ARMY
16.1 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

INTRODUCTION

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 Website: https://www.armysbir.army.mil/.

Solicitation, topic, and general questions regarding the SBIR Program should be addressed according to the DoD Program Solicitation. For technical questions about the topic during the pre-release period, contact the Topic Authors listed for each topic in the Solicitation. To obtain answers to technical questions during the formal Solicitation period, visit https://sbir.defensebusiness.org/. Specific questions pertaining to the Army SBIR Program should be submitted to:

John Smith
Program Manager, Army SBIR
usarmy.apg.rdecom-ac.mbx.sbir-program-managers-helpdesk@mail.mil
US Army Research, Development and Engineering Command (RDECOM)
6200 Guardian Gateway, Suite 145
Aberdeen Proving Ground, MD 21005-1322
TEL: (866) 570-7247, FAX: (443) 360-4082

The Army participates in three DoD SBIR Solicitations each year. Proposals not conforming to the terms of this Solicitation will not be considered. Only Government personnel will evaluate proposals with the exception of technical personnel from Geneva, General Dynamics Information Technology and Clinical Research Management who will provide Advisory and Assistance Services to the Army, providing technical analysis in the evaluation of proposals submitted against Army topic numbers:

- A16-053 Secure Wireless Disposable Pulse Oximeter Patch that Generates a PPG Waveform, Geneva
- A16-054 Machine Learning & Medical Predictive Algorithm for Medical Applications on End User Devices, Geneva
- A16-057 IND-Enabling Studies for Development of a Novel Therapeutic Agent for the Treatment of Combat-Related Posttraumatic Stress Disorder, General Dynamics Information Technology and Clinical Research Management

The individuals from Geneva, General Dynamics Information Technology and Clinical Research Management will be authorized access to only those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. This institution is expressly prohibited from competing for SBIR awards and from scoring or ranking of proposals or recommending the selection of a source. In accomplishing their duties related to the source selection processes, the aforementioned institution may require access to proprietary information contained in the offerors' proposals. Therefore, pursuant to FAR 9.505-4, this institution must execute an agreement that states that they will (1) protect the offerors' information from unauthorized use or disclosure for as long as it remains proprietary and (2) refrain from using the information for any purpose other than that for which it was furnished. These agreements will remain on file with the Army SBIR program management office at the address above.

PHASE I PROPOSAL SUBMISSION

SBIR Phase I proposals have four Volumes: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report. The Technical Volume has a 20-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any other attachments. Small businesses submitting a Phase I Proposal must use the DoD SBIR electronic proposal submission system (https://sbir.defensebusiness.org/). This site contains step-by-step instructions for the preparation and submission of the Proposal Cover Sheet, the Company Commercialization Report, the Cost Volume, and how to upload the Technical Volume. For general inquiries or problems with proposal electronic submission, contact the DoD SBIR Help Desk at 1-800-348-0787 (9:00 a.m. to 6:00 p.m. ET).

The small business will also need to register at the Army SBIR website: https://portal.armysbir.army.mil/Portal/SmallBusinessPortal/Default.aspx in order to receive information regarding proposal status/debriefings, summary reports, impact/transition stories, and Phase III plans.

Do not include blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume in other sections of the proposal as these will count toward the 20-page limit.

Only the electronically generated Cover Sheets, Cost Volume and Company Commercialization Report (CCR) are excluded from the 20-page limit. The CCR is generated by the proposal submission website, based on information provided by you through the Company Commercialization Report tool. **Army Phase I proposals submitted containing a Technical Volume over 20 pages will be deemed NON-COMPLIANT and will not be evaluated. It is the responsibility of the Small Business to ensure that once the proposal is submitted and uploaded into the system it complies to the 20 page limit.**

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 proposals will be reviewed for overall merit based upon the criteria in Section 6.0 of the DoD Program Solicitation.

16.1 Phase I Key Dates

Solicitation closes, proposals due	17 Feb 2016, 6:00 am ET
Phase I Evaluations	19 Feb – 5 May 2016
Phase I Selections	9 May 2016
Phase I Award Goal	16 Jun 2016

**Subject to the Congressional Budget process*

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

The Army implements 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 have the Phase I Option exercised. The Phase I Option, which **must** be included as part of the Phase I proposal, should cover activities over a period of up to four months and 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.

PHASE I COST VOLUME

A firm fixed price or cost plus fixed fee Phase I Cost Volume ($150,000 maximum) must be submitted in detail online. Proposers that participate in this solicitation must complete Phase I Cost Volume not to exceed a maximum dollar amount of $100,000 and six months and a Phase I Option Cost Volume not to exceed a maximum dollar amount of $50,000 and four months. The Phase I and Phase I Option costs must be shown separately but may be presented side-by-side in a single Cost Volume. The Cost Volume DOES NOT count toward the 20-page Phase I proposal limitation. When submitting the Cost Volume, complete the Cost Volume form on the DoD Submission site, versus submitting within the body of the uploaded proposal.

PHASE II PROPOSAL SUBMISSION

Commencing with Phase II's resulting from a 13.1 Phase I, invitations are no longer required. Small businesses submitting a Phase II Proposal must use the DoD SBIR electronic proposal submission system (https://sbir.defensebusiness.org/). This site contains step-by-step instructions for the preparation and submission of the Proposal Cover Sheet, the Company Commercialization Report, the Cost Volume, and how to upload the Technical Volume. For general inquiries or problems with proposal electronic submission, contact the DoD Help Desk at 1-800-348-0787 (9:00 a.m. to 6:00 p.m. ET).

A single Phase II proposal can be submitted by a Phase I awardee only within one, and only one, of four submission cycles shown below and must be submitted between 4 to 17 months after the Phase I contract award date. Any proposals that are not submitted within these four submission cycles and before 4 months or after 17 months from the contract award will not be evaluated. Any follow-on Phase II proposal (i.e., a second Phase II subsequent to the initial Phase II effort) shall be initiated by the Government Technical Point of Contact for the initial Phase II effort and must be approved by Army SBIR PM in advance.

SUBMISSION CYCLES	TIMEFRAME
Cycle One	30 calendar days starting on or about 15 October*
Cycle Two	30 calendar days starting on or about 1 March*
Cycle Three	30 calendar days starting on or about 15 June*
Cycle Four	30 calendar days starting on or about 1 August*

*Submission cycles will open on the date listed unless it falls on a weekend or a Federal Holiday. In those cases, it will open on the next available business day.

Army SBIR Phase II Proposals have four Volumes: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report. The Technical Volume has a 38-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes), data assertions and any attachments. Do not include blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume in other sections of the proposal as these will count toward the 38 page limit. As with Phase I proposals, it is the proposing firm's responsibility to verify that the Technical Volume does not exceed the page limit after upload to the DoD SBIR/STTR Submission site by clicking on the "Verify Technical Volume" icon.

Only the electronically generated Cover Sheet, Cost Volume and Company Commercialization Report (CCR) are excluded from the 38-page limit. The CCR is generated by the proposal submission website, based on information provided by you through the Company Commercialization Report tool.

Army Phase II Proposals submitted containing a Technical Volume over 38 pages will be deemed NON-COMPLIANT and will not be evaluated.

Army Phase II Cost Volumes must contain a budget for the entire 24 month Phase II period not to exceed the maximum dollar amount of $1,000,000. During contract negotiation, the contracting officer may require a Cost Volume for a base year and an option year. These costs must be submitted using the Cost Volume format (accessible electronically on the DoD submission site), and may be presented side-by-side on a single Cost Volume 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.

Small businesses submitting a proposal 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.

DoD is not obligated to make any awards under Phase I, II, or III. For specifics regarding the evaluation and award of Phase I or II contracts, please read the DoD Program Solicitation very carefully. Phase II proposals will be reviewed for overall merit based upon the criteria in Section 8.0 of the solicitation.

BIO HAZARD MATERIAL AND RESEARCH INVOLVING ANIMAL OR HUMAN SUBJECTS

Any proposal involving the use of Bio Hazard Materials must identify in the Technical Volume 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.

FOREIGN NATIONALS

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 3.5 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 country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. Please ensure no Privacy Act information is included in this submittal.**

OZONE CHEMICALS

Class 1 Ozone Depleting Chemicals/Ozone Depleting Substances are prohibited and will not be allowed for use in this procurement without prior Government approval.

CONTRACTOR MANPOWER REPORTING APPLICATION (CMRA)

The 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.

Offerors are instructed to include an estimate for the cost of complying with CMRA as part of the Cost Volume for Phase I ($100,000 maximum), Phase I Option ($50,000 maximum), and Phase II ($1,000,000 maximum), 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 nine Technical Assistance Advocates (TAAs) 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: https://www.armysbir.army.mil, then click the "SBIR" tab, and then click on Transition Assistance/Technical Assistance.

As noted in Section 4.22 of this solicitation, firms may request technical assistance from sources other than those provided by the Army. All such requests must be made in accordance with the instructions in Section 4.22. It should also be noted that if approved for discretionary technical assistance from an outside source, the firm will not be eligible for the Army's Technical Assistance Advocate support.

COMMERCIALIZATION READINESS PROGRAM (CRP)

The objective of the CRP effort is to increase Army SBIR technology transition and commercialization success and accelerate the fielding of capabilities to Soldiers. The CRP: 1) assesses and identifies SBIR projects and companies with high transition potential that meet high priority requirements; 2) matches SBIR companies to customers and facilitates collaboration; 3) facilitates detailed technology transition plans and agreements; 4) makes recommendations for additional funding for select SBIR projects that meet the criteria identified above; and 5) tracks metrics and measures results for the SBIR projects within the CRP.

Based on its assessment of the SBIR project's potential for transition as described above, the Army utilizes a CRP 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 CRP investment fund must be expended according to all applicable SBIR policy on existing Phase II 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 https://portal.armysbir.army.mil/Portal/SmallBusinessPortal/Default.aspx and is due within 30 days of the contract end date.

ARMY SUBMISSION OF FINAL TECHNICAL REPORTS

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

ARMY SBIR PROGRAM COORDINATORS (PC) and Army SBIR 16.1 Topic Index

Participating Organizations	PC	Phone
Aviation and Missile RD&E Center (AMRDEC-A) (AMRDEC-M)	Dawn Gratz	256-842-8769
Armaments RD&E Center (ARDEC)	Benjamin Call	973-724-6275
Army Research Lab (ARL)	Francis Rush Sabrina Hall	301-394-4961 301-394-3665
U.S. Army Test & Evaluation Command (ATEC)	Jessica Knight	443-861-9339
Communication-Electronics Research, Development and Engineering Center (CERDEC)	Joanne McBride	443-861-7654
Edgewood Chemical Biological Center (ECBC)	Amanda Hess Martha Weeks	410-436-5406 410-436-5391
Engineer Research & Development Center (ERDC)	Theresa Salls Melonise Wills	603-646-4591 703-428-6281
Medical Research and Materiel Command (MRMC)	J.R. Myers Susan Dael	301-619-7377 301-619-5047
Natick Soldier Center (NSRDEC)	Cathy Polito	508-233-5372
PEO Ammunition	Vince Matrisciano	973-724-2765
PEO Aviation	Randy Robinson	256-313-4975
PEO Command, Control and Communications Tactical	Meisi Amaral	443-395-6725
PEO Combat Support & Combat Service Support	Munira Tourner	586-282-4822
PEO Ground Combat Systems	Rachel Dugan	586-282-9521
PEO Missiles and Space	David Tritt George Burruss	256-313-3431 256-313-3523
PEO Simulation, Training and Instrumentation	Robert Forbis	407-384-3884
Space and Missile Defense Command (SMDC)	Gary Mayes	256-955-4904
Tank Automotive RD&E Center (TARDEC)	Martin Novak	586-282-8730

DEPARTMENT OF THE ARMY PROPOSAL CHECKLIST

This is a Checklist of Army Requirements for your proposal. Please review the checklist 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 **$100,000** with up to a six-month duration) AND 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 5.4 of the Solicitation.

4. SBIR Phase I Proposals have four (4) sections: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report. The Technical Volume has a 20-page limit including, but not limited to: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents [e.g., statements of work and resumes] and all attachments). However, offerors are instructed to NOT leave blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume in other sections of the proposal submission as THESE WILL COUNT AGAINST THE 20-PAGE LIMIT. ONLY the electronically generated Cover Sheet, Cost Volume and Company Commercialization Report (CCR) are excluded from the 20-page limit. As instructed in Section 5.4.e of the DoD Program Solicitation, the CCR is generated by the submission website, based on information provided by you through the "Company Commercialization Report" tool. Army Phase I proposals submitted over 20-pages will be deemed NON-COMPLIANT and will not be evaluated.

5. The Cost Volume has been completed and submitted for both **the Phase I and Phase I Option** and the costs are shown separately. The Army prefers that small businesses complete the Cost Volume 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 Volume (offerors are instructed to include an estimate for the cost of complying with CMRA).

7. If applicable, the Bio Hazard Material level has been identified in the Technical Volume.

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 16.1 Topic Index

A16-001	Reduced-Order Inflow Model for Propeller-Airframe Flow Interaction Noise Assessment
A16-002	Metal Matrix Composite Bearing Liner Installation for Rotorcraft Drive Systems
A16-003	Rotorcraft Chaff Dispense Modeling
A16-004	High-Strain Capable, High-Strength Composites
A16-005	Three-Dimensional Imagery Presentation from Multiple Aircraft Sensors
A16-006	Printable Materials with Embedded Electronics and Radio Frequency Components
A16-007	Innovative Hypervelocity Control Techniques for future Army Aerospace Vehicle
A16-008	Dynamic Vehicle Modeling Composed of Mechanical and Thermal Interaction with High-Resolution Synthetic Scenes
A16-009	Laser Source with Variable Pulse Width Capability
A16-010	Colloidal quantum dots as the fluorescent penetrant for nondestructive examination of surface flaws
A16-011	Multimodal trace explosive detection at stand-off distances
A16-012	Multimodal nondestructive evaluation of internal surfaces of holes in steel structures
A16-013	Research in Tool Shape Optimization for Electrochemical Machining
A16-014	Laser Nanostructured Surfaces for Armament Applications
A16-015	Innovative, shock-load resistant Pulsed Power supply.
A16-016	High-strength Nanostructured Silver for Shape Charge/EFP Liner Applications.
A16-017	High Quality Factor, Thin-Film, Electrically Tunable Varactors and Filters
A16-018	Development of a Non-Contact Transmission for Helicopter Applications
A16-019	Bone Conduction Audio & Vibrotactile Transducer for Dual-Use Communication
A16-020	Low-Loss Commercial Deposition Technology for Thick Ferrites and Ferrite/Insulator Films on Printed Circuit Boards
A16-021	Electronic grade, single crystal or large-grain polycrystalline diamond wafer development.
A16-022	Development of Lightweight Heat Exchangers for Man-Portable Battery Recharging System
A16-023	Processing of Metallic Scrap Materials for Battlefield Additive Manufacturing
A16-024	Development of a high resolution long-wave infrared (LWIR) Polarimetric imaging system for long range human identification
A16-025	On-Demand Property Modification for Performance Enhancement of Adaptive Systems
A16-026	Optical Thin Film Technologies for High Energy Lasers
A16-027	Cyber Battlefield Operating System Simulation Tools for LVC Simulations
A16-028	Miniature, software-defined Man-Portable Doppler Radar (MPDR) for Atmospheric Measurement
A16-029	Computationally Driven Development of Energy Absorbing Materials and Manufacturing Processes for Rotorcraft
A16-030	Mode 5 Identification Friend or Foe (IFF) simulation and subsequent RF injection
A16-031	Forest/Jungle Positioning Based on Geo-Registered Images from Foliage Penetrating Radar
A16-032	Innovative X-Band Antenna Architecture for BFT 3
A16-033	Multi-Band Body Wearable Antenna
A16-034	Open Architecture Antenna Controller for Directional MANET
A16-035	Multi Product UHF L-band System Extension (MPULSE)
A16-036	Mission Command of Micro-Robot Swarms: How to select individual agent actions so as to evoke a specific emergent swarm behavior
A16-037	Predicting, Prognosticating, and Diagnosing via Heuristics and Learned Patterns
A16-038	Superimposing Computer-Generated Imagery within Mission Command Environments.
A16-039	Thin Film High-k Dielectric Semiconductor Materials Development for IRFPAs
A16-040	Digital Readout Integrated Circuits With Efficient, Low Power On-chip Data Compression Development
A16-041	Use of Augmented Reality in Experimentation with New Equipment Training for Electro-Optic Infrared (EOIR) Sensors
A16-042	Extended Short-Wavelength Infrared (SWIR) Focal Plane Arrays (FPA) for Hyperspectral Imaging
A16-043	Enterprise Enabled Intelligent Agents to Optimize Intelligence, Surveillance, and Reconnaissance (ISR) Collection

