in Phase I will assess the feasibility of the design by assessing component performance either by physical or computational simulation. The contractor will develop the work plan for subsequent testing with human volunteers. Human testing requires approval by the Human Research Protections Office at the US Army Medical Research and Materiel Command. Phase I should include submission of appropriate and necessary regulatory documents to execute Phase II testing using human subjects. Finally, the contractor shall deliver a report on the proposed prototype hardware design, plan for prototype performance testing, and software design.

PHASE II: The contractor will build the prototype data recording device by delivering functional prototypes to the Government along with the software needed to operate the data collection devices. Along with the prototypes, the contractor shall deliver documentation with scientific data demonstrating prototype's performance capabilities (testing procedure with results) and full descriptions of the current hardware and software design, including user's guides for hardware and software. The contractor will refine the prototype design by addressing the physical and power requirements (i.e., miniaturizing the physical packaging, hardening packaging, if necessary), demonstrating operations with additional testing with volunteers, and developing the required interface software for a Windows based PC. The contractor will produce and deliver 6 functional prototypes with software to the Government for independent testing and evaluations. These should be delivered approximately 12 months after Phase II award. The Government representatives will evaluate the devices and software for 2 months and provide critiques of its suitability. Based on this feedback, the contractor shall refine the design and software to correct any identified deficiencies along with any deficiencies identified by the contractor's own evaluations. After additional refinement, at least two functional second generation prototypes will be delivered at the conclusion of Phase II.

PHASE III: The final prototypes will be tested in laboratory and field studies to demonstrate capabilities, reliability, ruggedness, and user acceptance for military application. While the initial application of the Personnel High Rate Data Recorder is for use on Warriors and their personnel-borne equipment in laboratory and field training environments, the next step extends into the combat environment and more destructive environments with uncontrolled exposure, including blast and crash environments. Such a high rate data recorder could be fielded in support of future generations of the currently-fielded sensors on helmets in OIF (Operation Iraqi Freedom) and OEF (Operation Enduring Freedom). Furthermore, a ruggedized, miniaturized data recorder could move beyond a personnel device to a vehicle device in similar environments. The civilian automotive industry, the U.S. Army Research, Development, and Engineering Command, and U.S. Army Aberdeen Test Center could also take advantage of the advances in vehicle testing, crash/explosive testing, and manikin-based injury assessments. This SBIR effort would advance biomedical and mechanical data acquisition options.

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2. "New Helmet Sensors to Measure Blast Impact" by Donna Miles, American Forces Press Service; Jan 07, 2008, <http://www.defenselink.mil/news/newsarticle.aspx?id=48590>

KEYWORDS: Data Acquisition, Dynamic Loads, Frequency Response, Blast, Crash, Sensors

A09-110            TITLE: Personnel Borne Blast Dosimeter

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a small lightweight, yet robust, disposable sensing system that reveals exposure to dynamic pressure waves in excess of adjustable thresholds.

DESCRIPTION: Deployed Warriors are often exposed to blast during training and combat operations. These exposures often produce injury due to blast pressure exposure and local body accelerations. Combat medics and other medical personnel need a means to accurately and quickly assess the blast exposure level of personnel. While Generation 1 helmet sensors are on helmets of deployed Army Warriors, they do not provide immediate exposure feedback to combat medics and other medical personnel. Additionally, there is some directional limitation with Generation 1 helmet sensors and no correlation between measured helmet sensor data (acceleration and pressure) with level of blast exposure or potential injurious conditions. Although Generation 1 helmet sensors are electronic based devices, an innovative personnel borne blast dosimeter could be purely mechanical, chemical, electronic, or use any combination of basic principles to assess blast exposure level. Current pressure sensors are highly directional dependent, which alter the measured pressure level depending on the sensor orientation relative to the blast source location of obstructions placed between the sensor and pressure source. Ideally the device design could be modular to be Soldier worn or vehicle mounted. The proposed device could be single use or designed for multiple uses, but it should have the ability to maintain, readily accessible blast exposure level data until medical or research personnel have observed or recorded the exposure data. If electronic, the device must be self powered and have a useful life of 1 year from the time it is activated. Additional consideration should be given to determine how the proposed blast dosimeter could be incorporated into the Warfighter Physiological Status Monitor (WPSM). Further general system requirements include: (1) no increased harm or risk for the Warrior or the mission; (2) minimal physical dimensions and weight; (3) adjustable levels of sensitivity; (4) validated relationship between dosimeter measure and objective physical quantities associated with blast exposure; (5) omni-directional capability of measuring blast exposure. The system "dose" measure and sensitivity should be defined with response to the known objective quantities that describe blast exposure. Measurable exposure may be related to blast pressure, blast duration, blast impulse, acceleration, temperature, or other quantities describing blast exposure. Because blast research is ongoing, some flexibility in sensing metric(s) could be advantageous. Location and attachment of the sensing system must be investigated and defined for optimal blast exposure level detection. The intent of this effort is to produce a device/system suitable for wear by Warriors during training activities when exposures to blast environments are likely (i.e., Breacher and artillery training). Furthermore, if the blast dosimeter can sense blast exposure independent of military gear, the blast dosimeter could become a standard issue item, like radiation dosimeters in hospital settings, for individuals working in civilian law enforcement, mining operations, and building and road construction.

PHASE I: Develop blast sensing device concepts and designs that address the desired blast sensing capabilities. Develop the relationship between the sensing ability and blast exposure level. Perform a technical trade assessment of the conceptual designs. Work in Phase I should demonstrate the field compatibility of the design by delivering 2 weight and geometrically representative mock-ups to the Government. Along with the mock-ups, the contractor shall deliver documentation on the two most promising concept designs, anticipated developmental testing

requirements, proposed test procedures and preliminary data to demonstrate functionality, working principles, and use. The contractor will develop the work plan for subsequent development and prototyping.

PHASE II: Mature the selected design and produce Refine the prototype design for wear by Warriors in blast environments by additional testing and design improvements. Produce and deliver 12 functional prototypes to the Government for independent testing and evaluation. The prototype will also include any hardware/software interfaces that are required for system functionality. The Government representatives will evaluate the blast sensing systems for 2 months and provide critiques of the sensing device and its suitability for the training and combat environments. Based on this feedback, the contractor shall refine the design to correct identified deficiencies along with any deficiencies identified by the contractor's own evaluations.

PHASE III: After final system design refinement, 6 functional prototypes will be delivered during Phase III along with design and validation testing documentation. The final prototypes will be tested in laboratory and field studies to demonstrate capabilities, reliability, ruggedness, and user acceptance for military application. If the blast sensing system can be used successfully in the military training environment, it could be considered for the combat environment: one blast sensing device/system for each deployed Warrior as issued by PEO Soldier. Furthermore, if independent of military equipment, a personnel blast dosimeter could become standard issue equipment for the civilian law enforcement community, bomb squads, miners, and construction personnel. Depending on the technological basis for the sensing system, the system could easily translate to remote sensing devices and be incorporated into vehicle blast exposure sensing systems, similar to airbag deployment sensors, sonar sensors, or remote automated personnel/vehicle alert systems.

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KEYWORDS: Dosimeter, Frequency Response, Blast, Sensors, Injury, Dynamic Loads

A09-111            TITLE: Development and Commercialization of Analyte Specific Reagents (ASRs) for the Diagnosis of Rickettsial Diseases on FDA-cleared Real-time PCR Platforms

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acquisition

OBJECTIVE: Develop, evaluate and commercialize ASRs for the detection of rickettsial agents in blood and tissue from clinically ill patients. ASRs that are developed must meet all FDA requirements (21 CFR 809.10(e), 809.30, and 864.4020) pertaining to ASRs and should be capable of being used on all commercially-available real-time PCR equipment. Each ASR should serve as the foundation for a rickettsia-specific assay that is at least as sensitive and specific as current "gold-standard" assay and that has a limit of detection (LOD) low enough to reliably detect the pathogen in clinically ill service members.

DESCRIPTION: Rickettsial diseases, to include: murine typhus, spotted fever group (SFG) rickettsioses, scrub typhus, ehrlichioses, human granulocytic anaplasmosis, and Q fever, pose a significant threat to deployed military forces (Kelly et al 2002, Burnette et al. 2008). In order to minimize the impact of rickettsial diseases on military operations, the rapid identification of the pathogen causing illness in military troops is required. Although the Department of Defense (DoD) desires FDA-cleared diagnostic assays for all of the more than 40 infectious diseases

that threaten our deployed forces, the time and cost to develop these FDA-cleared assays (estimated at >\$100 million over a 20 year period) is prohibitive. When combined with the relative rarity of each disease along with the limited commercial market, it is difficult to develop a business model that justifies the development of all of these FDA-cleared assays. The DoD is therefore interested in evaluating alternative strategies that can rapidly and cost-effectively deliver diagnostic capabilities for militarily-relevant infectious diseases. Key requirements for any alternative strategy include the following: i) must be acceptable to the FDA, ii) must provide commercially available solutions that can yield diagnostic assays, iii) should allow for the rapid (<1-year) development of assays at a modest cost (<\$100,000 per assay), and iv) should provide flexibility to both the commercial company and to the DoD so that specific assays can be rapidly provided on an “as-needed” basis. ASRs provide a potential solution to this problem. The goals of this SBIR topic are to i) evaluate ASRs as a mechanism by which rickettsial diagnostic capabilities can be provided to the DoD, and ii) develop and commercialize ASRs for six specific arthropod-borne rickettsial diseases.

**Desired Capability:** The goal of this SBIR is to successfully develop and commercialize a total of six ASRs that can be used to develop molecular assays for the detection and identification of *Rickettsia typhi*, *SFG rickettsiae*, *Orientia tsutsugamushi*, *ehrlichiae*, *Anaplasma phagocytophilum* and *Coxiella burnetii*, the causative agents of murine typhus, SFG rickettsioses, scrub typhus, ehrlichioses, human granulocytic anaplasmosis, and Q fever, respectively. Each ASR should meet all current FDA requirements (21 CFR 809.10(e), 809.30, 864.4020 at the time this document was prepared) for ASRs, should be produced under cGMP conditions, should be commercially available, and should be capable of being used on a variety of real-time PCR platforms. Although the manufacturer of a specific ASR can make no claims about the performance of the product, laboratories that purchase the ASR will have to establish and validate the assays. Therefore, diagnostic assays developed using the specific ASRs should be at least as sensitive and specific as current accepted diagnostic assays and should not cross-react with other infectious agents. Although not absolutely required, ASRs should be lyophilized if possible. As part of this effort, positive and negative control material for each ASR shall be provided as separate products.

**PHASE I:** The selected contractor determines the feasibility of the concept by developing prototype ASRs (to include positive and negative control material) for at least one of the six rickettsial pathogens listed above. By the conclusion of Phase I, the selected contractor must provide the Contracting Officer Representative (COR) with sufficient prototype ASR material to establish the assay in a government laboratory and to carry out 100 tests. The degree to which the prototype ASR material meets the desired capability outlined above will be evaluated at the government laboratory. Data from this independent evaluation will be used in the determination of the Phase II awardee.

**PHASE II:** The goal in Phase II is the successful development and commercialization of ASRs for each of the six pathogens listed above. Specific goals for each ASR include: i) that the LOD of each assay developed using the ASRs will be low enough to detect and identify the pathogen causing illness in a clinically ill service member, ii) that each assay developed using the ASRs is as specific as current “gold-standard” assays when evaluated using a panel of “near” and “far” neighbor DNA preparations, and iii) that assays developed using the ASRs are as sensitive and specific for the pathogen of interest as current “gold-standard” assays when evaluated using a panel of clinical samples. Once these objectives have been met, each ASR (to include positive and negative control material) should be made available commercially in accordance with FDA guidelines pertaining to ASRs.

**PHASE III:** ASRs developed under this SBIR topic will be suitable for use in a variety of military medical units, to include both deployable units and non-deployable units with a real-time PCR platform. ASRs will also be available for non-military medical purposes, such as use by regional medical clinics or non-governmental organizations (NGOs) in areas of the world where the specific pathogens are present. We envision that the contractor that develops the ASRs for these selected pathogens will be able to sell and/or market these products to a variety of commercial medical organizations, and that this market will be adequate to sustain the continued production of this device.

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KEYWORDS: Analyte Specific Reagents, Diagnostic Assays, Rickettsial Diseases, Rickettsia Detection

A09-112            TITLE: Dual Purpose Handgrenade with Enhanced Non-Lethal and Lethal Effects

TECHNOLOGY AREAS: Electronics, Weapons

OBJECTIVE: Developed an innovative, lightweight (1.5# max) modular hand grenade capable of delivering both Non-Lethal (N-L) and Lethal effects. The N-L effect should be capable of being efficiently scaled and selected to Lethal effect. An optimization of the Lethal effects is desired to provide significantly improved projection of N-L force yet minimize catastrophic and collateral damage to a defined range when the Lethal mode is selected.

DESCRIPTION: The evolving nature of MOUT (Military Ops in Urban Terrain) has highlighted the increasing need & benefit of applying a Non-Lethal (N-L) force in certain scenarios. A massive application of lethal force is no longer considered the optimum approach for MOUT.

In an effort to increase the effectiveness & survivability of the US Soldier, provide significantly improved projection of effective N-L force in sensitive MOUT and GWOT missions, and address an ever-increasing combat-load weight burden, this topic seeks to develop an improved N-L technology which can be effectively scaled to lethal levels yet be capable of minimizing the catastrophic or collateral damage associated with current lethal mechanisms. The ability for the user to reliably select & deliver either non-lethal or lethal effects from this one device is critical.

The desired effects obtained with the device in Lethal Mode should attempt to produce overall effects within a 15 meter radius such that lethal effects occur at close range to the device and then progress to N-L effects reliably outside the 15 meter range. An optional feature capability to allow delivery of the grenade via present grenade launchers is also highly desired.