A16-044	Simple Cognitive Based Visualization
A16-045	Portable Ultraviolet Raman Imaging Spectrometer for Explosives Detection
A16-046	High Conductivity Carbon Microfibers for Infrared Obscuration
A16-047	Leveraging Networked Mobile Devices to Improve Terrain Analysis and Intelligence Preparation of the Battlefield
A16-048	Heuristic-based Prognostic and Diagnostic Method for Installations
A16-049	Conservation and Maintenance of Trauma Injured Tissues for Autologous Repair and Reconstruction
A16-050	On-Demand Cell and Tissue Biologics for Mass Casualty Response
A16-051	Particulate delivery system for next-generation malaria vaccine
A16-052	Semi-Autonomous Airway Management Device
A16-053	Secure Wireless Disposable Pulse Oximeter Patch that Generates a PPG Waveform
A16-054	Machine Learning & Medical Predictive Algorithm for Medical Applications on End User Devices
A16-055	Miniature, point-of-care device for establishing sterile connections in combat environments.
A16-056	Portable Occult Hemorrhage Detector and Resuscitation System
A16-057	IND-Enabling Studies for Development of a Novel Therapeutic Agent for the Treatment of Combat-Related Posttraumatic Stress Disorder
A16-058	Device Solution to Enhance Vascular Access by Reducing Pain and Simplifying Procedure
A16-059	Effective targeted treatment of peripheral neuropathy
A16-060	Visual and Physical Footprint Reduction of Parachutes on the Ground
A16-061	Continuous Mode Conveyor Cooking Appliance for Unitized Group Rations (UGR-A) for Military Field Feeding
A16-062	High Pressure Resistant, Non-Powered, Flexible Chemical/Biological Protective Closure System
A16-063	Adjustable Reusable Platform for Expeditionary Military Shelters
A16-064	Biofidelic Headform for Evaluation of Head Protection Against Blast, Sound and Blunt Trauma Threats
A16-065	Nanostructured Metal Alloy for Individual Armor
A16-066	Solid State High Voltage Switching Device for Multi-Point Initiation
A16-067	Next Generation Materials for Armor Piercing (AP) Small Caliber Projectiles
A16-069	Airborne Based Sense and Avoid (ABSAA) Sensor for Tracking Non-cooperative Aircraft for RQ-7 Shadow and Larger UAS
A16-070	The Internet of Things for Body Area Networks
A16-071	Back Extraction Blast Seat
A16-072	In-Field Repair Procedure for Fiber-Reinforced Composite Structures
A16-073	Abrams Engine Stall Detection Sensor
A16-074	Two-Speed Final Drive for Recovery Vehicle
A16-075	Synthetic Megacity Representation in Army Modeling and Simulation (M&S) Environments
A16-076	Augmented/Mixed Reality for Force-on-Force Combat Casualty Care Training
A16-077	Micro-Electro-Mechanical Systems (MEMS) for Image Stabilization in Small Missiles
A16-078	Repurposed Software Programmable Radio Technology to Support Flexible Missile Uplink/Downlink Implementations
A16-079	High Bandwidth Redundant Communication Links for Small Satellites
A16-080	High Power Direct Diode Laser
A16-081	Advanced Reverse Osmosis Elements
A16-082	Structural Battery Development for Military Vehicle Applications
A16-083	Laser Protection for Day Cameras
A16-084	High Power Density Diesel Engine Piston Temperature Measurement System
A16-085	Lifecycle Test Optimization
A16-086	High Fidelity Simulator for Hardware-in-the-Loop Testing
A16-087	Gallium Nitride (GaN) based 28 VDC Circuit Protection and Distribution
A16-088	Gallium Nitride (GaN) based 28 VDC to 120 VAC Inverter
A16-089	Robotic/Automated Occupant Assist of Unmanned Ground Vehicles

ARMY SBIR 16.1 Topic Descriptions

A16-001 TITLE: Reduced-Order Inflow Model for Propeller-Airframe Flow Interaction Noise Assessment

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Development of an efficient, physics-based model that simulates dominant source noise mechanisms associated with the interactional aerodynamics between the airframe and a pusher-propeller system.

DESCRIPTION: Recent DoD interests in future vertical lift systems have spawned aircraft designs with auxiliary propulsion devices to provide forward thrust necessary for high speed operations beyond that of conventional single main rotor/tail rotor configurations. Designs such as Sikorsky's X-2/S-97 Raider/SB-1 Defiant are augmented with a pusher-propeller, positioned behind horizontal/vertical tail surfaces, which can incur interactional aerodynamics that leads to increase in radiated noise levels. Past research [1,2] have identified that this increase in noise is attributed to the shedding of the shear-layer flow from the trailing-edge of the horizontal/vertical tail surfaces. This local phenomenon generates a non-uniform flow field [3] (velocity deficit) downstream that is subsequently ingested by the propeller. As the propeller rotates behind these surfaces, each blade encounters this non-uniform flow field as a time-varying inflow disturbance that causes unsteady propeller blade loads and impulsive noise radiation. The unsteady nature of such blade loads is known to strongly influence the harmonic tones of external noise radiation and subsequently the aural detection distance [4].While this type of interactional aerodynamics/acoustics have been studied for out-of-plane directions [1,2] for community annoyance, there are very little in/near horizon noise measurements that documents the harmonic tonal composition to-date for aural detection assessment. Intent of this topic is to develop a tool (model) for identifying the most relevant non-uniform flow field structures from the horizontal/vertical tail surfaces responsible for the unsteady propeller inflow, unsteady propeller blade loads and in/near horizon noise. The tool should be reduced order [5] in nature but capture the physics of the shear-layer and the non-uniform flow field under realistic pressure gradients, turbulence sources, and their corollary impacts on propeller sound generation. The tool should be well validated with experimental data covering a range of Reynold's numbers, tip-Mach numbers (0.1 – 0.75), and representative tail configurations (horizontal, horizontal+vertical, V-tail, Y-tail, etc.). The tool should be able to make propeller inflow predictions which can be fed into existing rotor noise prediction tools such as PSU-WOPWOP, and that accurately resolve the unsteady aerodynamic forces resulting in high in/near horizon noise. The tool should be applicable to the range of vehicle designs in consideration by DoD and Army Joint Multi-Role (JMR) [6] and must be able to run efficiently on a standard personal computer.

PHASE I: The objective of phase I is to create a proof-of-concept reduced-order tool for characterizing the horizontal/vertical tail surfaces non-uniform flow field/time-varying propeller inflow/turbulence structure identification and the resulting unsteady blade loads on the propeller. Proof-of-concept tool must be compared with at least one set of experimentally acquired inflow and blade loads data not used in the generation of the model. Develop strategies to generate unsteady inflow predictions that are scalable to full-size systems. Develop technology transition plan and initial business case analysis.

PHASE II: The objective of phase II is to further develop the reduced-order inflow prediction tool and implement output with a rotor noise prediction model. The model must be well validate using experimentally acquired inflow and blade loads data over the specified range of Reynold's numbers, tip-Mach numbers, and tail configurations. Extensive experiments and/or simulations to fill gaps in validation data for pusher-propeller and advanced technologies inflow predictions are recommended. Multiple inflow and blade load predictions must be fed into existing rotor noise prediction tools with resulting noise predictions compared to experimentally acquired rotor noise data for similar conditions. Refine transition plan and business case analysis.

PHASE III DUAL USE APPLICATIONS: Further development of the above propeller inflow prediction tool to become finalized. Final tool must be well validated against experimental data and will provide a predictive capability to assess performance and noise impacts from new pusher-propeller configurations and noise suppression technologies for future compound VTOL aircraft. The integrated path from vehicle configuration and flight condition to predicted noise footprint must be well validated and documented. The resulting tool is applicable to both military and commercial aircraft and rotorcraft. Key military applications include predicting in-horizon-plane noise from pusher-propeller vehicles, such as those planned, developed, or in development for JMR-TD and FVL

programs, as well as UAV's such as those in the MQ-series. The improved inflow modeling capabilities will provide the missing data needed to improve existing rotor noise models. Their associated/validated mathematical models will be useful for accurate mission planning and land use models for both military and civilian community operations. The tool would also be useful in low noise design of manned and unmanned propeller driven aircraft, including compound helicopters and tilt rotors

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KEYWORDS: Aerodynamics, Aeroacoustics, Helicopter, Propeller, Noise, Reduced Order Modeling

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A16-002 TITLE: Metal Matrix Composite Bearing Liner Installation for Rotorcraft Drive Systems

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop an innovative room temperature installation method to achieve precision interference fits for bearing liners made of fiber reinforced metal matrix composites used in aerospace drive system assemblies.

DESCRIPTION: Bearing liners and inserts are used in a variety of aerospace structures to support the position of shafts as a sacrificial element that protects mating components from concentrated stresses, cyclic loads, and fret wear. Rotorcraft gearbox housings are typically manufactured from magnesium or aluminum alloys, and use steel bearing liners. Newer materials, such as fiber reinforced metal matrix composites, can reduce the weight of these steel liners by 50%. Bearing liners are typically installed using conventional interference press-fit or thermal shrink-fit installation processes. In shrink-fit applications, the achievable interference is dependent upon the thermal

expansion of the bearing, which may severely constrain the materials suitable for the application. There are also corrosion issues that arise from the condensation associated with use of cryogenic fluids when freezing or shrink-fitting a liner into place. In press-fit applications, the applied interface pressures may be highly non-uniform, requiring significant safety margins in geometry and weight. With both press and shrink-fitting, the compressive forces applied during installation do not correlate well with predictive diametrical changes, and actual interference fit and uniformity are not measurable. Follow-on operations to ream the inside diameter to maintain precise dimensions also adds additional time and cost to the installation process. Neither shrink-fit nor press-fit bearing configurations are well suited for field maintenance, where substantial disassembly of the component may be extremely expensive and time consuming. In order to overcome the current disadvantages of installing bearing liners, this SBIR topic seeks an innovative room temperature installation method to achieve precision interference fits for bearing liners made of fiber reinforced metal matrix composites. The proposed solution shall not include rework of a gearbox housing. Liners shall be retained or locked by a positive method to prevent rotational and axial motion. They shall have a minimum life of 4500 hours based on operation under a mission spectrum duty cycle or 75% of the associated gearboxes Gearbox Power Rating, whichever is greater. The proposed solution shall use fiber reinforced metal matrix composites in order to provide weight savings and enhance wear characteristics compared to steel liners. The proposed installation process shall be developed to be affordable, practical, fast, and non-damaging to install interference fit bearings into housings at room temperature during manufacturing and repair operations. A method to inspect and verify interference fit and interference fit uniformity must also be addressed. Overall, the solution shall reduce total maintenance costs over the platform lifecycle.

PHASE I: Demonstrate suitable fiber reinforced metal matrix composite materials that can be installed using a room temperature installation process. The method shall achieve moderate interference fits of 0.001” to 0.003” at diametric ranges scalable between 0.3” and 4”. Demonstrate bearing installation methodology, retention, and integrity with basic test specimens. Conduct mechanical properties testing according to national standards (e.g. ASTM D3552, ASTM E18, ASME B46.1) or equivalent specifications to achieve the following goals: minimum yield strength = 103 ksi, minimum core hardness = 34 HRC, and maximum surface finish = 16 Ra. Weight savings of matrix composite materials should demonstrate a density 50% less than steel. Offerors are encouraged to work with helicopter manufacturers and suppliers to identify suitable bearing configurations on existing platforms.

PHASE II: Conduct further testing with modeling of interference fit and localized internal residual stresses using full-scale parts. Develop a bearing installation procedure that addresses design inputs of speeds, loads, service life, and service environment. Optimize and refine the bearing liner material and installation process based on Phase I results. Optimization includes manufacturing processes, such as surface coatings to increase fretting, sliding, and micropitting resistance, and tooling to enhance interference fit repeatability and dimensional consistency. Perform tribological testing, and demonstrate that the mechanical properties provide increased life over existing steel liners. Perform bearing installation and repair on the selected drive system. Validate bearing liner performance in a full scale Army rotorcraft gearbox with endurance testing at maximum continuous power. The proposed solution shall demonstrate lifecycle (production plus maintenance) cost savings and system weight reduction in the selected application. Aerospace manufacturer requirements and depot/field repair activities should also be considered.

PHASE III DUAL USE APPLICATIONS: Further collaborate with Army rotorcraft Original Equipment Manufacturers or suppliers to transition technology towards qualification. Coordinate with an Army Program Executive Office to implement installation procedures for production and sustainment. Additional specimens and testing may be performed as needed to further demonstrate the effectiveness of the proposed technology to achieve significant weight reduction, mechanical performance increases, and simplified installation for both initially manufactured and field repair applications. Applications can be extended to components across Army platforms, in other industries, and in the commercial sector.

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KEYWORDS: bearings, liners, interference fit, fret wear, fiber reinforced, metal matrix composite, installation, manufacturing process

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A16-003 TITLE: Rotorcraft Chaff Dispense Modeling

TECHNOLOGY AREA(S): Air Platform

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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop and validate tools for modeling of rotorcraft chaff dispense and radar cross section. Of particular interest is the initial dispense trajectory and bloom.

DESCRIPTION: Development of RF chaff countermeasures systems for rotorcraft typically requires dedicated flight testing. Optimization of the dispenser location and trajectory may be prohibitive due to flight testing and test range cost. High-fidelity computational fluid dynamics (CFD) for rotorcraft has reached a relative state of maturity

with the ability to accurately model the complex fuselage geometries and predict the vortical, interacting wakes, while low order methods such as vortex free wakes (VFW) now offer the potential for real-time application. In any case, the unsteady complex flow field about the helicopter, as opposed to fixed wing, should be considered for optimal chaff dispersal. Although the technology exists to convect chaff in the unsteady flow field and analyze the radar cross section (RCS), there is little knowledge and understanding of the initial dispense phase of the chaff ejection. Tools are sought which will predict the chaff dispense and initial bloom out of the cartridge, before the flow field convection takes over. Experimental efforts may be required to characterize this initial phase using various dispensers and types of chaff. The developed model and tools should modularly incorporate with high-fidelity time-dependent CFD or real-time free wake methods, particle tracking algorithms, and RCS signature prediction software to create an integrated process. It is expected that high performance computing will be required for the CFD and RCS simulations. For low-order methods (VFW), a real-time simulation is sought. With the developed tool set (dispense model, CFD/VFW, particle tracking, RCS) it will be possible to analytically and cost-effectively optimize chaff dispense for a range of flight conditions and maneuvers.

PHASE I: Develop and validate modeling tool to predict initial chaff dispense and bloom. Use existing data and/or execute experimental studies to augment current knowledge. Develop an approach which integrates dispense tool with aerodynamics (such as high-fidelity CFD or real-time VFW) and RCS modeling software.