The topic vision is to significantly enhance the capabilities of and promote the use of N-L force projection. A chief nemesis of N-L systems is their inability to deliver decisive long lasting control effectiveness. By definition N-L effects are limited to short duration times of approximately 20 seconds. As a result of this overall weakness in N-L capabilities, catastrophic lethal force is often applied when less than catastrophic force may have sufficed to effect control. The development of the improved combined N-L and Lethal scalable technology in this topic should promote a significantly broader appeal for N-L by combining it with more prudent levels of Lethal force which are capable of delivering decisive crowd control effects. Developing the technology limiting lethal effects to a defined cutoff range facilitates the use of lethal effects to project decisive warnings or control perimeters while minimizing other aggravating effects normally associated with lethal. The user would also then be afforded the option to combine N-L and Lethal in one engagement, The development of innovative new combinations of N-L and Lethal to

achieve an overall controlling effect would be facilitated, further enhancing the promotion of reliable/containable force.

Dual-use applications of a successful hand-deliverable dual mode N-L/Lethal device include State & Local Police, Corrections Departments, riot control, Prison security/control, Border Patrol, Air Marshalls, and Homeland Security applications.

Technology challenges can be summarized to include:

- 1) Size and Weight parameters; hand delivered and 1.5# (max)
- 2) Development of a viable N-L technique capable of effectively immobilizing an average adult for a minimum of 20 sec.
- 3) Scale of N-L effect to Lethal but with range containment of Lethal effects to be near zero outside 15 meter radius from the deployed device.
- 4) Allow incorporation of safe and arming devices suitable for lethal mechanisms with the potential for the device to become MilStd-1911 Fuzing Compliant (see Reference below).

Note: This effort is not intended to deliver a MilStd-1911 fuzing solution. However, the proposed design should have the potential to incorporate a MilStd-1911 fuzing solution once such a fuze becomes available.

**PHASE I:** Feasibility study and detailed analysis of a proposed N-L effect and scalability to deliver Lethal effects with a defined 15 meter radius. Research and selection of an effective N-L effect adaptable for incorporation with a viable lethal effect in a suitable configuration. Develop the prototype design of a single, viable, 2-mode A-P device weighing 1 - 1.5# (max). Provide designs for a device that are suitable for progression to an advanced prototype design in Phase II.

**PHASE II:** Produce & demonstrate a reasonable number of prototypes capable of demonstrating reliable and selectable Non-lethal or Lethal A-P effects within the defined radius of 15 meters. Demonstration should highlight the device's desired size/weight, reliable selection of desired effects, ease of operation, and effectiveness of both the N-L and Lethal modes.

**PHASE III:** Evaluation & Transition to an Army Program. Success of this topic development may inspire a new class of soldier portable N-L munitions solutions or improved man-portable weapons systems capable of defeating personnel as well as other targets. Upon successful demonstration the sponsoring Army Org will evaluate the performance and maturity of the technology. If the technology/item/system is adequately mature, performance is deemed successful, relevant technology gaps are not being addressed, and adequate Program funding is available, the demonstrated technology/item/system will be transitioned to the Army for further development/refinement and potential Fielding.

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**KEYWORDS:** Grenade, Lethal, Non-Lethal, effects, MOUT, GWOT, crowd, control

A09-113            TITLE: Advanced low-power personnel/vehicle detecting radar for smart unattended ground sensor/munition systems

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Electronics

OBJECTIVE: Develop a compact radar ranging sensor system for smart ground emplaced unattended sensor/munition systems capable of detecting personnel and/or vehicles which employs novel processing solutions and state of the art chip based implementations to optimize low power utilization.

DESCRIPTION: One of the chief technical challenges of unattended ground emplaced smart sensor/munitions systems is to reliably detect personnel and/or vehicles effectively while achieving prolonged unattended operation. A number of radar systems have been developed and miniaturized for such sensor/munitions systems but significant compromises must be made in terms of alerting the radar using lower performance sensors, employing extensive duty cycling, or reducing the overall active life to unacceptably short durations.

The technical challenges for this topic can be summarized as 1) develop a miniaturized radar that optimizes chip based FPGA or ASIC implementations for small size and ultra-low power 2) employ advanced processing techniques which allow reliable alert of threat targets and higher power signal processing (such as target classification or tracking) only when necessary 3) consider use of advanced low power radar techniques such as Ultra-wide band micro-power impulse radar 4) sense personnel at ranges of approximately 50 meters and vehicles at approximately 200 meters 5) operate at average power consumption of 1 watt or less.

PHASE I: Provide design solution and essential chip implementation approach. Verify design, expected radar performance, and power consumption using modeling and simulation. Test key design assumptions during Phase I to verify expected power consumption.

PHASE II: Pursue chip implementation, verify chip design, layout, and performance parameters in first year, followed by chip implementation and test in year two. Fabricate 3 complete radar systems for government test and proof of principle.

PHASE III: Pursue transition to PM-CCS sponsored Intelligent Munition System and/or other smart ground unattended sensor system currently in development.

Pursue Phase III commercial transitions in the following areas 1) low powered unattended distributed sensors for wide area surveillance applications, border security networks and "smart fences". 2) long life battery powered home surveillance systems comprised of smart networked sensors which can be placed in ad hoc arrangements without concern for dedicated hardwire power.

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KEYWORDS: radar, personnel, low-power, range, munitions, sensors

A09-114            TITLE: Automatic Test Equipment (ATE) for Non-Destructive Test/Non-Destructive Inspection/Non-Destructive Evaluation/Non-Destructive Test Evaluation (NDT/NDI/NDE/NDTE) of Composite Rotor Blades

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors

ACQUISITION PROGRAM: PEO Aviation

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, demonstrate, and field a Non-Destructive Inspection (NDI) Automatic Test Equipment (ATE) for field units and depot to utilize in inspecting and/or repairing composite rotor blades at designated locations in near real time (less than 1 second). Field unit ATE shall be less than twenty-five pounds, portable size, and self-sustaining without a need for contractor support. The ATE shall have the capability to automatically ascertain structural health of composite materials up to twelve inches thick, ascertain metal and metal alloy materials that are part of a blade, provide an automatic assessment of the composite sample(s), feed information to the user for automatic processing for maintenance actions, provide a three dimensional picture of the material, and data be available and transmittable back in an open architecture format for analysis by engineers working in Condition Based Maintenance Plus (CBM+) and Prognostics Health Management (PHM) initiatives. Technologies to be considered in this proposal are ultrasonic devices with a depth of field of at least ¼ inch or more, thermography, and microwave technologies.