PHASE II: Further develop and validate chaff dispense/bloom modeling software for a range of operational configurations (dispensers, chaff types). Fully develop integrated process and modular tools for prediction of chaff RCS signature using dispense model, CFD or real-time VFW, particle tracking algorithm, and RCS software. Demonstrate capability to predict RCS of helicopter chaff cloud on a representative DoD rotorcraft configuration.

PHASE III DUAL USE APPLICATIONS: Transition to operation by government and industry. Implement for optimization of chaff countermeasures systems on Army rotorcraft. Implement in real-time simulators.

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KEYWORDS: Chaff, countermeasures, rotorcraft, aerodynamics, wakes, particle tracking, real time

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A16-004 TITLE: High-Strain Capable, High-Strength Composites

TECHNOLOGY AREA(S): Air Platform

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 5.4.c.(8) of the solicitation.

OBJECTIVE: The objective of this effort is to increase strain capability in composite aerospace structures while maintaining strength and stiffness, through innovative material applications.

DESCRIPTION: In recent years, synthetic nanoparticles, such as carbon nanotubes and graphene oxide have garnered much attention for their exceptional mechanical properties. However, efforts to translate the load-bearing capabilities of these nanostructures to macroscopic composite materials have been unsuccessful. Additionally, current composite material processing methods such as z-pinning and stitching do not yield performance improvements without associated reductions in strength or stiffness. The Army desires improvements in Durable and Damage Tolerant (D&DT) aerospace structures to meet future availability and performance requirements. D&DT incorporates “Durability,” or the resistance to damage during usage, with “Damage Tolerance,” the ability of damaged structure to continue operating without needing repair. D&DT can be realized in aerospace structures through methods such as structural component redundancy, component oversizing, or other load governance methods. However, this effort seeks to increase the inherent capability of the structural material systems. Areas of interest include innovative applications of novel or enhanced material solutions in structural components. Recent computational models revealed polymer-grafted nanoparticles that undergo dynamic structural reconfigurations preserved the materials' mechanical integrity when subjected to tensile deformation. Additionally, nanofibers prepared via electrospinning were shown to possess simultaneously high strength, stiffness, and toughness.

PHASE I: Effort in this phase shall develop a concept to increase strain capability in aerospace structures. Proof of concept testing shall be performed to show a minimum of 20% improvement in strain capability over a modern high strength composite such as IM7/8552. Testing shall show strength and stiffness are maintained without a weight penalty. Required deliverables for this phase shall be a project management plan, progress reports, and a final report. The final report shall document the scientific methodology underlying the concept, anticipated benefits, lessons learned, and the future plans to demonstrate and manufacture the concept. Additionally, the final report shall include a cost analysis of the developed technology solution compared to a modern high strength composite such as IM7/8552.

PHASE II: Effort in this phase shall mature and demonstrate the capability increase achieved in Phase 1. This phase shall further develop and optimize the concept through demonstration testing. Additionally, manufacturing techniques shall be developed through component fabrication. Models to analyze performance of the material system shall be developed and validated. Required deliverables for this phase shall be a project management plan, progress reports, test plans, components for independent testing, and a final report. The final report shall document the Phase 2 effort in detail, lessons learned, and the future plan for commercializing the developed material system.

PHASE III DUAL USE APPLICATIONS: Effort in this phase shall further mature and commercialize the high-strain capable, high-strength composite. Consideration shall be given to improving manufacturing readiness level and material qualification through modeling and testing. The vision is that high-strain capable, high-strength composites will be used in aerospace structures, increasing availability and performance. Future Army vertical lift platforms as well as U.S. commercial aircraft are likely transition paths.

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KEYWORDS: strain capability, material enhancements, composite, durability, damage tolerance, damage resistance

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A16-005 TITLE: Three-Dimensional Imagery Presentation from Multiple Aircraft Sensors

TECHNOLOGY AREA(S): Human 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 5.4.c.(8) of the solicitation.

OBJECTIVE: To support future Mission Commander situational awareness and decision-making through the development of presentation techniques capable of fusing visual information collected from multiple distributed sensors into a single, cohesive, three-dimensional display.

DESCRIPTION: Background: As Army aviation continues to implement increasingly advanced levels of automation, human operators will transition from their current roles actively piloting vehicles to serve instead as Mission Commanders (MC) supervising highly intelligent autonomous systems. In these manned-unmanned teaming (MUM-T) operations, the MC's primary function will be decision-making – delegating tasks to be executed by the autonomous system(s) under their command. The MC's many tactical decisions include: finding the optimal routes for aircraft to fly, defining ground regions to be surveyed for intelligence gathering, processing intelligence to identify threats, and determining how to prosecute identified threats. The effective execution of these functions will require the MC to synthesize information collected from a variety of sensors distributed across the battlefield in order to maintain high-level situational awareness (SA). With existing technologies this task requires high levels of visual attention, frequent task-switching to perceive information from multiple displays, and very high levels of working memory. These cognitive demands significantly degrade the MC's decision-making ability. Solution: This task seeks to develop visual information presentation techniques capable of fusing information from multiple

sensors to generate a single three-dimensional visual representation of the battlefield using existing techniques such as photogrammetry. Each individual sensor will provide full-motion video as well as accompanying metadata describing the geospatial position and orientation of the sensor. A centralized processor will analyze the imagery from each sensor to render the scene in three dimensions, and synthesize information collected from many distributed sensors into a single common database. The MC can easily manipulate the display to view the environment from any vantage point without the risk of entering dangerous airspace or the expense of time and fuel to reposition an aircraft. The three-dimensional world model will also support the display of additional information using synthetic visualization methods, such as flight paths, line of sight calculations, and weapon effectiveness ranges. The resulting three-dimensional database will be presented to the MC utilizing existing display hardware, such as a panel-mounted display or a stereoscopic head-mounted display (HMD) such as the Microsoft HoloLens. The use of an HMD will allow the imagery to be presented as a virtual hologram, allowing the MC to see a virtual representation of the entire battlespace floating inside their cockpit. Combining this holographic presentation with gesture input devices such as the LeapMotion will provide a natural means of interacting with the imagery. Ultimately, this world model can be used as the virtual “sand table” on which all relevant battlespace information is presented to the MC in a single interface. Current Limitations: Commercial software packages such as Pix4Dmapper provide similar functionality. However, existing products are intended for agricultural and geological surveying purposes. For these applications spatial accuracy is of primary importance, with little concern for processing latency. Existing processing methods also have little to no tolerance for moving objects. These limitations greatly restrict the ability of existing technologies to support military operations in rapidly evolving dynamic urban environments, where tolerance for latency is limited, and the accurate display of moving targets is critical.

PHASE I: Develop a functional proof-of-concept system capable of integrating visual and meta-data information from at least two distributed sensors imaging a scene with a single moving target. Processing time will introduce a latency of no more than 60 seconds between the collection of the original sensor imagery and the final presentation of the three-dimensional moving image to the user.

PHASE II: Expand the proof-of-concept system to integrate information from at least three distributed sensors imaging a scene with up to ten moving targets. The resulting imagery will support presentation through both traditional flat-panel displays and holographic displays using a selectively transparent stereoscopic HMD. The system must be compliant with relevant DOD/industry standards (STANAG, MISB, FACE, etc.). Processing time will introduce a latency of less than 30 seconds.

PHASE III DUAL USE APPLICATIONS: The system will provide a means of augmenting the collected imagery with synthetic supplemental geo-referenced information, such as flight paths, line of sight calculations, and weapon effectiveness ranges. Processing time will introduce a latency of less than 15 seconds. Transition the system to the SUMIT (Synergistic Unmanned-Manned Intelligent Teaming) 6.3 research program, which is investigating human-machine interface and cognitive decision-aiding concepts for future MCs involved in MUM-T. The system will also be well-suited for transition to a variety of commercial applications, including: monitoring systems for police, border patrol, and private security; and the entertainment industry, specifically motion capture for the production of video games and movies.

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KEYWORDS: image processing, three-dimensional imagery, photogrammetry, human systems, Mission Commander, situation awareness, sensor, computer vision

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A16-006 TITLE: Printable Materials with Embedded Electronics and Radio Frequency Components

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop a set of prototypes utilizing additive manufacturing with embedded electronic components and RF waveguide/antenna components and demonstrate an RF dual-pol or fractal front-end.

DESCRIPTION: Additive Manufacturing is a quickly growing field of technology that has been adopted across the military and even deployed on the ISS by NASA. The technology allows the creation of components that cannot be achieved using traditional subtractive methods such as machining. The Aviation and Missile Research Development and Engineering Center is interested in using Additive Manufacturing to create components that fit the design space available. This will allow the AMRDEC to overcome the necessity of designing technology around commercially-available parts (such as COTS connectors). This is not platform-dependent, but pervasive across all Army technology as an affordability metric. The purpose of this topic is to develop multiple prototypes using Additive Manufacturing with embedded electronic components and RF waveguide/antenna components. The definition of embedded here is the integration of conductive surfaces on and within the additive manufactured structure. Barriers to this development include, but are not limited to, the ability to stop the additive manufacturing process of non-conductive layers, integrate conductive layers (such as ink), re-register (if necessary), ensure layer cohesiveness, and complete the additive manufacturing process. The topic requires the use of commercial additive manufacturing tools or hobby level printers such as Lulzbot and Makerbot. This is to ensure cost effectiveness.

PHASE I: In Phase I, the offeror will research and develop prototypes of embedded electronic structures to include analog and/or digital traces. Electronic structures (traces) shall also be simulated and evaluated to capture circuit parameters and loss/resistivity characteristics. The offeror shall also develop designs for connectors, Ku-band RF waveguides (such as GSG), and basic antennas. An RF simulation package, capable of modeling structures at Ku-band frequencies, shall be used to generate data on losses, conductivity and resistivity of the resulting RF designs.

PHASE II: In Phase II, the offeror shall use methods developed in Phase I and expand the research and development to include rugged prototypes of embedded connectors that can withstand environmental concerns that include humidity, dust, shock, vibration, and thermal fluctuations such as that of a missile launch and relevant lifetime. Connector types that shall be prototyped include BNC, DVI, VGA, 2-, 3- and 4- pin DC power connectors (RoHS compliant), SMA, and SMP and shall include the minimum pin number but not necessarily in the COTS connector form factor to allow scalability and reformatting of size/shape specific to Army design requirements. In other words, the connectors do not have to follow the format (size) of the COTS product, and should be developed with flexibility in mind to allow the creation of a connector around an available design space or size. In addition, the offeror shall

print low-loss microwave PC board material and FR4-type printed circuit board materials, resulting in a low cost, high performance circuit board. Multiple layers with embedded electronic traces and vias that can be filled during the printing process (or after) should be considered. Finally, the offeror shall research and develop, fully model/simulate, build and evaluate a prototype of an embedded 8-element Ku-band RF front end, with dual-pol and/or 3D fractal elements with RF connections (such as SMA, 2.92 K-type connectors or G3PO, SMP push connectors). Losses, individual element antenna gain/patterns, integrated aperture gain/patterns, and S-parameters shall be modeled and also collected in laboratory evaluation. All results are to be fully documented.

PHASE III DUAL USE APPLICATIONS: Since the 1957 launching of Sputnik, commercial satellite communication has matured and become commonplace in the lives of humankind. The proliferation of hobby-level Additive Manufacturing tools is going to bring 3-D printing into all aspects of our lives. For Phase 3 of this effort, the offeror shall research, develop, fabricate, and evaluate a connectorized passive Ku-band RF planar array utilizing additive manufacturing with embedded electronic and RF components that will consist of a minimum of 64 elements (either dual-pol or fractal) with a satellite application in mind. The array shall have integrated RF connections capable of a mono-pulse combination, culminating in integrated connectors (per quadrant) that will mate to COTS Ku-band connectors for collection of RF energy that will be evaluated by AMRDEC in an anechoic chamber. The prototype shall be printed in as few steps as possible with minimal pieces – the goal would be a single piece, integrated, connectorized array after multiple printing steps. Phase 3 dual use applications: Particular military applications include design space specific connector capability, and ground radar or generic radar sensor system applications for use on the Modular Missile Technologies (MMT) program. Commercial applications include satellite sensor system applications and also design space specific connector capability. Transitions of opportunity include both immediate and local capability generation of additively manufactured designs with electronics embedded along with field replacement of sub-system components at the connector level and above (i.e., connectors, waveguides, antennas, etc.). The most likely path to transition the connector and the radar sensor technology is for MMT to adapt the technology during their development and test cycle which runs through FY20. The MMT approach of designing the system from a modular point of view makes this program a good fit. With sufficient information at the interface, which must be non-proprietary, MMT parts can be developed independently from other MMT parts, time-to-market is shortened, and customization is possible.

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KEYWORDS: Additive Manufacturing, Ku-band, connectors, embedded electronics, embedded RF, 3-D Printing.

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A16-007 TITLE: Innovative Hypervelocity Control Techniques for future Army Aerospace Vehicle

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Innovative component control technology concepts (with an associate conceptual aerospace vehicle) are sought that would enable the development of a future class of Army maneuvering hypervelocity vehicles. Aerodynamic control technologies and associated Navigation, Guidance and Control (NGC) techniques should identify and address the technology gaps that prevent the vehicle from maneuvering at hypersonic speeds. Potential technology gaps that might face future hypervelocity vehicles traveling at speeds up to Mach 18 could include: regions of non-continuum flow, laminar and turbulent flow transition, order of magnitude pressure variation between windward and leeward control force application, multi-phase flow, ablation issues, significant center of pressure shifts, and so on.

DESCRIPTION: Hypersonic vehicle technology is quickly approaching the point where a small-unmanned glider, flying at 13,000 mph and at an altitude of 30 to 50 km, could fly to any location in the world in under 60 minutes. The Army aerospace vehicle will need to have similar speed but will likely require significantly enhanced maneuver capabilities. Timelines and avoidance considerations for future hypersonic vehicles could place very challenging velocity and maneuverability requirements on the vehicle. To address this concern, new innovative aerodynamic control technology must be developed for hypersonic air-breathing and unpowered vehicles. Potential maneuver and control options might include propulsive, aerodynamic, blended methods and other innovative ideas.

PHASE I: This solicitation seeks innovative control technology concepts (with an associate conceptual aerospace vehicle) that will enable the development of a future Army hypervelocity aerodynamic vehicle. The innovative control technology concepts will be identified, simulated, and compared with propulsive and blended propulsive/aero maneuver and control techniques covering the anticipated hypersonic Mach range. Trade space analysis shall include comparisons that address both the component control technology and the associated aero-shaped concept. At a minimum, the analysis should include the total maneuver capability, magnitude of the maneuver capability, stability margin sensitivity, and overall vehicle response and system fly-out timelines.

PHASE II: The control concepts and associate vehicle concept formulated in Phase I will require the development of analytical models that are necessary to demonstrate flight maneuverability performance satisfying control characteristics necessary to perform flyout and maneuver in a six-degree of freedom simulation. It would be desirable to demonstrate the most promising component model performance in a hardware-in-the-loop setting. Alternately, limited aerodynamic testing may be used to verify performance predication for either the vehicle or vehicle subsystem.

PHASE III DUAL USE APPLICATIONS: If successful, the end result of the Phase-I/Phase-II research effort would be to experimentally validated aerodynamic maneuver and control methods/concepts (vehicle and control hardware) for use in a ground based aerospace vehicle that can be tested full scale for the desired flight conditions to demonstrate the sought maneuver, control, and intercept performance. This Phase III effort can lead to a control technique and/or design that may benefit the Army's future upgrades to such defensive systems such as PAC3 or THAAD. For military applications, this technology is directly applicable to all high speed air-breathing missile systems. For commercial applications, this technology is directly applicable to advanced maneuver and control techniques for commercial applications such as high speed supersonic transports and to orbital launch systems. While the focus of this SBIR Topic is on aerodynamic maneuver and control for missile systems, the topic also has

direct application in both the military and commercial hypersonics arenas. The most likely customer and source of Government funding for Phase-III will be those service project offices responsible for the development of advanced hypersonic missile systems such as the Navy/DARPA HyFly, Air Force X-51, and DARPA Facet programs. However, it is possible that as NASA continues its access to space projects, this technology will become very important.

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KEYWORDS: aerodynamic, maneuver, control, air-breathing, missile, hypersonic glide

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A16-008 TITLE: Dynamic Vehicle Modeling Composed of Mechanical and Thermal Interaction with High-Resolution Synthetic Scenes

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop efficient vehicle modeling capability utilizing physics-based techniques and state of the art computational applications to obtain dynamic high-resolution, on-the-fly, thermal and mechanical interaction with terrain model scenes. The vehicles model shall interface and dynamically interact with terrain modeling toolsets and be suitable for implementation within existing scene generation technology.

DESCRIPTION: The Army has need for the accurate and timely representation of dynamic, thermally active vehicles moving within operationally realistic terrains and surroundings to support the Modeling and Simulation (M&S) efforts of missile-borne seeker development, system-level performance evaluations, and mission planning. The primary goal is the development of this capability for InfraRed (IR) seekers and sensors but development efforts should include the implementation of a software architecture that is readily extensible to other wavebands such as Visible (Vis), Near-IR (NIR) and Radio-Frequency (RF). Likewise, the software architecture should represent the vehicle using individual, component-level elements allowing the rapid adaptation of the developed capability to other thermally active objects besides vehicles. This SBIR seeks innovative approaches for analytically representing

the time-evolving thermal signature of these vehicles within existing IR scene generation capabilities and terrain modeling toolsets without incurring unsustainable increases in runtime. Simulated scenarios typically include terrain models measured in 100's of square kilometers, and contain both passive elements, such as trees and bushes, and active elements, such as vehicles, buildings, and power transformers. In particular, vehicles can have rapidly varying thermal signatures and complex, dynamic interactions with the local environment. This is true both thermally and mechanically since the vehicle's motion over the terrain is coupled through the suspension system and, ultimately, into induced vehicle dynamics. Dampening by the suspension and breaking are also contributors to heating within the vehicle that need to be accounted for. Therefore, it is essential that the developed capability correctly model both the mechanical and thermal dynamic couplings between the vehicle and the adjacent terrain and surroundings. Historically, the required data for modeling these scenarios has been generated using empirical measurements from expensive, on-site data collections that, by their very nature, support only a temporally static representation of the scene and its contents. Recent advancements in thermal simulations have allowed all but the active thermal elements of these scenarios to be generated using predictive methods and models. These simulations generate predicted thermal distributions for the slowly varying terrain and passive elements that generally have a temporal response on the order of several minutes to hours. For typical Army applications, these scene elements can be treated as static. In contrast, thermally active vehicles require a temporal resolution measured in seconds to capture the time-varying thermal response. This difference in time-scales suggests a two-tier approach: use the existing thermal predictive solution for the large-area terrain and wide spread passive elements and develop a new capability for modeling the localized thermally-active vehicles which then couples the vehicle with the terrain. The goal of this topic is the demonstrated capability to represent these vehicles via modeling processes suitable for use in scene generation code and system-level simulations while meeting runtime requirements. This includes dynamic coupling of the vehicle's thermal signature and induced motion with that of the otherwise static local area around it. The developed capability must account for all major thermal processes including solar loading and shadowing, convection (with advection), conduction, and radiation exchange with all relevant elements within the simulated environment. Likewise, the developed capability must account for the major mechanical interaction processes involved between the vehicle and the ground including wheel or tread motion, suspension loading and travel, induced body roll/pitch/yaw positions and rates, and compression of the underlying vegetation and soil. The runtime objective is to generate the vehicle's updated thermal distribution and dynamic state and then couple them with the local background within a minute for each simulated time-step.

PHASE I: Develop a comprehensive detailed plan for the physics-based modeling capability. The plan must address both high fidelity signature generation and mechanical interaction with a terrain model. The plan shall embrace modes for simulation and the software architecture required for implementation and hosting on different computational platforms such as multi-core PCs, graphic processors, and DoD HPC centers. All supporting software tools, necessary processes, implementation strategies, VV&A, maintenance, and security to realize and sustain a model instance are to be planned and defined. Source data shall be identified to support Phase II development and verification/validation activities. A draft Interface Control Document (ICD) and preliminary Software Test Plan (STP) would be part of the Phase I deliverables. Metrics shall be identified in that will be used to assess speed, accuracy, and fidelity in a vehicle model operating on a terrain model.

PHASE II: Execute detailed plan developed in Phase I to implement the proposed capability. Developments should include source code and all required supporting software tools. The ICD and STP should be updated and integration with a background model demonstrated. It is important that functionality be demonstrated on desktop and HPC platforms. ITAR control is required and Contract Security Classification Specifications, DD Form 254 will also be required. Demonstration of the developed capability will include a real-world, large-scale, scenario of approximately 100 km2 containing the vehicle model. The results will be evaluated by comparison against current technologies for improvements in fidelity, operational complexity, resource usage, and runtime. Metrics identified in Phase I will be utilized. Computational usage results will include number and type of computational nodes, memory usage, data storage, and other resources necessary to completely execute the process.

PHASE III DUAL USE APPLICATIONS: Design, develop, and demonstrate a real-time optimized, high-fidelity, predictive thermal and kinematic solution for vehicles operating within existing hardware-in-the-loop (HWIL) architectures supporting Army systems such as the Joint Air to Ground Missile (JAGM) and the Small Diameter Bomb (SDB). To achieve Phase III runtime objectives, novel algorithm and hardware enhancements will be required to minimize execution speed while maintaining code portability and functionality. These developmental efforts will then be leveraged to extend the vehicular thermal and kinematic prediction capabilities to HWIL applications where reasonable tradeoffs in fidelity are acceptable to achieve required real-time constraints while retaining the core dynamic thermal modeling capability. The V&V process will be updated, executed, and documented as needed to

demonstrate maturity for Army customers needing these capabilities. Additional commercialization opportunities exist both within the DoD and private sector. The modeling capabilities developed under this program have a wide range of applications for IR-centric systems. This includes M&S-based development and performance evaluation of many current missile programs. Additional applications include mission planning and hazard identification. Commercialization opportunities also include thermal predictions derived from satellite data, Heating, Ventilation, and Air Conditioning (HVAC) system design, analysis and evaluation, and integration into scene generators operating in the emissive band.

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KEYWORDS: Physics models, target signatures, infrared, terrain models, interaction, scene generation, graphic processors, physics-based techniques

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A16-009 TITLE: Laser Source with Variable Pulse Width Capability

TECHNOLOGY AREA(S): Weapons

OBJECTIVE: Design and build an inexpensive 1064 nanometer laser source that can be integrated into seeker test facilities to evaluate the effects of laser pulse width on seeker performance.

DESCRIPTION: Pulse processing of laser returns by semi-active laser (SAL) missile seekers can be adversely affected by the pulse width of the laser. Diode-pumped laser designators can produce high energy, small pulse width pulses and are increasingly been integrated into sensor payloads for aviation and ground platforms. The Army needs innovative research into instrumentation laser technology to support lab testing of SAL seekers that requires a laser source that can automatically and rapidly produce pulses of variable pulse widths from 2 nanoseconds (ns) to 160 ns.

The primary mode for the variable pulse width laser is to maintain the pulse's peak energy constant as the pulse width changes. A secondary mode is to hold the peak power constant as the pulse width changes. The laser source will be required to have laser pulse energy from 1 to 10 milli-Joules (mJ) and have an externally triggered laser pulse repetition frequency (PRF) from 8 Hz to 75 Hz (threshold) with an objective PRF of 100 Hz. The 1064 nm laser source should be capable of being automated through a controller to modify the pulse width, energy levels, and pulse timing. Inter-pulse timing will be selectable to allow fixed or variable inter-pulse time intervals. The laser source will be capable of producing a laser pulse stream for up to 15 minutes. It is desired that the laser head be no more than 7"x3"x2". The new laser source will allow lab facilities to simulate laser sources in order to evaluate performance of SAL seekers as well as to test signal processing algorithms and new laser coding techniques.

PHASE I: Develop a 1064 nm laser source design that provides the technical performance detailed in the description.

PHASE II: Develop, construct, and demonstrate a prototype laser source that achieves the performance required in the SBIR topic for supporting SAL seeker testing. Demonstration of the prototype design is preferable in a government lab facility.

PHASE III DUAL USE APPLICATIONS: The technologies produced from the research into a variable pulse width laser source could be used in a broad range of military uses and commercial uses. For military use, this research will produce laboratory laser technologies that will support experimental testing of SAL seekers in order to investigate pulse width effects on seeker performance. For commercial applications, variable pulse width lasers will be used to modulate telecommunications signals for improved data coding methods or provide precision etching of materials for semi-conductor manufacturing.

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KEYWORDS: Variable pulse width lab laser; laser designator; laser seeker testing; laser illumination; test equipment; lab testing; 1064 nm laser

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A16-010 TITLE: Colloidal quantum dots as the fluorescent penetrant for nondestructive examination of surface flaws

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: The objective of the topic is to develop inorganic colloidal quantum dots in the visible wavelength range as the fluorescent penetrant for nondestructive examination of surface flaws, in particular of cracks in stress corroded pits of bore evacuator holes of gun tubes. The nondestructive examination of cracks will be demonstrated by the fluorescent indications of the penetrant probed via a suitable laser or an LED source. The ability to detect micron size cracks and quantify their depth by the intensity of the emission will be demonstrated.

DESCRIPTION: Liquid penetrant examination (LPE) (known also as dye penetrant inspection) is one of the well-known methods for nondestructive testing (NDT) of surface discontinuities such as cracks that are not easily detectable by visual inspection in a wide variety of materials including metallic and nonmetallic materials. Its appeal stems from the fact that it is a low cost method for NDT of surface flaws. The penetrant material is drawn into the surface discontinuities due to capillary action and after removing the excess penetrant a developer is applied to the surface drawing out the penetrant in the flaws thereby producing a surface indication for easy detection. Besides indicating the presence and location, LPE may be able to a limited extent shed light on the nature and magnitude of the detected discontinuities as well. When the penetrant contains fluorescent ingredients, the detection can be facilitated by the fluorescent indications as the penetrant bleeds out into the developer coating. Similarly, visible penetrants can be used that will produce a distinct visible contrast against the background of the developer. In conjunction with the use of a fluorescent penetrant, the examination of the absorption of the penetrant in the cracks can also be done via a laser or an LED probe in place of a developer. While the LPE technique is a low cost method, care should be exercised in following carefully the various steps involved in surface preparation, cleaning and descaling of the part to be examined, application of the penetrant and the developer, examination and post cleaning. When acid solutions are used for cleaning/descaling of the parts there is a possibility of hydrogen embrittlement. In this case the part should be baked at a suitable temperature to remove the hydrogen. Hydrogen embrittlement is also an issue if the penetrant and/or the developer contains hydrogen containing compounds in which case baking of the part would be required following the NDT examination. The use of inorganic quantum dots (QDs) in a colloidal solution as the fluorescent penetrant offers an elegant method for NDT. QDs mixed in colloidal forms are fluid with a viscosity similar to water and are highly penetrant. As a penetrant QDs offer several advantages such as ease of use, fabrication in different sizes that absorb light over a wide wavelength range, and the ability to detect micron size cracks and to measure their depths.

PHASE I: Inorganic colloidal quantum dots (QDs) in the visible range as the liquid penetrant for nondestructive examination of surface flaws in steel structures will be developed. The QDs will be excited using either a laser or an LED source and the resultant fluorescence from them will be detected for confirmation of surface flaws in test steel structures. The applicability of the QDs for examining stress corrosion pits and cracks of a few microns in size along the axial and transverse sections of holes of diameter 5-7 mm will be demonstrated.

PHASE II: Based on the findings from Phase I improvements will be made in the QDs fabrication and the fluorescent excitation and detection methods for the intended application of detecting surface flaws in steel structures. Specifically, the method will be further developed for use in the nondestructive examination of bore evacuator holes in gun tubes. Techniques will be developed for the detection of cracks that are a few microns in size situated in and around stress corrosion pits in the bore evacuator holes. The intensity of the fluorescence emission will be used to precisely measure the depth of the cracks. Stability and reproducibility of the use of QDs as the penetrant will be evaluated. Reliable techniques will be developed to apply the QD penetrant in the holes. Finally, the overall technique will be demonstrated in Government furnished bore evacuator sections of gun tubes.

PHASE III DUAL USE APPLICATIONS: The end-state of the effort is envisioned to be the availability of inorganic colloidal quantum dots in the visible wavelength range as the fluorescent penetrant for in-field nondestructive examination of bore evacuator holes of gun tubes for unambiguous identification of surface flaws that may be hidden among corrosion pits. Successful completion of the project will result in the immediate transition of the technology to the examination of gun tubes in depot and/or in the field. As a strategy for transitioning the technology, we will engage with Project Manager Armored Brigade Combat Team (PM ABCT) who serves as the life-cycle manager for Army's combat vehicle programs including Paladin in which the routine examination of gun tubes will be of importance. In addition, we will approach the logistics and sustainment organization in Anniston Army depot who has the responsibility for field examination of gun tubes. Involving such stakeholders early on in the SBIR will increase the likelihood of transitioning the technology. The technology will also have multiple applications in the commercial sector including detection of fine cracks in nuclear steam generator tube, assessment of the integrity of gas generator injector tubes in the space industry and flaw detection in small bores in aircraft

components.

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KEYWORDS: Inorganic colloidal quantum dots, liquid penetrant, nondestructive testing, bore evacuator holes

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A16-011 TITLE: Multimodal trace explosive detection at stand-off distances

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: The objective of this topic is to develop a multimodal explosive detection capability that contains features such as modular design, small foot print, low cost, selectivity and sensitivity for a wide range of targets, low false alarms, detection at stand-off distances and rapid detection.

DESCRIPTION: Detection and neutralization of explosive hazards including Home Made Explosives (HMEs) and military grade hazards have become an important problem for the US Army for combating threats worldwide. Improvised explosive devices (IEDs) present an ever increasing threat globally [1]. For the period from April 15, 2012 to April 15, 2013, IED attacks accounted for 62% of all U.S. casualties in Operation Enduring Freedom [2]. It is now accepted that IEDs are a significant threat to the deployed U.S. forces all over the world and that the IED threat in the homeland is likely to persist [3]. Combating the menace of IEDs is a difficult problem owing to the fact that a wide variety of explosives and activation methods are used in their manufacture and deployment. The explosives used in making the IEDs include HMEs (e.g., ammonium nitrate, potassium chlorate) as well as military grade explosives (e.g. RDX) [2,3]. Hence, from a detection perspective, a capability to detect a wide range of military and HME explosives used in IEDs is required. Several methods ranging from spectroscopic, colorimetric, chemical, optical and luminescence based techniques have been applied for the detection of explosive hazards to levels varying from micro to milligram per cm^2 (trace) to grams per cm^2 (bulk) [4,5]. However, there is no one technique that can meet all the desired features required for widespread deployment. For example, many of the spectroscopic techniques suffer from high cost and a medium to large footprint which constrain their use in only certain scenarios such as in a forward operating base. Some of the spectroscopic techniques employ laser illumination which raises radiation safety issues. The high cost ($100K and above) of some of the techniques also precludes their widespread use. Some of the colorimetric techniques provide trace or bulk detection of a class of hazards at considerably low cost but suffer from multiple tests requiring ‘field chemistry’ that involve extensive hands-on manipulation in the field. Although limited to a few select hazards, colorimetric techniques involving molecular imprinted polymers have solved the problem of ‘field chemistry’ to some extent. There exists the need now to explore revolutionary approaches to develop a capability for trace explosive detection at stand-off distances for a range of targets with low false alarms such that easy and widespread deployment can be achieved for combating the IED threat worldwide.