**DESCRIPTION:** The introduction of composite rotor blades into the Army Aviation systems brought new challenges to the safety of flight of these platforms. In the field, periodic inspections are required to determine whether a composite rotor blade is structurally sound to remain on wing or removed for replacement from the aircraft. Current inspection techniques exercised in the field are limited to a subjective tap test that does not accurately determine the actual material damage or whether the composite material has deteriorated to justify removal and replacement. The result is a higher operational and sustainability cost in excess of \$200,000 or more per defective blade with a total of forty man-hours necessary in some maintenance actions. Today's most common prone damage areas noted in the field and depot environments occur near the root of the blade and in the spindle lug areas. Current technologies available today either do not provide enough resolution, are not developed to a proper Technical Readiness Level (TRL) for use, are not compact enough for field use, or just not feasible for use in an Army field environment. The field environment requires automatic test equipment (ATE) systems in which the operator requires little or no training in order to operate; the system should be able to determine composite material condition of the rotor blades preferably while still attached to the helicopter and still be able to determine the material status of the entire root of the blade. This will be valuable to the user, engineers, and current maintenance and logistics modernization programs such as Condition Based Maintenance Plus (CBM+) and Prognostics Health Management (PHM).

This initiative is to develop, demonstrate, and field an affordable and reliable ATE NDT/NDI device to determine structural health of helicopter composite rotor blades in multiple failure modes to include but not limited to manufacturing defects, failures due to cyclic stress, projectile impact, battle damage, heat, water intrusion, and other external damage effects that cause delamination and/or degradation (to include marcel defects) to occur causing a significant loss of mechanical toughness. Output of the system shall include a three dimensional digital image of the defective areas with a capability to see the different layers, and the capability to locate and measure defects laterally, longitudinally, and transverse and be able to pinpoint and show damage locations. Composite materials of interest include but not limited to fiberglass, kevlar, and other materials as appropriate. ATE must also be able to ascertain the structural health of metal and metal alloys of titanium, aluminum, and steel that may make-up the composite system. The system shall have the intelligence to determine whether a composite material should be taken out of service for repair or discard based on failure analysis of the part. It shall take no more than thirty minutes to set-up in the field with no more than two men, take no more than thirty minutes to scan an area of approximately fifty square feet along the surface with the support of no more than two people, and a thirty minute teardown time with no more than two people. The two person limit does not include quality assurance personnel. Preferably, the ATE should operate with the rotor blade still attached to the rotor system while determining structural health of the specimen under test. Depot repair activities shall also have the capability to utilize the technology, in near real time, to effect repairs on the rotor blade. All resultant platform data collected on the rotor blades and system will be stored for transmission and to the appropriate Department of Defense (DOD) and/or US Army designated CBM data

depository in a readable and usable open architectural format (currently MIMOSA). System shall use a common process and approach to determine system health of any composite system no matter the application. Units shall have a manual mode of operation in order for trained operators to scan a specific area of interest. The system shall comply with DOD Unit/Part Identification (UID) standards, Condition Based Maintenance Plus (CBM+), and other current Logistics Modernization Program (LMP) standards.

PHASE I: Identify technologies promising to determine structural condition of composite materials to the capabilities listed in the description section of this topic. Define the techniques and processes needed to determine structural health and other detectable fault conditions to include top manufacturing defects and field usage failure modes. Develop an initial list of required inputs to the models, and outline a method and procedure to safely and easily inspect the rotor blades. Develop an initial prototype of the ATE unit and demonstrate in a laboratory environment the technical merit of the proposed solution to detect incipient failures of the composite materials and successfully collect information for analysis. Demonstrate three-dimensional graphical interface. Models and all software will be developed such that they can be run on a standard Personal Computer (PC) platform and optimized such that they utilize a minimum of computing resources. Define user interface.

PHASE II: Build upon initial prototype system and develop technology to advanced models, techniques, and programs on several composite rotor blade specimens to include any applicable platform. Assess the application boundaries, accuracy, and limitations for these modeling techniques. Develop, implement, and demonstrate the unit's Interactive Demonstration of automatic updates to ATE via DOD component system (C/MH-47, M/UH-60, AH-64D) shall be done. Proposer shall work with US Army in writing an airworthiness qualification plan as part of this phase.

PHASE III: Finalize the airworthiness qualification plan if necessary for different platforms. Implement a fielding plan for each platform Project Management Offices (PMO) and depot facility on each aircraft system of interest. ATE shall integrate the system data and decision making algorithms into the Integrated Electronic Technical Manual (IETM) interface and be able to show correct system diagnosis based on responses from the ATE system. Data shall conform to DOD Logistics Modernization Program (LMP), CBM+, and PHM initiatives. Apply these modeling programs on different programs as appropriate. Fielding, training, and depot support as required. Other potential applications include inspecting cracks on both composite and metallic materials on other structures such as aircraft skin, buildings, and other structures. Commercial applications include use as a materials quality inspection tool.

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KEYWORDS: Non-destructive Test (NDT), Non-Destructive Inspection (NDI), Non-Destructive Evaluation (NDE), Non-destructive Test Equipment (NDTE), Automatic Non-destructive Test Equipment (A-NDTE), Automatic Test Equipment (ATE), Diagnostics; Prognostics; Modeling; Useful Life Remaining Predictions; Prognostics and Health Management (PHM); Composite Material; Composite Rotor Blade; Delamination; Composites; Condition Based Maintenance (CBM); Condition Based Maintenance Plus (CBM+); Microwave; Ultrasonic; Laser Ultrasonic;

A09-115            TITLE: High Integrity, Low Cost Rotor State Measurement System

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

**OBJECTIVE:** Design, build, and demonstrate through flight test a low cost, reliable, and fail-safe rotor blade motion measurement system suitable for operational use in flight critical flight control, individual blade control, and vibration reduction systems on rotorcraft.

**DESCRIPTION:** Although the rotors of a helicopter or tilt-rotor aircraft are the main force and moment generators, their dynamic state is seldom if ever measured for use in flight critical control systems. The benefits of rotor state feedback for rotorcraft flight control have been known for several decades [1 ,2]. However, fly-by-wire flight control technology is a critical complement to rotor state feedback, and until recently, it has not been widely available on rotorcraft. The potential benefits of rotor state feedback include improved gust rejection, increased control bandwidth, increased component life reduced weight, improved performance of model-following control laws, and decreased control system sensitivity to changes in operating conditions [3 ,4 ,5]. For swashplate-actuated systems, measurement of the rotor first harmonic responses (tip path plane) is usually sufficient to realize these benefits [6]. Measurement of higher-harmonic responses may improve the performance of individual blade control and higher-harmonic control systems in reducing vibration and/or acoustic noise [ 7]. In either type of system, active control of the rotor with rotor-state feedback improves our capability to transmit only desired forces and moments from the rotor to the fuselage and to filter out unwanted disturbances.

Key requirements for the incorporation of rotor state feedback in production rotorcraft are low cost, reliability, safety, and maintainability. Existing military fleet helicopters are currently undergoing upgrades to include fly-by-wire flight control systems that would facilitate the incorporation of rotor-state feedback control laws. It is therefore also desirable for production rotor state measurement systems to be readily retrofitted to existing rotors. Furthermore, the placement and location of the sensor system is critical to production aircraft especially for aircraft with fly-by-wire systems integrated with legacy airframes. Implementation of a sensor without need for a slip ring while meeting electromagnetic emission and compatibility, and susceptibility requirements for production platforms is critical to adoption of this technology. Such a capability may require installation of the sensor in the fixed frame or development of robust wireless technologies to reduce weight and maintenance issues associated with a slip ring implementation.

Several prototype rotor state measurement systems have been documented in the literature, but these systems have primarily been developed as flight test instrumentation for open-loop data collection, with little consideration of cost, maintainability, or reliability [8 ,9]. Flight safety has not usually been a factor in the use of these systems because they are either not used for closed-loop control, or the failure of the affected control loops does not affect flight safety. However, it may be beneficial to integrate rotor state sensing systems into control systems such that they are flight critical, which drives the requirement for a sensing system which is fail safe independent of the control system. The author is aware of only one flight test demonstration of closed-loop rotor-state feedback, conducted more than 30 years ago on a Navy CH-53A [10].

**PHASE I:** Conduct a conceptual design trade study to determine suitable architectures for a low-cost, high-integrity rotor state measurement system for helicopters. Illustrate design performance and cost trades through analysis. Based on the results of these analyses, select the most appropriate conceptual design for further development. Conduct a preliminary design of the selected architecture focused on application to the UH-60A Black Hawk helicopter. Estimate system performance through analysis. Document the design and analysis in a phase I report.

**PHASE II:** Develop a detailed design, and build a prototype rotor state measurement system based on the preliminary design of Phase I. Demonstrate the performance of the prototype system in a relevant environment. The U.S. Army Aeroflightdynamics Directorate, AMRDEC will provide the RASCAL JUH-60A fly-by-wire Black Hawk helicopter, associated facilities and personnel to support this test. Document the results of the prototype system evaluation in a final report.

**PHASE III:** A cost-effective system could be used in a broad range of military and civilian applications to improve aircraft stability, increase agility, improve ride quality, reduce weight and reduce aircraft structural usage. Specific examples include the potential to reduce weight and increase component life through the elimination of existing passive and active vibration control systems on Army helicopters. Civil helicopters can similarly benefit from reductions in vibrations, improved ride quality, and improved stability enabled by rotor state feedback. The prototype system of Phase II should be further developed and demonstrated in one of these application areas in Phase III.

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KEYWORDS: helicopter, rotorcraft, rotor state feedback, flight control, higher harmonic control, individual blade control, vibration, active rotor control

A09-116            TITLE: Man Portable Desalination System

TECHNOLOGY AREAS: Biomedical, Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Design and build a Soldier portable desalination system to support Individual Soldier On-The-Move Hydration. The desalination system will interface with in-line water purification technologies to provide potable drinking water from any indigenous water source, and be compatible with the current Modular Lightweight Load-carrying Equipment (MOLLE) Personal Hydration Systems (National Stock Number (NSN)8465-01-525-5531).

DESCRIPTION: The Man Portable Desalination System will provide the individual Soldier with a capability to convert salt water into fresh water through the use of a portable desalination system, supporting the Individual Water Treatment Device (IWTD) requirement for hydration at will during the performance of mission critical functions in an expeditious and convenient manner. The desalination system will provide the dismounted Soldier with the capability to be self-sustaining during continuous operations for at least 72 hours without receiving replenishment of supplies. With Soldiers increasingly engaged across the globe in a spectrum of environments, the need exists to reduce the Soldier logistical footprint while maintaining individual hydration capabilities. The Man Portable Desalination System will address Increment 4 of the On-The-Move Hydration System (OTMH) for individual

desalination. The requirements for the OTMH system state a total dry system weight (hydration system, water purification system, desalination system) of less than 2 lbs, a system flow rate no less than 200 ml/min, water quality in accordance to TBMED 577, and purified water production of no less than 45 liters before component replacement.

This effort requires the development of an innovative approach to desalinate salt water in a small, lightweight, portable system. At this time the state of the art in man-powered individual desalination devices lies in two areas. The first is a Reverse Osmotic hand pump with a salt rejection rate of 98.4%, weight of 2.5 lbs, dimensions of 5" x 8" x 2.5", and pure water output of 0.89 l/h. The output rate and weight of this technology prevents it from satisfying user requirements. The second technology is a passive Forward Osmosis system that produces a concentrated sports-drink like solution rather than purified water. This technology has a salt rejection rate of 97% and can produce a total of 4 liters of the drink solution at the rate of 0.1 l/h. The Forward Osmotic system creates a concentrated drink solution rather than desalinated water, and also fails to meet the user requirements for flow rate and production volume.

The Man Portable Desalination System must interface with the current MOLLE Hydration System and currently fielded individual Load Bearing Equipment (LBE). The cube and weight of the System must not degrade a Soldier's maneuverability during combat operations, and therefore must not exceed the current state-of-the-art in man powered individual desalination devices (the Reverse Osmotic Pump). The system must have a volume of <100 cubic inches and weight of <2.5 lbs. The Man Portable Desalination System must provide fresh water on demand (> 200 ml/min) from salt water without the use of sugar substances by removing 95% of the salt in the incoming water. The system must be capable of interfacing with in-line water purification technologies to produce drinking water in accordance with TBMED 577. The system must desalinate up to 45 liters of salt water through manual, passive, or electrical methods.

PHASE I: Provide an overall system approach that addresses desalination, portability, size, and weight. The approach should include calculations, material assessments, etc. that leads to proposed candidate designs and prototype for subsequent testing. Conduct preliminary laboratory testing if possible.

PHASE II: Demonstrate and refine a prototype system, providing an assessment of conversion values of salt water, and efficiency of conversion. Produce minimum 5 prototype systems for user assessment and evaluation in a relevant environment or in a simulated operational environment. Testing in a simulated environment should be robust enough in this phase to assess performance, capability, durability, and capacity of water purification devices.

PHASE III: Successful technologies developed under this effort will be transitioned for military application by Project Manager Soldier Equipment as a part of a pre-planned product improvement to the Soldier on-the-move hydration system. The final system will be evaluated in a simulated relevant operational environment to meet a TRL 6 or higher. Potential commercial applications include recreational and occupational safety, as well as law enforcement, first responders, and disaster relief.

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KEYWORDS: desalination, hydration, individual, portable, hand held, salt water, drinking, system, Soldier

TECHNOLOGY AREAS: Materials/Processes, Biomedical, Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop a pad that can be used with the current Advanced Combat helmet (ACH) to reduce shock front and concussive injuries which will ultimately reduce Mild Traumatic Brain Injuries (MTBI).

DESCRIPTION: The current ACH uses a 7 pad configuration with three different shapes of pads (1 circular crown pad, 4 oblong side pads and 2 trapezoidal front and rear pads) to protect against blast, blunt and ballistic threats. These pads are  $\frac{3}{4}$  of an inch in thickness and are commonly made from polyether urethane. Increases in the size of the threats, specifically IEDs, have caused more injuries and increased cases of MTBI. While the specific cause of MTBI is being researched and debated, current injuries may be reduced with the improvement of pad performance. The current Army standard for blunt impact protection is a maximum acceleration of 150g at an impact velocity of 10 ft/s. With minimal space within the helmet (3/4") to absorb and distribute energy from impacts, the pad must be able to absorb a lot of energy quickly to reduce injuries. The approaches of this effort are to improve the current pad materials or identify new pad materials that will protect better against blunt and ballistic threats with considerable focus on increasing blast protection. An improvement may be to increase the impact velocity to 17 ft/s while still maintaining a peak acceleration of 150g. The objective will be to identify materials that are light, comfortable and more effective than the current pads.