PHASE I: A design for a novel multimodal explosive detection capability will be developed. It will consider a range of sensing methods that include spectroscopic, colorimetric, chemical, optical, and luminescence based techniques. When imaging based schemes are considered both passive imaging and that with active illumination will be considered. Emerging nanotechnologies will be taken into account. Fusion algorithms will be an essential feature of the design. The design should ultimately be governed by the final desired features of the system such as modular design, small foot print, low cost, selectivity and sensitivity for a wide range of targets, low false alarms, detection at stand-off distances, rapid target detection, communication & report and easy deployment. Proposals which do not adequately demonstrate the above system design attributes will be considered unresponsive to the topic intent.

PHASE II: Based on the design from Phase I, a prototype multimodal trace explosive detection at standoff distances capability shall be demonstrated at the end of Phase II. Aspects of system features such as modular design, small foot print, low cost, selectivity and sensitivity for a wide range of targets, low false alarms, detection at stand-off distances, rapid target detection, communication & report and easy deployment shall be adequately demonstrable and quantifiable in the prototype. Novel algorithms for fusing the multimodal detection will be an inherent feature of the system. The prototype shall have the capability of trace detection (micro grams per cm^2 (threshold); ~ 100 nano grams per cm^2 (objective)) at standoff distances of 50 meters (threshold), 100 meters (objective) on select targets to be suggested by the Army sponsor. Detection shall be accomplished in real or near-real time in < 2mins (threshold), < 1min (objective). The prototype shall include a user interface for providing alerts and reporting the results. Communication interfaces to disseminate the threat detection is a desired feature in the prototype.

PHASE III DUAL USE APPLICATIONS: The end-state of the effort is envisaged to yield a robust multimodal explosive detection technology for trace detection at stand-off distances of a wide range of Home Made Explosives, military and commercial explosives. Explosive detection is a desired force operating capability (FOC) as listed in multiple FOCS in the TRADOC Pamphlet 525-66 (dated 7 March 2008) such as FOC-04-03 (Reconnaissance, Surveillance, and Target Acquisition and Attack Operations), FOC-06-06 (Understand the Operational Environment), FOC-07-01 (Protect Personnel a. Capstone Capabilities) and FOC-07-04 (Protect Unit a. Capstone Capabilities). In particular, FOC-07-01 encompasses integration of data from disparate sensors to produce a synergistic data improvement commensurate with the expected outcome of this topic. As a strategy for transitioning the technology developed through this effort, customers such as the Product Manager Counter Explosive Hazard (PdM CEH) who has the charter for providing integrated family of capabilities which include but are not limited to handheld and standoff hazard detection and counter IED solutions, will be kept informed. At the end of Phase II results will be briefed to PdM CEH and other stakeholders (e.g. Joint Project Manager Guardian) and efforts will be made to identify insertion of the technology in programs upon further maturation. The capability can be transitioned to applications in Homeland Security and law enforcement agencies for wide use. The target space can also be extended to include illicit drugs so as to expand the application space of the technology to drug interdiction.

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KEYWORDS: Explosive trace detection, stand-off distance, Home Made Explosives, military grad explosives, multimodal detection and fusion.

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A16-012 TITLE: Multimodal nondestructive evaluation of internal surfaces of holes in steel structures

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: The objective of the topic is to develop a multimodal nondestructive testing device, consisting of at least two complementary modalities, to examine flaws in internal surfaces of holes in steel structures.

DESCRIPTION: Nondestructive evaluation (NDE) [1] of internal surfaces of holes or pipes in steel structures for the presence of surface flaws such as stress corrosion pits and cracks is a difficult task, particularly when the internal space is small, the structure is large and rapid inspection with high precision is desired. The difficulty is further exacerbated when initiation of small cracks (~ few microns in size) is to be ascertained in the presence of other surface features such as pits. Given the importance of NDE to multiple industries, an extensive ensemble of analysis techniques leveraging various scientific principles is available [2]. While the list is exhaustive, typical among the NDE methods that have widespread use are dye penetrant inspection, magnetic particle inspection, Eddy current testing, Infrared thermal testing, laser based probes, optical microscopy, radiography, Ultrasonic testing and 3D computed Tomography. Depending on the application one or a combination of methods is applied to examine the sample of interest. Moreover, NDE is an evolving discipline with continuous improvements in the methods, sample preparation, signal analysis and so forth as well as with developing new techniques. NDE of small spaces such as internal holes or pipes in engineering structures is generally a challenging task. The difficulty mostly arises owing to the small space to insert a probe and the consequent impediments to manipulate the probe in the tight space and acquire reliable data at high speed with precision and accuracy. Oftentimes detection of surface flaws such as cracks in such internal surfaces is almost impossible if other imperfections like stress corrosion pits are also present. It is generally true that environmentally assisted cracks are often initiated at corrosion pits and models that are developed to predict lifetime of the parts rely on accurate information on the pit to crack transition and on the statistical distribution of the pits/cracks. Bore evacuator holes in gun tubes such as M284 [3] exemplify a small space that presents a challenge for NDE for the reasons mentioned above. Unambiguous identification of surface flaws in the midst of corrosion pits and the derivation of accurate and reliable statistical parameters of their distribution are an important problem which requires an innovative NDE approach.

PHASE I: A novel multimodal NDE device consisting of at least two complementary modalities will be developed for examination of the internal surfaces of small holes such as the bore evacuators in gun tubes. The modalities considered shall be limited to techniques that rely on electromagnetic testing, microwave/millimeter-wave, ultrasonics and laser testing. Signal processing and fusion of results from the modalities will be an essential feature of the final design. Considerations should be given in the design for a portable and field-usable product at the end of Phase II. The design should be capable of examining holes of nominal diameters 5-7 mm and of either cylindrical or conical geometries in steel structures. It should be able to examine surfaces of different surface finish. It is preferred that this technology easily lends itself for integration with existing bore mapping equipment, such that all barrel inspections can be accomplished through one machine. At the end of Phase I either by prototyping or by modeling the capability of the multimodal method to detect cracks of the order of 10-20 um inside of the holes will be demonstrated. The technology should be scalable to larger holes up to 160mm.

PHASE II: Based on the design from Phase I, a multimodal device for nondestructive examination of the inside surfaces of bore evacuator holes in gun tubes shall be demonstrated at the end of Phase II. The device shall have features such as portability, field-use, field-calibration, easy and rapid inspection (e.g., less than 10 minutes per hole). It shall be capable of detecting cracks of the order of 10-20um or less in the presence of other surface flaws such as corrosion pits inside the holes. It shall be adaptable for examining holes of both cylindrical as well as conical geometries. It shall include advanced signal processing and algorithms to derive reliable statistical information of various surface texture parameters as defined in International Organization for Standardization, ISO 25178 for

quantification of areal surface texture.

PHASE III DUAL USE APPLICATIONS: The development of a multimodal NDE device for probing the internal surfaces of small holes in steel structures will have an important military application in the examination of bore evacuator holes in gun tubes for unambiguous identification of surface flaws that may be hidden among corrosion pits. Successful completion of the project will result in the immediate transition of the technology to the examination of gun tubes in depot and/or in the field. As a strategy for transitioning the technology, we will engage with Project Manager Armored Brigade Combat Team (PM ABCT) who serves as the life-cycle manager for Army's combat vehicle programs including Paladin in which the routine examination of gun tubes will be of importance. In addition, we will approach the logistics and sustainment organization in Anniston Army depot who has the responsibility for field examination of gun tubes. Involving such stakeholders early on in the SBIR will increase the likelihood of transitioning the technology. The technology will also have multiple applications in the commercial sector including detection of fine cracks in nuclear steam generator tube, assessment of the integrity of gas generator injector tubes in the space industry and flaw detection in small bores in aircraft Components.

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4. http://en.wikipedia.org/wiki/ISO_25178

KEYWORDS: Nondestructive evaluation, multi-modal methods, bore evacuator holes, gun tubes, surface cracks, stress corrosion pits.

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A16-013 TITLE: Research in Tool Shape Optimization for Electrochemical Machining

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Electrochemical machining (ECM) is a manufacturing technology that allows metallic work piece material to be precisely dissolved into an electrolyte solution as opposed to removal by mechanical cutting and shearing. ECM is domestically employed in the production of complex and often irregularly shaped parts including advanced jet and Army helicopter engines [1] and gun barrels through 40mm caliber [2, 3]. It also has application to artillery projectiles [4] and large caliber cannon [5,6]. Of particular current interest is the potential to apply turbine cooling channel technology [7] to cannon cooling. And the machining of rifling and chambering details in new tough cannon materials including high strength steel, nickel alloys, and tantalum alloys. It may also be employed in the fabrication of warhead liners for shaped charges and explosively formed penetrators. While ECM has many advantages, it suffers a significant impediment to wider adoption for new applications. Some aspects of the process,

such as chemical kinetics, remain challenging to model. Therefore, current tooling design methods employ a combination of physics based and empirical based methods to design the shape of the cathode and determine related electrolyte chemical and flow requirements. As a consequence, it is challenging and expensive to achieve first part machining accuracy and surface finish. This is a root cause of a commonly cited drawback of ECM. The challenge of tool design[4]. Pragmatically, the implication is that tool design for accuracy and surface finish may become iterative. In effect, when implementing a new tool design, the result provides empirical data to allow a more accurate second generation tool design. When parametrically far removed from prior precedent, a few generations may be required. And it may be challenging to predict the number of generations confounding efforts to predict developmental cost and schedule. It would be highly advantageous to develop tool shape design methods that are not reliant upon multiple evolutionary iterations to achieve accuracy. This is particularly true for disruptive applications that may be empirically far removed from prior precedent. Tool design and accuracy address two of the five research challenge areas raised for ECM in Rajurkar's keynote paper to the International Academy for Production Engineering (CIRP) [4].

DESCRIPTION: Research in the area of tool shape for first part machining accuracy is interdisciplinary. Electrochemical texts, such as the one by Newman et al [8] provide a systematic discussion of the foundational topics of thermodynamics, kinetics and reaction rates, transport, migration, diffusion, convection, and over-all cell potential. Further, shaping the tool to achieve a desired potential distribution within the gap is a "… formidable inverse boundary problem of Laplace's equation [4]." Tool shape is also affected hydrogen bubble generation and Joule heating in-turn affecting conductivity and temperature [4]. Research proposals should comprehensively address these and other aspects of the tool shape optimization methodology. Although undesired, it is likely that some level of empirical guidance will continue to bridge gaps in science, mathematics, and numerical computing limitations. The application of empirical methods should be clearly articulated and held distinct from first principles methods. Process design methods such as advances in pulsed ECM that are less sensitive to tool shape are also of interest. However, it is important that tool design methods compatible with existing direct current and pulsed technology to facilitate realistic commercialization. Also, a key advantage of ECM is the simplicity and reliability of the cathode tool holder that often merely sinks the tool into the workpiece at a controlled feed rate. Methods that employ new degrees of freedom to the tool holder to dynamically position the tool would forfeit this key advantage and are not sought.

PERFORMANCE METRICS: 1) Geometric accuracy: how close is the geometry of a first article test to the predictions? This may be normalized by a measure of how far parametrically removed the test is to prior runs. 2) Surface finish: how close is the surface finish of a first article test to the predictions? This may be normalized by a measure of how far parametrically removed the test is to prior runs. In addition, two less quantifiable, yet important metrics of performance are: 3) User interface: how hard is it to train operators of the new technology? 4) Technology robustness: how readily may the resulting design methods be transferred from one computational language or computer architecture to another? Experimental work conducted must demonstrate due consideration of safety and regulation compliance.

PHASE I: Phase 1 will provide a study, well grounded in existing peer reviewed literature, and extended by innovative research to develop design methods to predict die sinking ECM tool shapes to accurately and precisely achieve desired first-part geometry and surface finish. Bench scale experiments with steel parts shall be conducted to demonstrate the accuracy of the methods.

PHASE II: Phase II will document and implement a tool shape design methodology extending beyond die sinking that may be computationally implemented in diverse programming languages. Contractors are encouraged to collaborate with the Army to directly apply the methods to planned armament efforts to include traveling electrode artillery rifling and machining of patent pending mortar blast flow channels [9], die sinking of integral perforated muzzle brake's [10],electrochemical turning of mortar tubes [6], and ECM die sinking of armament components.

PHASE III DUAL USE APPLICATIONS: The contractor shall license the design technology to industry and may further develop the optimization methods to more diverse ECM challenges.

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KEYWORDS: Electrochemistry, Electrochemical machining, Tool design, Optimal Design.

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A16-014 TITLE: Laser Nanostructured Surfaces for Armament Applications

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: To develop laser nanostructuring technologies for durable, anti-corrosive, self-cleaning, hydrophobic surfaces.

DESCRIPTION: Under a prior Army R&D effort, the Army observed promising results using laser nanostructures to create super black surfaces. This effort will explore novel methods that leverage this technology to create durable, low-cost nanostructured surfaces for armament applications. In particular, this SBIR topic seeks to explore novel means of employing lasers to treat large areas and large volumes of material in a cost-effective manner. The primary properties of interest include super-hydrophobic, anti-corrosive, and self-cleaning metal surfaces. The topic also

solicits low-cost, high-volume methods for using this technology to impart anti-reflective, self-cleaning surfaces to transparent glass. A successful proposal will address how to optimize the longevity of the treated surface for rugged environments. Solutions that involve the deposition of another material on the substrate should avoid hazardous materials and processes.The effort should also address laser treatment methods for difficult geometries, e.g., a gun bore.

PHASE I: Using the proposed methods, treat five G43400 (4340) steel test panels for each manufacturing concept under consideration. Document the contact angle and the sliding angle achieved and demonstrate the self-cleaning property. Evaluate the treated samples using standardized ASTM salt fog corrosion testing, hardness and abrasion tests. Demonstrate the proposed concept for treating glass on a curved glass surface. Treat four 75mm diameter plano-convex lenses (focal length of 150mm or less) for each manufacturing concept under consideration. Document the hydrophobicity, reflectivity/transmissivity, and abrasion resistance of the surface. Document aberations induced by the process, to include both traditional optical aberrations and hazing effects. Provide a detailed scale up plan, including cost analysis, for large-scale, low-cost (no more than 20 percent of the treated material cost) production. Incorporate a design for a prototype process to treat large surface areas.

PHASE II: Optimize the treatment methodologies proposed in phase I for glass, with a focus on high-volume treatment (volume defined as ~10,000 units per month). Address any technical deficiencies identified in Phase I (i.e. abrasion issues, hazing). Demonstrate the proposed concept for treating other steel and engineering alloys, including UNS G10100 (1010) steel, S17400 (17-4 PH) steel, UNS A97075 (7075) Al, and UNS R56401 (Ti 6Al-4V) Ti. Address any technical deficiencies identified in Phase I (i.e. corrosion issues, hardness issues, abrasion issues). Demonstrate the ability to uniformly treat 3'x 3' metal and glass surface area at a rate of three units per hour. Demonstrate the ability to treat the interior geometry of smooth and angular 0.30"x20" G43400 (4340) steel alloy tube in a repeatable fashion at a rate of at least 12 per hour.

PHASE III DUAL USE APPLICATIONS: Provide small arms demonstration articles to evaluate improvements to reliability, maintainability, and system longevity. License or subcontract treatment process to prime DoD contractors producing armaments, marine articles, vehicles, aircraft, CBRNE equipment, textiles, and medical devices.

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KEYWORDS: hydrophobic, self-cleaning, anti-corrosive, laser nanostructures, anti-fog, laser etching, laser patterning, high throughput laser processing

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A16-015 TITLE: Innovative, shock-load resistant Pulsed Power supply.