PHASE I: Research and develop one or more material systems which have potential to exceed current Army's performance specification blunt impacts (10 ft/s). This material system (helmet pad) shall be capable of absorbing and/or dissipating high energy impacts under the influence of forces and loads at impact velocities as high as 17 ft/s. The finished helmet pad(s) shall be designed as so to be coupled to the ACH and utilized as a suspension system between the wearers head and ACH inner shell. The pads when integrated with the ACH shall not interfere with any other equipment, components and accessories such as chin straps and eye wear retention straps, liners, covers, communication devices and night vision goggles. The ACH when installed with these helmet pads shall demonstrate a measured performance capability which limits direct translation and general motion impact accelerations less than 150 G's at temperature ranging from -60 ° - 160 ° F. Inter-comparison testing shall be done on the existing ACH pads, and new candidate solution materials to demonstrate the magnitude of improvements and repeatability of the materials behavior when subjected to multiple impacts and varying temperatures. This study will validate the correlation between the materials dynamical thermo-mechanical characteristics as a function of its impact behavior protection. This Phase I effort would lead to developing material processes and technique towards the production of a finished item. Deliver a report documenting the research of the material system and its dynamic energy absorption and dissipation criteria established based on the overall pad performance.

PHASE II: Develop the material system and the processing technology identified in Phase I. Fabricate sufficient samples for extensive shock tube and impact testing with the new candidate helmet pads installed into the ACH. Perform shock tube testing with the ACH mounted on an appropriate sized Hybrid III headform and/or ISO full faced headform instrumented with references sensors mounted at the headforms center of gravity. Shock tube testing methodologies will be provided by the government to baseline the over pressure loading parameters. Perform impact tests with the ACH mounted on an appropriate sized, bare metal, DOT anthropometric headform instrumented with references sensors in accordance with the requirements of DOT FMVSS 218 and ACH (CO/PD 05-04) with the exceptions where velocities range from 10-17ft/s. The government will specify multiple size configurations for the ACH being mounted on the DOT headforms. Perform a human factors test to ensure that the materials are comfortable and are feasible in a simulated combat environment. Tests performed must include specially designed ellipsoidal physical human head models which closely match the size of human's skull and cranial bone for an average male and is filled with brain stimulant type gels or equivalent medical standards to obtain biomechanical data which correlates to impact behavior protection. The human factors assessment must validate and demonstrate that the pads reduce peak linear accelerations below 150 G's for velocities ranging from 10-17ft/s.. Deliver a report with prototypes documenting the research the development efforts along with a detailed description of the proposed material systems and their overall performance as so to improve head protection and reduce event related MBTI. Proposed exit criteria – Technology Readiness Level (TRL) 4.

PHASE III DUAL-USE APPLICATIONS: Upon successful completion of the research and development in Phase I and Phase II, the new pads will be manufactured and deployed for field use. A new protective pad would be applicable in both military and civilian armor arenas. The civilian law enforcement community would reap a substantial benefit from this effort. Sport venues such as football, hockey and lacrosse would also be able to use this technology. Proposed exit criteria – TRL 7.

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KEYWORDS: Pads, Mild Traumatic Brain Injury, Advanced Combat Helmet, Shock Tube , Impact Protection.

A09-118            TITLE: Ultra Compact Energy Efficient High Voltage Switches for Switching Very Small Energy Stores

TECHNOLOGY AREAS: Ground/Sea Vehicles, 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: The objective of this effort is to develop compact, energy efficient, high voltage switches. These switches will be used to deliver the energy from power supplies, such as ferroelectric generators, that store very small amounts of prime energy to various loads.

DESCRIPTION: The US Army has programs that require the switching of very small energies in very compact geometries. In general, simple over voltage switches will consume 1/8 to 1/2 of a joule of energy in the process of igniting the breakdown by the breaking of dielectric bonds and heating materials in a small channel. In some

instances, this amounts to the total energy budget available from the power supply. Therefore, the Army is seeking innovative approaches to switching small energy stores with significantly lower losses than observed in simple voltage breakdown switches that meet form factors of interest and that can withstand high g-forces. In addition, the candidate switches must fit into small geometrical spaces; i.e., less than 40 mm diameter by 25 mm long. While multi-shot switches are desirable, single shot systems will satisfy minimal requirements.

PHASE I: Design and develop new compact efficient high voltage switches and conduct proof-of-principle demonstrations 1) to verify that these new switches transfer energy with minimal losses and 2) to assess their ability to function properly with explosive and/or non-explosive driven low energy power supplies.

PHASE II: Since different low energy power supplies may require different switching characteristics, several different switches will need to be designed and their range of operating characteristics determined. In order to verify switch performance, each switch must be integrated with its intended power supply and undergo testing. Other issues that need to be addressed are high g-force survivability, manufacturability, environmental effects, and platform integration.

PHASE III: These switches would be used in pulsed power technologies that are applicable to multiple military and commercial applications. These include water purification units, nondestructive testing systems, portable lightning simulators, expendable X-ray sources, medical instrumentation, manufacturing, and oil and mineral exploration. Since several government labs and prime contractors are developing advanced munitions, the contractor will need to have developed a business plan for working with these agencies and/or companies. This technology could find use in the following Army Technology Objectives: Standoff IED detection and defeat, fuze and power for advanced munitions, advanced lasers, multi-mode high power microwave (HPM), power for the dismounted soldier, solid state laser, compact radar technology, smaller, lighter, and cheaper munitions, pulsed power and directed energy weapons, and sensor, warhead, and fuze technology.

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KEYWORDS: Pulsed power, Switch, High Voltage, Electrical Breakdown

A09-119            TITLE: Coherent High Power Diode Laser Array

TECHNOLOGY AREAS: Sensors, 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: The U.S. Army has a need for a coherently phased high power diode laser array that will generate upwards of 100KW of output power. Smaller scale proof-of-concept experiments for developing a coherent output beam from a laser diode array are being sought. Novel approaches for combining the output of multiple laser diodes in an array would benefit future Army directed energy weapon systems goals.

DESCRIPTION: Laser diodes typically produce high conversion efficiencies from electrical power to photon output. This conversion efficiency has been reported as high as 73% in the literature. Most current solid state directed energy systems typically require a method for converting electricity to photons and then using those photons to pump another laser gain medium. This adds another efficiency problem to those type lasers and therefore increases the initial power requirements to generate desired laser output. It would be desirable to remove this last step in the process and use the diode laser output directly and therefore be able to implement the diode's inherent electrical efficiency and likewise reduce the complexity of the directed energy system.

The problem with using the output of the diode laser arrays for directed energy weapon applications is that the laser arrays produce multiple laser beams, each of which are highly divergent and mostly incoherent with each other. The array of beams therefore cannot be steered properly onto a target (such as an incoming artillery round) efficiently enough to kill it.