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Conduct innovative research, develop, and demonstration of novel design and manufacturing technology to enable high energy density electrical pulsed power systems that may be integrated directly to recoiling large caliber weapon systems.

DESCRIPTION: Pulsed power may be used in future weapons as well as providing significant weapon performance and accuracy enhancement for 120mm tank guns [1]. It has also been advocated for artillery range extension [2] and multi-role weapons [3]. It would be useful to integrate a pulsed power system as a subcomponent of the recoiling cannon or bolt assembly. In this context, cannon is used "… to denote the shooting part of a complete weapon" [4]. To date, pulsed power systems have integrated into the laboratory or even test vehicles with the high power electrical energy bussed to the cannon assembly. Typically consisting of coaxial cables, the bussing must accommodates three degrees of freedom of cannon movement consisting of elevation, azimuth, and recoil. This can be achieved through flexible cables, telescoping contacts, or even make-brake and slip ring connections. A significant simplification could be achieved if the pulsed power system was rigidly coupled to the recoiling components. This would eliminate all three degrees of freedom from the bussing. In addition, it is well known that increasing recoiling mass reduces the kinetic energy of recoil. In particular, advances in lightweight composite materials may enable weapon weight reduction [5]. However, full realization of the lightweight advantage may be lost as the recoiling mass must be sufficiently high to meet recoil stroke and force constraints. Therefore, the weight allocated to a recoiling pulsed power system could be offset in part by its enabling of more aggressive cannon weight reduction. More critical than performance is safety. Design for reliability and safety engineering functions and regulation compliance must be thoroughly integrated with the research. It is anticipated that novel manufacturing technology will be essential to enable energy storage, power conditioning, and thermal management to withstand recoil loading in a robust manner. In addition to enduring such accelerations, it is ultimately essential that the inertia of the recoiling pulsed power supply be amenable to achieve balance about the centerline of the weapon to avoid loss of weapon accuracy. This is all to be achieved in a compact system suitable for vehicle integration. While futuristic applications remain of interest, the focus will be on modern advance in electro thermal chemical (ETC) propulsion that has found that a small ratio of electrical to chemical energy provides an optimal solution for current weapon applications. This is often considered to be electrothermal ignition (ETI). To support this conclusion: Lehman at the ISL in France in their "optimization of power" study advocate 0.1% to a few percent in the ratio of electrical to muzzle energy [10]. Dyvik at BAE considers the advantages of 0.1% and found that the lower threshold appeared to be under 0.02% for the most recent Armament Research Development and Engineering Center (ARDEC) sponsored 120mm ETC gun firings [6]. Coffee at the Army Research Lab (ARL) modeled and analyzed firing results of 120mm ETC guns with ratios of approximately 0.1% to 0.2% [11]. ETI also provides a near term gun accuracy enhancement due to its repeatability in ignition timing [1, 9]. To clarify what it sought, it may be most prudent to use a mature baseline system that is well published in the open literature [6,9]. The baseline is also consistent with comparable energy densities to other systems [10]. These supplies were developed and delivered by BAE Systems as part of an Armaments Research Development Center contract for line of sight (LOS) and beyond line of sight (BLOS) technology [6,9]. While not intended in any way to represent a preferred technical approach or vehicle application, the volume, mass (220Kg), and power present a baseline of performance LOS/BLOS weapon technology efforts starting in the FY19 timeframe. Such technology may also apply to artillery range extension [2] and Navy railgun calls for research opportunities in compact pulsed power systems.

PHASE I: Conduct research and development to achieve the program objectives. Deliver a study that demonstrates novel methods of manufacturing a compact shock loading tolerant pulsed power supply. For the purposes of the phase I effort we would like to target a nominal value 300 Gee for recoil. Transverse acceleration may be as high as 10%. The pulsed power supply metrics should be compared with those tabulated for the prior art ETIPPS systems described technology [6,9]. This study shall include modeling that allows the contractor to demonstrate the

capabilities of the recoiling pulsed power supply. Also, it is highly desirable to incorporate some testing to experimentally reveal some of the phenomena governing the design. Two designs are sought. First, an objective design for a large caliber LOS/BLOS gun demonstrator in the FY2019 timeframe analogous to the prior 120mm gun work [6,9]. Second, designs for component and subsystem demonstration in follow-on laboratory and relevant environments. A successful solution is sought, but not required for a recoiling vent bolt assembly [ ]. With anticipated shock loading an order of magnitude higher than cannon recoil, it is recognized it may not be tenable while maintaining the intended advantage over non-recoiling power supplies. The intent is to increase the potential breadth of utility for the research fostered in phase I and to carry this into phase II without undue encumbrance beyond the focus on cannon assembly applications.

PHASE II: Upon successful completion of Phase I, design, fabricate, and test, recoiling pulsed power supply components and subsystems to meet or exceed phase I performance claims. Using validated design models, refine the objective large caliber recoiling power supply design and manufacturing methods. Develop a cost model to produce objective designs. Contractors are encouraged to collaborate with the Army on integrating the recoiling power supply as a cannon and/or bolt assembly subcomponent and this would require special consideration to manage unclassified limited distribution data. A culminating working prototype should be delivered to the Army. In addition to the focus on a near term LOS/BLOS gun application, design excursions to other recoiling weapon applications may be conducted within the scope of the effort.

PHASE III DUAL USE APPLICATIONS: The contractor shall design, fabricate, and test recoiling power supplies suitable to support weapon prototype demonstration.

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KEYWORDS: pulsed power, energy storage, manufacturing for shock loading.

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A16-016 TITLE: High-strength Nanostructured Silver for Shape Charge/EFP Liner Applications.

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop a new high-strength nanostructured Ag or Ag alloy for shape charge and Explosively Formed Penetrator (EFP) liner applications.

DESCRIPTION: The U.S. Army requires a high strength Ag or Ag alloy for use as liners in explosively formed penetrators (EFPs) and shaped charges. Currently Ta has most commonly been selected for these applications because of its appealing combination of strength, density, ductility at high strain rates and relative safety in handling. However, Ta is challenging to manufacture into appropriate shapes and is quite expensive as a result. Improved performance is also desired. Ag is used routinely in commercial shape charge applications, but rarely in EFP applications due primarily to insufficient strength. Recent work at the Army has suggested that a higher strength Ag could outperform Ta as a liner material. Nanostructured (NS) and ultra-fine-grained (UFG) metals, in which grain sizes are usually in the range of 1-1000 nm, are well known to have substantially improved strength relative to coarser-grained metals, and Ag or Ag alloy with such a structure may have sufficient strength for EFP applications. For example a traditional microcrystalline Ag might have a yield strength of 50-150 Mpa, while a UFG or NS Ag might have a yield strength of 250 to 500 Mpa. However, even when demonstrated to have appropriate properties, the manufacturing of NS or UFG materials in monolithic form to the geometries and length scales required for EFP liner applications has not traditionally been possible. The desirable grain structures are lost during the consolidation, forming, and/or melting and casting processes required to achieve full density and shape. The contractor shall demonstrate the feasibility of creating an Ag alloy with a hardness of at least 100 VHN and tensile strength of at least 300 Mpa after consolidation, and of forming the new material into a final piece with at least 2.5 cm-scale dimensions on all axes while maintaining appropriate properties. The density of the resultant alloy shall not be less than 90% that of pure Ag, and an increase in density relative to Ag will be preferred. Appropriate strength, high-rate performance, density and manufacturability will all be demonstrated as part of this work.

PHASE I: Develop NC or UFG Ag alloy. Demonstrate a hardness of at least 100 VHN with a density of at least 90% that of pure Ag in this alloy. Demonstrate ability to form this alloy into monolithic pieces with minimum of 5 mm dimension on each side. Provide at least 2 samples to the Army for independent characterization.

PHASE II: Optimize new alloy to maximize hardness and density. Produce monolithic pieces of preferred alloy(s) with minimum 8.2 cm in diameter by 0.5 cm thick, including appropriate test specimens for uniaxial mechanical tests, Split Hopkinson Bar testing, and standard Army Shaped Charge Jet testing (see reference 4). Perform uniaxial mechanical testing and Split Hopkinson Bar testing of optimized alloy, and demonstrate uniaxial yield strength of at least 300 Mpa. Demonstrate ability to make multiple characteristic plate and dish geometries at these length scales. Provide at least 5 samples each to the Army for uniaxial mechanical testing, Split Hopkinson Bar testing, Shaped Charge Jet and EFP testing.

PHASE III DUAL USE APPLICATIONS: The developed technology will be transitioned to prototype scale and tested at high strain rates. Partnerships with major materials manufactures will be formed to transition the technology to full-scale manufacturing for military sector applications. Dual use applications in the civil sector are anticipated, including in industrial and commercial electronics and electricity transmission.

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KEYWORDS: silver, shape charge, explosively formed projectile, nanostructured, warhead

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A16-017 TITLE: High Quality Factor, Thin-Film, Electrically Tunable Varactors and Filters

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop high quality factor (Q) electrically tunable varactors and filters from thin film materials for application in military and commercial communications systems in the 1 - 6 GHz frequency range.

DESCRIPTION: The requirements for high functionality from commercial and military wireless communications systems drives high performance standards from varactors, filters, and phase shifters. The US Army Program Executive Office (PEO), Intelligence, Electronic Warfare, and Sensors (IEW&S) and Command, Control, and Communications - Tactical (C3T), have cited the need for tunable filters among their top 10 Capability / Technology Gaps. Filters are critical components for radar, EW, and communications systems. Low cost tunable thin film filters promise greater functionality, better channel selectivity, and reduced size and weight compared with traditional approaches using banks of fixed filters. The lack of a low cost tunable filter technology presents a critical barrier to the success of the Joint Tactical Radio System (JTRS) program, which requires operation in the frequency range 3 MHz to 3 GHz. Many technologies have been considered for tunable filters, for example mechanically tuned filter technology is well established, but such filters are slow and bulky (see ref. 1). A standard tuned filter approach in many radar and radio applications has been for a long time tunable YIG (Yttrium-Iron-Garnet) resonators, which have multi-octave tuning ranges, excellent spurious free response, low insertion loss, and high Q. However they are tuned by an external magnetic field, which generally comes from external electromagnets, resulting in an inherently non-planar architecture, high tuning currents, high power consumption in the tuning, low tuning speeds (milliseconds), and relatively large size and weight. Additionally, the required YIG crystal processing as well as the external magnetic field architecture is relatively expensive. Recent approaches to tunable filters generally break down to micro-electrical mechanical systems (MEMS), semiconductor diodes, and electrically tunable ferroelectric thin film devices. MEMS tunable filters are reincarnations of mechanically tuned filters (see ref. 2). They are small, capable of planar integration, have low insertion loss and high quality factors (high Q), and the reliability and tuning voltage requirements are improving, but the fastest tuning speeds are around a microsecond (see ref. 3). Current and future electronic warfare (EW) and communications systems under electromagnetic threat will require the fastest possible tuning speeds. The reverse-biased semiconductor diode is another varactor technology enabling tunable filters, but these have relatively high insertion loss, resulting in low Q factors at microwave frequencies and have

limited power handling capability. Recently, low cost tunable antenna matching networks and tunable power amplifier matching networks have been fabricated from thin film materials such as Barium Strontium Titanate (BST). These developments point to the potential for electrically tunable thin film devices, with relatively low bias voltage levels (2-5 V), tunability at room temperature, planar circuit integration, and relatively high power operation, however the Q values achieved to date have been too low for most reconfigurable filter and other varactor applications. Recent advances in the growth of tunable dielectrics demonstrate high intrinsic material Q values greater than 1000 (see refs. 4 and 5), a factor of nearly 10 over legacy technology (see ref. 6). These advances in materials growth anticipate the application to electrically tunable filters and varactors with high values of device Q which will provide new functionality to wireless handsets and communications systems.

PHASE I: Phase I: Develop a concept for a manufacturing scalable thin film process for deposition of tunable material with material Q values greater than 1000 and for low loss metallization. Demonstrate by simulation and analysis the feasibility for device Q values over 200 at 2 GHz for a varactor device structure. Design varactor structures and single element filters with device Q values greater than 200 in the frequency range 1 GHz - 4 GHz, with device size less than 100 microns x 100 microns, IP3 greater than 65 dBm in a 50 ohm environment. The varactors must have a continuous capacitance change of 3:1 and the filters capable of a frequency shift of 70% using control voltages less than 35 volts and tuning speeds of 100 nanoseconds or less. Determine the tradeoff between tuning speed and the generation of harmonics and intermodulation products. The purpose of phase I is to determine feasibility of the proposed solution. It could include design, computational studies, and analysis. Selected laboratory experiments could further reduce risk for phase II. Assess the military and commercial market opportunities for sales of these devices.

PHASE II: Develop and demonstrate packaged varactor and single element filters components capable of the metrics outlined in phase I above and capable of hot switching at 1 watt power levels. Demonstrate reliable operation at greater than 3 billion cycles. Deliver sample devices to a designated government laboratory for assessment and validation. Make contact with military wireless programs (including the JTRS program and CERDEC representatives) and wireless industry system providers to determine the specific design parameters for a customer base. Develop a commercialization plan to exploit the opportunities. Produce specific circuit designs of components, potentially with multiple devices, to meet the customer demand for tunable varactors and filters, either as separate components or integrated in an integrated circuit.

PHASE III DUAL USE APPLICATIONS: Demonstrate components and circuits capable of meeting selected customer specifications for varactor circuits or multi-element filter circuits for applications in tactical radio and commercial wireless system handsets and radio systems. Describe specific military applications where the new technology will enable solution of specific problems. Provide a firm technology transition pathway for their developments (for example establish a production line for the fabrication of these circuits and components, produce the individual components for sale, or establish a licensing relationship with a company with a production capability). The path to commercialization is expected to first address wireless handset requirements for military and commercial systems, but is expected to expand into other wireless and electronic systems applications.

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KEYWORDS: Keywords: tunable filters, ferroelectric filters, ferroelectric varactors, microwave filters, microwave filter manufacturing process

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A16-018 TITLE: Development of a Non-Contact Transmission for Helicopter Applications

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Develop a non-contact transmission for helicopter applications that converts high speed engine outputs to high torque mast shafting which eliminates gear contacts within the transmission.

DESCRIPTION: The Army utilizes a wide range of vehicles across ground and air platforms where mechanical transmissions are used to transmit power from the engine to the drive shaft. Gears are used to create a torque and speed conversion with mechanical contact between the gear teeth surfaces. Lubrication is necessary to create a protective film between rolling and sliding surfaces as well as provide sufficient cooling to prevent failure. As such, mechanical contact transmissions are vulnerable to loss of lubrication events and require regular maintenance for the lubrication system. The Army desires a solution to eliminate these gear, and potentially bearing, contacts within a transmission to reduce or even eliminate the dependence on lubrication. Non-mechanical contact gearboxes are of interest because of possible potential improvements in power density, wear resistance, noise reduction, and efficiency along with an inherent overload protection [1]. Simplification of the overall system with substantial weight savings is possible because the lubrication package would no longer be necessary. Eliminating the threat of loss of lubrication and minimizing wear allows the transmission life expectancy, robustness and survivability to increase greatly [2]. Recent efforts to develop non-contact gearboxes have focused on the magnetic planetary configuration. Magnetic planetary gearboxes transfer power within wind turbines, marine propulsion and hybrid electric systems [3]. Hybrid vehicles use this system in combination with a motor/generator to improve efficiency with a continuously variable transmission [4]. The use of magnetic gears is one example of an applicable non-contact transmission. In addition, new concepts for non-contact transmissions are highly encouraged. The Army is requesting innovative solutions for power transfer without the use of mechanical contact. Highly innovative game-changing power transfer concepts and configurations will be considered favorably. The concepts should aim to address the ability to accommodate multiple inputs and outputs at various connection angles. Configurations that are not able to accommodate the geometry needed for a helicopter transmission will also be considered, such as an automotive differential or co-axial configurations. Multi-speed capability is desired. At minimum, the gearbox concept should aim to give a torque and speed reduction typical of an Army scout helicopter. The typical speed reduction can be approximated with an input of 5,000 to 10,000 RPM and a main mast output corresponding to a 15:1 to 20:1 reduction at 500-800 hp. Concepts that lend themselves to future scaling up to the power class of a utility, attack or cargo class helicopter are desired [5]. Commercial applications of this technology span a wide range of helicopter and automotive drivetrains. This would include civilian rotorcraft, passenger vehicles, tractor trailers and construction vehicles with each application depending on scalability. The Army would like to apply the technology developed in non-contact transmissions to both block upgrades of current rotorcraft and potential new aircraft like the Joint Multi-role helicopter to reduce dependence on gear contacts.