PHASE I: Conduct research, analysis, and studies on the selected laser diode array architecture and develop measures of performance potential and document results in a final report. Provide analysis supporting the efficient coherent combination claim and prediction. The phase I effort should include modeling and simulation results supporting performance claims. The effort should also produce a preliminary concept and draft testing methodologies that can be used demonstrate the laser diode array system proposed during the phase II effort.

PHASE II: During Phase II, a laser diode array system concept design will be completed and selected components will be developed and tested to help verify the design concept. A subscale demonstration is desired. The data, reports, and tested hardware will be delivered to the government upon the completion of the phase II effort.

PHASE III: There are many potential applications for efficient high power lasers. 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 diode array 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 be scaled to weapons class power. 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: Solid State Laser, High power laser diode array, Coherent beam combination

A09-120            TITLE: Lightweight Nanosatellite Deployable Array

TECHNOLOGY AREAS: Sensors, 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 lightweight nanosatellite deployable arrays.

DESCRIPTION: The Operationally Responsive Space (ORS) program has been developed to meet the space-related urgent needs of the warfighter in a timely manner. The ORS operational concept calls for ORS satellites to augment or reconstitute existing “big space” systems. However, to be operationally responsive, i.e., timely, ORS space systems must be launched on relatively small launch vehicles with limited payload weights. With current technologies, smaller ORS-class satellites necessarily require smaller components which often translate into lower capabilities than their “big space” counterparts. Additionally, smaller ORS-class launch vehicles are limited to placing payloads into low earth orbit (LEO) or lower highly elliptical orbit (HEO). Some booster concepts under consideration for future use as responsive launchers may only lift satellites weighing 10kg (22 lbs) or less (i.e., nanosatellites).

Nanosatellites with masses on the order of 10 kg (22 lbs) or less are receiving an increasing level of attention within the national security community. However, the small dimensions of these satellites currently limit the size and therefore performance of subsystems that depend on array-type structures. For example, small, body-mounted nanosatellite solar arrays create undesirable power constraints and nanosatellite antenna size limitations necessarily lead to low antenna gains. Although some research has already been done on lightweight space deployable structures for the larger satellite classes, little has been done in the nanosatellite class (1-10 kg). A key area of need for tactically relevant military nanosatellites is an innovative mechanism to serve as a frame for deployable solar arrays, deployable phased array or conventional RF antennas for communications, or arrays for synthetic aperture radar applications (i.e., array structures for subsystems that benefit from larger surface areas). The mechanism, accounting for any solar panels or antenna attached to it, must be compact as well as lightweight so that overall satellite and launch vehicle mass and volume constraints are not exceeded. Deployable planar arrays, or other innovative types of arrays such as deployable reflector antenna structures, could significantly enhance the functionality of nanosatellites for warfighters.

Researchers into lightweight nanosatellite deployable array innovations should take several issues under consideration, including:

- Deployable array mechanism (including attached solar arrays or antennas) mass light enough to be part of an overall satellite with a total mass of 10kg (22 lbs)
- Deployable array mechanism (including attached solar arrays or antennas) undeployed volume compact enough for typical nanosatellite launch vehicle payload volumes (32 cm x 20 cm x 20 cm)
- Technological risk and reliability.
- On-orbit deployment reliability.
- Deployability/functionality/performance in regimes from circular Low Earth Orbit at 160 km (100 mi) to HEO apogees of 4000+ km (2500+ mi).
- The LEO/HEO space environment, including effects of atomic oxygen, radiation and solar wind.
- An on-orbit design life of 1-3+ years.
- Shelf life.

PHASE I: Conduct feasibility studies, technical analysis and simulation, and small scale proof of concept demonstrations of proposed lightweight nanosatellite deployable array innovations. Develop an initial conceptual

approach to incorporating solar panels or RF communications/SAR antennas onto a nanosatellite-sized deployable array mechanism and include system 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 deployable array 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 (solar array or RF/SAR antenna) phenomena. 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 deployable array 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 deployable array could include space-based satellite communications or remote sensing (SAR). Phase III should solidly validate the notion of lightweight nanosatellite deployable arrays with a low level of technological risk. The goal for full commercialization should ideally be Technology Readiness Level 9, with the actual system proven through successful mission operations. Specifically, Phase III should ultimately produce lightweight nanosatellite deployable arrays 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 systems 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 deployable arrays ready to mate to nanosatellite buses, which when launched responsively could meet urgent warfighter needs. Simultaneously, commercial versions of the deployable array could be produced for civilian and scientific applications. Universities could use the deployable arrays in research or student project nanosatellites. Commercial satellite manufacturers could incorporate lightweight nanosatellite deployable arrays 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.

**PRIVATE SECTOR COMMERCIAL POTENTIAL:** There is a perceived potential for commercialization of this technology. The primary customer for the proposed technology will initially be the Department of Defense, but there could also be other applications in the areas of commercial satellite communications or space-based remote sensing (e.g., SAR imagery).

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**KEYWORDS:** deployable array, planar array, solar array, lightweight array, deployable antenna, aperture, nanosatellite, nanosat, microsatellite, microsat, responsive space

A09-121            TITLE: Rapid Identification of Ordnance and IED Materials

TECHNOLOGY AREAS: Materials/Processes, Electronics, 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: Design, build, and test man portable technologies that can be utilized to identify foreign ordnance and improvised explosive device components and explosives. The technologies should be user friendly and require a minimal education to utilize.

DESCRIPTION: Recent advances in forensic analysis and computer science have shown that the identification of the origin explosive materials is possible using a variety of techniques. Radio Frequency characterization of the IED components along with analysis of the materials using stable isotope ratio, pollen analysis, plant DNA analysis, trace contaminant analysis, and other types of methods have shown that it is possible to show place of manufacture as well as point of origin of IED components.

PHASE I: Demonstrate the basic physics of automated identification of components and develop a basic system concept and methods for the automated identification of IED components. Components to be identified should include but is not limited to one or more of the following:

1. The manufacturer of the detonator and or fuse assembly or commonalities between them; or
2. The manufacturer of the explosive and the environments in which the explosive may have been housed or commonalities between them.

Proposed concept systems that can find commonalities between IED components will also be of interest.

PHASE II: Develop and demonstrate a brass board system for the identification of IED components and finding commonalities between the IED components. System should operate, at a minimum, in a standard laboratory environment. System should, at a minimum, be able to:

Identify the manufacturer of the detonator and or fuse assembly or commonalities between them.

-or-

Identify the manufacturer of the explosive and the environments in which the explosive may have been housed or commonalities between them.

PHASE III: These systems could be used in a broad range of military and civilian security applications where the identification of bomb components are necessary for example, the rapid interdiction and neutralization of international terrorist groups or in enhancing security in industrial facilities. The end state of the systems would be an easily used man portable unit that would give field identification of point of origin of components.

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KEYWORDS: Improvised Explosive Device, Identification, Component, Forensic, DNA

A09-122      TITLE: HemSim - Hemostatic Agent Hemorrhage Control Simulator

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

OBJECTIVE: To design and develop a low cost medical simulator to support training of hemorrhage control of non extremity wounds that requires the use of hemostatic agents. This training device will support the training of Army Combat Medics to conduct realistic, performance based, hands-on training of hemorrhage control.

DESCRIPTION: Army Combat Training Schools do not have a capability to conduct realistic hands-on training and evaluation of hemorrhage control using hemostatic agents. Hemorrhage Control is the most important life saving aspect in battlefield medicine. A Soldier can go into hypovolemic shock and bleed to death within minutes after injuring a large blood vessel. Over 2500 Soldiers died in Vietnam due to hemorrhage from extremity wounds. In fact Hemorrhage is the leading cause of preventable death in combat and it is the responsibility of every Soldier to know how to control hemorrhage in the battlefield. For most extremity wounds the use of a temporary tourniquet has been essential in stopping life threatening hemorrhage. If the wound is not an extremity wound and a tourniquet is not applicable as in the case of neck, axillary, and groin injuries, the application of a hemostatic agent with pressure is necessary to control the bleeding. The location of the wound is the factor that drives the tools necessary to control the bleeding. The more proximal the extremity wound the more difficult the application of a tourniquet. These types of wounds necessitate the use of a hemostatic agent in addition to direct pressure and eventually a pressure bandage to control bleeding. Wounds of the axilla, groin, and neck can be fatal if a means of controlling the hemorrhage is not readily available. The moulage manikin should have realistic wounds that are not amenable to a tourniquet. Wounds that are to proximal on the extremity to allow successful application of a tourniquet, but could be packed with Combat Gauze (currently the only recommended hemostatic agent) and wrapped with a pressure bandage to effectively control hemorrhage. Frequently medics rely solely on tourniquets to stop bleeding for extremity wounds. However, they need to have the experience of attempting to use a tourniquet that may not work on a very proximal wound. This requires them to reevaluate their intervention and successfully transition to another hemorrhage control measure if their initial attempt is unsuccessful. In addition, hemostatic agents are also taught as a means of transitioning away from a tourniquet in the event of a delayed evacuation and the possibility of extremely prolonged use of a tourniquet. Currently there are no good manikins available with these types of wounds to effectively train the use of hemostatic agents. Hemostatic agents are substances that promote homeostatic coagulation when applied to a hemorrhaging injury. Use of such agents has drastically reduced the number of deaths that could be prevented on the battlefield. In the last decade, significant advances have been made on hemostatic agents. Currently, there are at least three granular agents and several impregnated bandages and agents in use by Soldiers in theater. Each class of hemostatic agent differs in application and mechanism of action. There is a gap in training since no current training model capability is available and this skill need to be practiced and rehearsed for Army Combat Medic and Soldier competency development. Currently the only instructional media available are lectures and videos. There is currently a package of Combat Gauze in every Soldiers IFAK, every combat lifesavers and combat medics aid bags.

PHASE I: Conduct a 6 month effort to analyze the scientific, technical, and commercial merit and feasibility of using a low-cost medical simulation for training non-medical Army personnel in Army Combat, CS, and Basic Combat Training Schools. Proposed work will include research into feasibility of developing the capability, definition of performance parameters, and description of the overall concept. The simulator solution must be low-cost and realistic for use in the current training Program of Instruction (POI) at the Department of Combat Medic Training (DCMT) Ft Sam Houston Texas. Should provide hands-on training for the application and correct function of hemostatic agents to wounds that are realistic in appearance, feel, and operation. Instantiation of multiple non-extremity wounds to include neck, axillary and groin area are highly desirable. The overall concept should be specifically designed to work with Quick Clot Combat Gauze. It should also consider other popular hemostatic

agents as well, i.e. HEMCON, ChitoFlex, and Celox. Research should include identification of reactive simulated blood and providing a simulated combat gauze capability that could be reused multiple times. We seek innovative and novel ideas for exploration of concepts to provide this training environment.

PHASE II: Develop and demonstrate a prototype system from the recommended solution in Phase I. Provide realistic and meaningful interaction for hands-on treatment. The prototype should provide immediate student feedback without the aide of an on-site instructor.

PHASE III: This system could be used in a broad range of military and civilian medical training applications. Demonstrate the application of this system to civilian hospitals, paramedics, 68W Health Care Specialists, and other military medical personnel.

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KEYWORDS: Combat Medic Training, Medical, Simulation, Hemorrhage Control, Hemostatic agents.

A09-123            TITLE: Interactive Simulation on High Performance Computers

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: There exists a need to optimize the use of hardware and software design methods using high performance computer systems to meet the performance and real-time demands of emerging Interactive Simulation for Training (IST) applications. These emerging applications impose challenging demands on the performance and real-time response of general-purpose computing systems. With the proper high performance computing resources, multiple users of on-line and interactive virtual training environments can collaborate, interact and train anytime and anywhere. These resources are envisioned to provide a distributed net-centric information and visualization capability to facilitate trainers and training needs. This research will investigate the design methods and principles currently being used to meet these demands and formulate a collaborative training scenario that includes multi-modal human computer interaction to command and control both live and virtual entities within an on-line training environment that can take advantage of a high performance computing systems processing power.

DESCRIPTION: With the development and deployment of new hardware and software systems, and ever changing doctrine that identifies how to interact and perform within an area of conflict, the soldier is a prime example of the need for constant updated training. While physical locality is usually a hindrance to interacting with all the members needed to conduct training in a realistic real-time environment, the availability of on-line resources helps narrow that gap. What is needed is a hardware/software solution that can take advantage of a centrally located high performance computing solution that can handle multiple members interacting simultaneously in real-time for large scale IST scenarios.

PHASE I: Determine the feasibility of using high performance computer hardware and software systems for on-line, real-time interactive training of multiple personnel and/or equipment in large IST scenarios. Most uses for HPC are in the area of batch mode computing. Jobs are submitted and run with no user interaction to completion (ie. a weather model). Interactivity with High Performance computing is not traditionally done. This SBIR would develop improved methods for using HPC assets on Interactive Simulations. Develop a scenario by which the simulation can interact with and react to individual elements within the scenario, and have the ability to change the training parameters which modifies the outcome dependent upon user actions. Have the scenario take advantage of emerging human computer interaction capabilities including biometric and alternate interface modalities, for the control of simulated entities.

PHASE II: Implement and demonstrate a representative prototype of the system in a real-time training scenario. Evaluate the effectiveness and reliability of the approach. Show how IST can rapidly improve the Soldiers effectiveness and efficiency through real-time interaction with SMEs and updated training doctrine. One example of how this might be done is to take an interactive simulation that runs on normal Personal Computer (PC) and port it to run on HPC computers. Establish a benchmark running on one node of the cluster computer. Then using improvements developed in Phase I show a prototype system running faster and better than a PC could run it.

PHASE III: Private Sector Commercial Potential/Dual-Use Applications: Potential commercial applications include highly scalable 3D collaboration and training applications, including: Building distributed networked systems; Homeland Security; Police, Fire and Rescue; Maintenance applications, and; High performance and processing resources intense systems and applications.

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