PHASE I: Investigate the underlying physical principals necessary to create a non-mechanical contact gearbox. Show conceptual configurations for the input and output to the gearbox. Determine the technical feasibility of multiple inputs and multiple outputs to better represent helicopter transmissions. Develop a preliminary gearbox design with an input of 5,000 to 10,000 RPM and a gear reduction ratio of 15:1 to 20:1 at 500-800 hp. Supporting calculations and modeling for design shall be included.

PHASE II: Refine the design and calculations presented in Phase I. Determine the technical feasibility of scaling the gearbox concept to higher horsepower classes. Develop, test and demonstrate the technology on a component level and correlate with theory and calculations. Build a functional scaled prototype transmission for a proof of concept

demonstration. Work toward a commercialization pathway with an industry partner.

PHASE III DUAL USE APPLICATIONS: Design a full scale helicopter transmission. Develop, test and demonstrate the performance of a prototype transmission while working with industry. The intended end state is TRL 5 “Component and/or breadboard validation in relevant environment.” Collaboration with industry will produce opportunities to continue to develop non-mechanical contact transmissions for use in future Army helicopters. This technology would also be applicable to commercial helicopter platforms and could easily be applied to other ground vehicle and wind turbine gearboxes.

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KEYWORDS: helicopter, rotorcraft, propulsion, transmission, drivetrain, gearbox, gears, gear, non-contact, non-mechanical contact, differential, automotive, magnetic, continuously variable transmission

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A16-019 TITLE: Bone Conduction Audio & Vibrotactile Transducer for Dual-Use Communication

TECHNOLOGY AREA(S): Human Systems

OBJECTIVE: To develop a dual-mode transducer that provides both bone conduction (BC) sound transmission and vibrotactile capabilities. The transducer will be used as an alternative means of communication for company and below echelons to improve situation awareness (SA), and alleviate information overload on the auditory and visual channels currently faced by Warfighters on the battlefield.

DESCRIPTION: We seek novel approaches in developing a dual-mode BC and vibrotactile system with a compact transducer housed in lightweight and flexible material suitable for use on the human head. Today’s Warfighters must manage an information-intensive landscape and process real-world sensory input (sights, sounds, etc.) for SA while simultaneously monitoring radio communication and visual maps or helmet displays. Overreliance on two sensory channels – vision and hearing – can overburden these senses and lead to missed signals, cognitive fatigue, and degraded performance. Thus, moving functionality to other sensory channels and pathways can assist in unburdening the Warfighter. The vibrotactile sense (touch) can convey information that would otherwise be conveyed using visual or auditory pathways, while bone conducted audio transducers can convey remaining radio communication in a manner that does not degrade auditory SA of the external environment. Together, a unified bone conduction/vibrotactile device is predicted to ease the burden of information overload on the Warfighter, whether

used alone or in conjunction with the traditional visual and/or auditory channels. We have established the merit of each technology alone in enhancing performance and SA. If both technologies were combined in one electro-mechanical interface, the Warfighter could receive the benefit of both technologies from a single, convenient small device. This single, multimodal communication system would be a convenient way to allow flexible hearing protection use, high functionality in noisy environments, and more discreet communications in stealth applications. Such a system would also allow vision and air-conducted hearing to remain the primary channels for acquiring SA, while vibrotactile input and BC hearing would be used for alerting, networking and radio communications. Due to its potential impact on enhanced squad communication, a combined tactile/BC device will favorably support Warfighters in the course of the Department of Defense initiative to maintain a smaller, but more cognitively and physically capable force to defeat asymmetric threats on the homeland and over great distances. In addition, the system could also be considered as a solution for two Army Top 10 Challenges – enable communication in a CBRNE environment and ease overburdened Soldiers in small units. The envisioned multimodal communication system requires innovative solutions beyond what is currently available commercially off-the-shelf. BC audio transducers best contribute to speech intelligibility and offer very weak or no tactile stimulation. Tactile transducers are capable of both tactile and BC audio stimulation, but present poorly intelligible speech signals. In addition, the current metal transducers need to be adapted for battlefield conditions, and this requires flexible materials to reduce the incidence of greater impact injuries on the head that may be caused by a weapon or shrapnel. One challenge to developing a combined electro-mechanical interface is that some of the existing technologies require high voltages, which might introduce safety issues on the head. Other challenges are developing a combined device that is sufficiently lightweight and small such that it does not cause discomfort or extra physical burden on the user's head. We seek novel approaches in developing a dual-mode BC and vibrotactile system for military use with a small-sized transducer housed in lightweight and flexible material suitable for use on the human head. In the BC communication mode, the system should meet military requirements with speech intelligibility (SI) at a "normal acceptable" level (at least 91% SI using the Modified Rhyme Test (MRT) in quiet environments, MIL-STD-1472G) and should have a low air-conducted leakage sound level. In vibrotactile mode, the system should demonstrate effective vibrotactile stimulation at frequencies below 300 Hz with low power consumption.

PHASE I: Develop a preliminary model. The model should demonstrate the functional capability of effective vibrotactile stimulation at frequencies below 300 Hz and bone conduction audio transducer capability with speech intelligibility that meets military requirements at a "normal acceptable" level (at least 91% SI using the Modified Rhyme Test (MRT) in quiet environments, MIL-STD-1472G). The endeavor should also produce conceptual designs for a lightweight and flexible material housing for the transducer and include discussions of the technical challenges for phase II (e.g., miniaturization of the system).

PHASE II: Develop and demonstrate prototype systems including user instructions. The dual-mode transducer should be rugged, lightweight, small in size, water-proof and consist of flexible material housing. In addition, a signal-controlled interface to separate tactile and bone conduction (BC) communication functions will be developed with the capability to automatically detect the nature of an input signal and also allow a manual option for switching between the vibrotactile and BC functionalities. The performance of the final system shall demonstrate effective vibrotactile stimulation at frequencies below 300 Hz (at least 10 micron peak displacement amplitude in the range from 25 Hz to 300 Hz) and meet the requirements of BC communications (at least 91% SI using the Modified Rhyme Test (MRT) in quiet environments) with a low air-conducted leakage sound level. The speech intelligibility (SI) must be accomplished at an output level that produces an air-conducted leakage level detectable less than 50% of the time by a listener with normal hearing situated 1.5 meters from the transducer. The system shall also demonstrate the capability to be interfaced with existing military radio systems for BC communications. Demonstrate prototype system with a signal-controlled interface that can be worn on the head.

PHASE III DUAL USE APPLICATIONS: The final product will be useful for dismounted Infantry, Chemical, Biological, Radiological, Nuclear, and high-energy Explosives (CBRNE) operations, and Special Operations Forces. Other professional entities such as firefighters, rescue squads, aero-medical evacuation personnel and law enforcement agencies may benefit from an enhanced BC transducer, and an improved tactile transducer may potentially extend mission capabilities for the identified sectors. Additional commercial applications for the enhanced BC transducer include an open-ear communication system for drivers, bikers and joggers. Commercial applications for the tactile component include the First Person shooters gaming arena and a visual-, audio-, and hands-free navigational system for bikers and joggers

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KEYWORDS: Bone conduction, tactile, transducers, tactors, vibrators, communication, situation awareness.

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A16-020 TITLE: Low-Loss Commercial Deposition Technology for Thick Ferrites and Ferrite/Insulator Films on Printed Circuit Boards

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: The goal of the research is to develop a low-temperature spin spray deposition of low-loss, high quality nanocrystalline ferrite films and thick ferrite/insulator layers for non-reciprocal and tunable RF device circuits integrated on large scale printed circuit board (PCB) panels.

DESCRIPTION: RF and microwave ferrite materials can provide a tunable high permeability and ferromagnetic resonance, which can be exploited for tunable RF components such as resonators, filters, phase-shifters, circulators, isolators, compact magneto-dielectric antennas. Modern military radar, radio, and EW (Electronic Warfare) systems rely heavily on these components, which can be determining factors for the size, weight, and cost of the overall system. In particular, integration of low-loss high permeability ferrites on PCBs is highly desired for compact antennas with significantly enhanced performance, including improved gain, bandwidth and beam width for highly agile radar and radio beam patterns in military, as well as commercial systems. However, it has been challenging to integrate ferrite materials on PCBs.

Different methods have been explored for incorporating ferrite materials in PCBs. Incorporation of ferrite powders in PCBs and other materials has been investigated, which led to large loss tangents, low relative permeability of 1~3, and low operation frequency of < 300MHz. Ferrite films on PCBs would have the potential of operating from DC to several GHz with high relative permeability of over 100, and low loss tangents due to the large shape anisotropy associated with the thin film geometry. However, conventional ferrite film deposition processes such as pulsed laser deposition and sputtering or physical vapor deposition are not viable due to the high temperatures (>600°C) needed for forming high-crystalline quality ferrite materials, which will damage the polymer-based PCBs.

Spin spray deposition is a viable method that is able to produce fully dense, high crystalline quality, and low-loss RF ferrites at a low-temperature (< 90 degrees C) and using low cost aqueous solutions, which makes possible direct integration of ferrites on PCBs and RFIC (Radio Frequency Integrated Circuit) substrates. Spin spray deposited ferrites of various compositions have been successfully deposited onto Si and other substrates for integrated magnetic tunable bandpass filters, integrated magnetic inductors, tunable phase shifters, and on PCBs for compact antennas with improved performance (see refs. 1-7 and the references contained therein). However, integration of spin spray deposited ferrites on large-area PCBs panels is severely limited by two issues: (1) limited ferrite film thickness of <5~10 micrometers; and (2) limited area of deposition on PCBs.

Currently used spin spray deposition systems were designed for uniform deposition onto relatively small (1”~6”) circular wafers such as Si wafers, which is not compatible with the commercially available PCB panels with large sizes (e.g. 24”×36” and 36”×48”) that are critical for large arrays of antennas. There is an urgent need for developing a new spin spray deposition technique for uniformly depositing high crystalline-quality, low-loss thick ferrite films and ferrite/insulator multilayers onto large scale PCB panels, which will be an enabling technology for reduced cost, high functionality radar and radio phased antenna arrays for military and commercial systems. There would be significant challenges in transitioning this technology to industrial manufacturing and in scaling up the technology for larger antenna arrays.

PHASE I: By simulation and laboratory experiments or reports of experiments, explore the correlation between crystalline structure properties, chemical properties, and processing properties, and RF performance. Determine the RF / magnetic properties, such as dielectric constant, permeability, remanent magnetization, uniaxial anisotropy, internal field anisotropy, gyroresonance frequency, magnetic linewidth, magnetic softness required for integrated RF device applications in the frequency range 500 MHz to 3 GHz. Determine the best candidate ferrite materials and dielectric materials for integrated circuits on PCB. Develop and demonstrate in the laboratory low temperature (100 nm / minute, fully dense nanocrystalline films of > 5 - 10 micrometers without peeling, surface roughness < 10 % of the film thickness, and film thickness uniformity < 10%. Make the argument that the fabrication process can be scaled to larger deposition areas.

PHASE II: Demonstrate the laboratory process in phase I has good RF quality in the frequency range 500 MHz to 3 GHz, such as dielectric constant, loss tangent < 0.05, and other RF properties listed in PHASE I above. Develop and demonstrate a commercial scale spin spray process capable of the depositing ferrite and ferrite / dielectric films on PCB with the quality as described above, for areas 12 in by 12 in, and later for areas 24 in by 36 in. Demonstrate the RF quality of the films by fabricating single and integrated RF components with good RF performance competitive with components fabricated with other processes on other substrates. Demonstrate a technology transition pathway, and demonstrate a scalable means for the technology to be transitioned to manufacturing for practical implementation.

PHASE III DUAL USE APPLICATIONS: Demonstrate spin spray deposited low-loss ferrite/insulator multilayers on large panel PCBs up to 36” ×48” and fabricated integrated RF circuits and RF antenna circuits on PCB with superior RF performance. Potential paths to commercialization are to license the technology to industrial foundries and large RF systems companies, to establish a foundry to fabricate integrated circuits on PCB for other commercial companies, or to design and fabricate custom circuits and components for industrial customers, such as wireless applications or vehicle radar systems. Military systems will be impacted via commercial prime contractors. It is believed that the capability to fabricated high quality RF circuits on PCB will present a significant opportunity for low cost, high performance electronic systems for the commercial and military wireless and radar communities.

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KEYWORDS: RF ferrite, ferrite/insulator multilayer, spin spray deposition, printed circuit boards (PCBs), compact antennas, tunable RF components, ferrite film manufacturing process

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A16-021 TITLE: Electronic grade, single crystal or large-grain polycrystalline diamond wafer development.

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop a growth technique providing large-area low surface-roughness diamond wafers with minimum grains for surface channel based electronic devices.

DESCRIPTION: To increase battlefield communication distances for soldiers and UAVs, reduce electronics size and weight for agile, mobile systems, and increase information dominance with long range radar and high bandwidth data transmission, diamond semiconductor based electronics are promising. Diamond is a next generation electronic material promising enhanced capabilities for the Future Force due to its high thermal conductivity, high breakdown field strength, high charge carrier mobility, low thermal expansion, and mechanical and chemical stability. These lead to Johnson, Keyes and Baliga figures of merit for high-power high-frequency devices far exceeding those of other semiconductor materials. [1] For RF applications diamond transistors using a surface conducting channel have shown promising results with different devices reporting power gain cutoff frequency = 120 GHz, and on currents up to 800 mA/mm. [2] These devices consist of a conducting hole channel formed by a hydrogenated diamond surface topped by an adsorbed layer of molecules with high work functions to accept electrons from the negative electron affinity hydrogenated surface, leaving behind a high concentration of free hole charge carriers. Research exploiting these properties for radio frequency (RF) electronics, along with the growing demand for single crystal diamond wafers in the areas of quantum information science, superconductivity, magnetic sensors, biomedical applications, and photonics emitters and detectors, are making due with very small wafers and limited supplies of high quality material. To obtain the performance that diamond promises, wafers are needed with low defect densities, low impurity concentrations and low surface roughness. Single crystal diamond growth has produced small wafers of under 1 cm x 1 cm squares with limited control of impurities or roughness. Current

techniques of diamond wafer growth include chemical vapor deposition energized with either microwave source or a hot filament, and thermodynamic growth under high-pressure high-temperature. For manufacturability large area wafers are needed and demonstrated techniques include heteroepitaxial growth of polycrystalline diamond on lattice mismatched substrates, joining smaller diamond tiles as in a mosaic or by heteroepitaxial growth on a carefully chosen substrate. [3], [4] Large grain polycrystalline wafers have exhibited good quality surface conducting channels due to a preferred grain orientation compared to single crystalline wafers, however, the thermal conductivity is degraded and control over grain size and orientation is needed.[5] Post growth processes such as polishing or atomic layer etching following growth may reduce surface roughness.[6] A variety of innovative growth and post growth processing techniques may be proposed to provide diamond wafers with a root-mean-square surface roughness of 4 Angstroms or better that lead to surface channel electronic devices exhibiting at room temperature a surface free carrier concentration of at least 2 x 10^13/cm^2, surface conducting channel Hall mobility of at least 200 cm^2/V/s and bulk thermal conductivity of at least 1200 W/cm/K over a 6 cm^2 diamond wafer.

PHASE I: Develop a diamond wafer growth method, and if needed a post growth processing method, that will provide a semiconducting wafer for diamond surface channel field effect transistors. This wafer should exhibit a room temperature free hole density of at least 2 x 10^13 /cm^2 and surface conducting channel Hall mobility of at least 200 cm^2/V/s for a circular test region 100 micron in diameter placed uniformly throughout the a 6 cm^2 diamond wafer. The wafer should also exhibit a bulk thermal conductivity of at least 1200 W/cm/K and a 4 Angstrom or better root-mean-square roughness over a 6 cm^2 diamond wafer. This demonstration should provide all these results but the wafer can be smaller than 6 cm^2 as long as a clear path is outlined for achieving the larger wafer by the end of Phase II.

PHASE II: Demonstrate a diamond wafer growth method, and if needed a post growth processing method, that will provide a semiconducting wafer for diamond surface channel field effect transistors. This wafer should exhibit a room temperature free hole density of at least 2x10^13 /cm^2 and surface conducting channel Hall mobility of at least 200 cm^2/V/s for a circular test region 100 micron in diameter placed uniformly throughout the a 6 cm^2 diamond wafer. The wafer should also exhibit a bulk thermal conductivity of at least 1200 W/cm/K and a 4 Angstrom or better root-mean-square roughness over a 6 cm^2 diamond wafer. The wafer growth from start to finish should be within one day. Provide validation with fabricated test structures across the complete 6 cm^2 wafer surface. Thickness and quality should uniform within 5 percent over the entire surface. By the end of Phase II the technology should reach a Technology Readiness Level 4.

PHASE III DUAL USE APPLICATIONS: Military applications include light-weight high-power microwave radar systems, jammers and communication systems. Commercial applications include power conversion and distribution systems, electronic vehicle power systems, base stations and biocompatible electronics.

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KEYWORDS: diamond, chemical vapor deposition (CVD) growth, manufacturing materials, microwave plasma CVD (MPCVD), polycrystalline, RF, MISFET, MOSFET, wide bandgap semiconductor, manufacturing technology

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A16-022 TITLE: Development of Lightweight Heat Exchangers for Man-Portable Battery Recharging System

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: Development of new heat exchangers to be used with thermoelectric power generation systems that enable 1.) enhanced heat dissipation, and 2.) reduced weight.

DESCRIPTION: This SBIR topic seeks the development and reduction to practice of advanced light-weight heat exchangers for optimizing the tradeoff between power output (by maximizing temperature difference) and minimizing physical weight. Advanced heat exchangers such as these would impact thermoelectric-based power generators that are particularly useful for hand-held, off-grid battery recharging applications. Innovative heat exchangers that enable enhanced thermal dissipation could simultaneously reduce the weight burden and increase the temperature difference for hand-held devices that convert heat energy into electrical energy. Any new innovation for this application would be of interest. However, as a notional example, heat pipes are passive heat conduits that offer significantly enhanced heat transfer compared to solid high-thermal-conductivity metals. Solid bulk heat conductors such as aluminum and copper have thermal conductivities in the range from 250 W/m•K to 400 W/m•K. However, heat pipes offer effective thermal conductivities that range from 5,000 W/m•K to 200,000 W/m•K.[Ref. 1] Any alternative thermal design in lieu of heat pipes would be of equal interest. The state-of-the-art man-portable thermoelectric battery recharging systems can produce up to 35 Watts in a 1 kilogram package. If the weight could be reduced by 50%, and the heat extraction could drive the power output by 2X, then the Watts/kg would be increased by a factor of 4X. If such a solution can be developed, then there could be notable solutions to significant Army problems beyond this example. Significant commercial applications would be enabled including improved thermoelectric cooling, improved industrial waste-heat recovery, and improved energy harvesting by maximizing small adventitious temperature differences.

PHASE I: Work in Phase I SBIR efforts should focus on developing new thermal solutions using appropriately chosen materials/structures and include computational modeling and simulation of spatial temperature distributions using finite element methods, and simulation of the hot and cold side heat exchangers under a range of thermal loads. Simulations of the thermal profiles will be used to guide thermal design so as to maximize heat transport. Particular focus should be made in the trade-off between mechanical strength and thermal transport. The thermal transport will be mediated by selective choice of materials, and the structural geometry. At the end of Phase I, several integrated heat pipe heat exchanger designs will be proposed as solutions that are suitable for reduction to practice. At the end of Phase I, in consultation with the Government, more than one suitable design would be down selected. The design would be subjected to computational modeling with thermal loading across a range of values, and the effective thermal conductance would be theoretically determined. The results of the design optimization and the performance testing would be made available to the Government in the form of proposed design(s), a written report on the performance, and a set of boundary conditions for proper optimal use of the heat exchanger components. The metrics for Phase I should include a design that is capable of effective thermal conductivity that is larger than copper (>400 W/mK) and have less mass density than copper (<8.9 grams/cm3).

PHASE II: Work in Phase II should focus on optimizing thermal design, fabricating prototype exchangers, and performance calculation for a much wider range of thermal input, and continued reduction to practice for integration with working models of thermoelectric based power generators useful for 10-100 Watts of electrical power. Simulations of the thermal profiles will be used to guide thermal design to maximize heat transport. Particular focus should be made in the trade-off between mechanical strength and thermal transport. At the end of Phase II, several integrated heat pipe heat exchanger designs will be reduced to practice such that they can be integrated with thermoelectric power generator devices. At the end of Phase II, in consultation with the Government, more than one

different designs of variable dimensionality (area, thickness, etc.) would be down selected and reduced to practice. The designs would be subjected to modeling, as well as physical comprehensive thermal loading across a range of reasonable boundary conditions, and the effective thermal conductance would be determined. The results of the design optimization and the performance testing would be made available to the Government in the form of a hard deliverable, a written report on the performance, and a set of boundary conditions for proper optimal use of the heat exchanger components.

PHASE III DUAL USE APPLICATIONS: In the end state of this work, the performer would be capable of supplying high-quality purchasable products to the Government, or to commercial entities. Such products would be of immediate impact to man-portable/hand-held battery recharging systems that employ thermoelectric power generation to convert heat to electricity. The state-of-the-art for man-portable systems is roughly 15 Watts/kg, and at the end state, that metric could be as high as 60 Watts/kg or higher which provides significant value to the Army, and effectiveness to the soldier.

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KEYWORDS: Heat pipe, thermoelectric, heat exchanger, light-weight

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A16-023 TITLE: Processing of Metallic Scrap Materials for Battlefield Additive Manufacturing

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: The objective of this program is to develop a process for producing metallic powder from battlefield scrap, reclaimed and/or recycled materials for use with 3D printing / additive manufacturing equipment. The concept of utilizing indigenous materials in-theater, at a forward operating base (FOB) could potentially reduce the huge logistics tail needed to conduct wars on foreign soil, saving valuable resources and lives. This effort can also be leveraged by private industry for recycling goods.

DESCRIPTION: One of the Army's "Next Five" S&T Challenges addresses this, by listing the problem of "Sustainability / Logistics: Transport, Distribute & Dispose [1, 2]. The Army needs to develop processes for creating strategic materials on forward operating bases and smaller satellite bases in remote, austere, dispersed locations to eliminate supplier and equipment risk [3]. Current state-of-the-art in industrial metallic powder processing for laboratory additive manufacturing equipment includes gas or plasma atomization, mechanical and chemical processes. Atomization is the method of choice based on the fact that it yields very spherical and dense particles. Spherical geometry is essential in additive manufacturing processes for two main reasons. Consistent flowability is required to ensure uniform powder layering across the build plane, and spherical particles exhibit more uniform energy absorption; weld pool formations are more consistent and repeatable However, it is hard to envision atomization processes occurring on a FOB based on size, energy requirements for melting stock, and inert environment constraints. Mechanical methods such as milling are currently used for industrial powder production, but spherical shaped resultant powder is not a guarantee. That being said, this may be the easiest method to employ on a FOB. Chemical methods of reducing metal oxides are known to yield irregular shaped particles with high internal porosity. Hydrometallurgy techniques such as leaching and precipitation in solution can yield particles in a spherical shape but could be difficult on a FOB with the various aggressive chemicals involved. Thermal decomposition, typically of metal carbonyls, can yield spherical to angular particles but are generally on the

submicron scale and a low production rate technique. Another industrial method, electrospark erosion, has shown capabilities of producing spherical particles in the range of 0.5 - 50¿m [4]. These result from the melt and steam quenching phase of the process. Unfortunately with the process comes some degree of mechanical disintegration, as well, which results in some larger irregular shaped particles [5]. With fine tuning of the process and powder sieving, however, this technique could yield a sizeable amount of powder (production rates up to 0.5 kg/hr for certain cases) and the particle size/morphology required for additive manufacturing techniques. A major benefit of utilizing the electrospark erosion process is that it does not require melting of the source metal, a key issue for atomization on a FOB. Electrospark erosion's metal source is addition of 3/8-3/4 inch diameter metal chunks between electrodes in a dielectric fluid. These chunks can be produced relatively easily by a scrap metal shredding step. The Army is seeking the capability of developing metallic powder on a FOB, for potential use with additive manufacturing equipment deployed to the battlefield. As such, the processing equipment must be robust enough for shipment, storage and utilization in harsh environments, fit entirely within an intermodal container (conex), and be limited to the power available on a forward operating base (approximately 180KW for a typical 500 soldier FOB [6]). This program will focus on the development of powder for selective laser melting (SLM) equipment, or any other common metallic powder additive manufacturing technique. Issues such as particle size, particle size distribution and purity will need to be taken into account. Powders need to have tight size resolutions (+/- 10µm of mean). Also of issue is the utilization of powder processed in the field, since studies have shown that flowability of "used" powders is less than that of virgin powders [7]. The offeror will also need to provide a plan for mitigating oxidation buildup on powder production, since oxygen is deleterious during additive manufacturing.

PHASE I: This phase is primarily intended for identifying a means of producing metallic powder for battlefield additive manufacturing. This proposed powder producing capability must be able to produce powder on a battlefield, and of sufficient size and quality to be utilized with common metallic powder additive manufacturing techniques.

PHASE II: This phase is primarily focused on the development of the metallic powder production equipment (hardware) and power / process control / containment / deployment strategies. The method of powder production is left up to the offeror, but the restrictions listed herein must be conformed to.

PHASE III DUAL USE APPLICATIONS: This phase is to miniaturize, package and transition the developed metallic powder production technology for battlefield usage. The developed technique should be demonstrated using similar materials to those that may be found as scrap on a forward operating base and/or battlefield. The developed process must be contained within an intermodal shipping container (conex), with power requirements commensurate with that supplied from a forward operating base, producing powder that has the purity, particle size, and particle size distribution that can be used with common metallic powder additive manufacturing techniques.

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KEYWORDS: Powder Processing, Additive Manufacturing, 3D Printing, Materials on Demand and by Design, Point of Need Production

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A16-024 TITLE: Development of a high resolution long-wave infrared (LWIR) Polarimetric imaging system for long range human identification

TECHNOLOGY AREA(S): Air Platform

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 5.4.c.(8) of the solicitation.

OBJECTIVE: To develop a passive long-wave-infrared (LWIR) polarimetric imaging platform that is designed for robust biometric identification appropriate for both day and night operation. Such a system must be capable of both short (1-5 meters) and long-range (1-2 km) operation in which calibrated polarimetric imagery/video is generated and displayed in real-time, e.g., Stokes and Stokes product imagery/video, degree-of-linear-polarization (DoLP) imagery, etc. [1-3]

DESCRIPTION: It is currently projected that the market for biometric identification will reach $15 billion dollars during this FY 2015. The majority of these expenditures will involve implementing conventional facial recognition technologies that often rely on large sets of “visible” imagery that must be recorded under ideal illumination conditions. [4,5] However, there is a growing need for accurate “night-time” detection and identification of human subjects that are located at distances the order of a kilometer (km) or more. [6] For covert night-time operation, passive LWIR thermal imaging is best suited for the detection of a human, but unfortunately such imagery does not produce the detailed spatial features necessary to actually “identify” who or what the subject is, i.e., thermal imagery of humans exhibit a “ghosting” affect in which facial/biometric features appear washed out and devoid of the detailed textures required for robust biometric identification. Recently researchers have shown that the information content inherent in all thermal imagery can be significantly improved by determining the polarization-state of the image forming radiance, i.e., thermal polarimetric imaging. In particular, researchers have shown that by using thermal polarimetric imaging techniques in the LWIR, the resultant polarimetric imagery of humans, recorded in complete darkness, produce highly detailed imagery that approach the same level of information that is usually only seen in well illuminated visible imagery. [7-10] What is required is a robust, high-resolution, LWIR polarimetric imaging camera capable of displaying in real-time a variety of Stokes imagery.[11-13] The proposed camera system must include the following components, 1) telephoto-lens appropriate for long range viewing, 2) a polarimetric filter mechanism, e.g., spinning-achromatic-retarder or division-of-focal-plane, 3) a cooled LWIR focal-plane-array (FPA) with sufficient spatial resolution capable of displaying detailed human features, and 4) a control and image processing unit appropriate for real-time computation and display of the Stokes images S0, S1, S2, as well as the degree-of-linear-polarization (DoLP) image. Additional characteristics to be considered during the design phase of the proposal include, maximizing radiometric throughput, reducing pixel misregistration error to less than 1/20 of a pixel, and overall reduction in size, weight, and power consumption (SWaP).

PHASE I: During the Phase I candidates will be expected to conduct a feasibility study which will consist of predictive analysis and/or preliminary prototype development in support of their proposed design. This should include identifying and assessing (with costs) all critical components necessary to develop the proposed LWIR polarimetric imaging system. Specifically, the candidate should define and identify particular FPA architecture,

readout circuitry, minimum integration time, optical design, spectral responsivity, and control/analysis hardware and software required for high resolution, high frame-rate operation. Analysis should include optical design modeling and optimization in which both radiometric and polarimetric response characteristics are predicted, e.g., expected noise-equivalent-delta-temperature (NEDT), and noise-equivalent-delta-polarization state (NEDP). Although not necessary, prototype development and bench-top assessment of any (or all) critical components is desirable.

PHASE II: Based on the design criteria established during the Phase I, the candidate will procure all necessary components in order to assemble, test, and demonstrate a fully functional prototype device. Because the camera is expected to be operated on a variety of small autonomous/semi-autonomous unmanned aerial vehicle (UAV) platforms, the candidate should strive to meet the following SWaP parameters, i.e., overall volume approx. 0.25 cubic meter, weigh less than 10 lbs., and unit should be capable of operating on 30 watts or less. Initial prototype development and testing will include both laboratory and field-based assessment in which standard image quality metrics will be determined, e.g., modulation-transfer-function (MTF), NEDT, and NEDP. Final prototype testing and evaluation will be conducted at a government facility in which various human identification metrics will be determined as a function of range, atmospheric conditions, and tactical scenario. To be conducted concurrent with the prototype development, the contractor will begin identifying all possible commercialization opportunities and partnerships necessary to successfully bring their developed intellectual property (IP) to market. Transition from research to DoD operational phase will be coordinated through ARL to the appropriate Research and Development Centers (RDEC), e.g., Night Vision and Electronic Sensors Directorate (CERDEC), Army Space and Missile Defense Command (SMDC), and Special Operations Command (SOCOM).

PHASE III DUAL USE APPLICATIONS: Upon successful completion of Phase II, the contractor may be asked to demonstrate the full utility of the developed the high-resolution LWIR polarimetric imaging system. Possible DoD applications to be evaluated include the following: 1) Human identification, i.e., discerning the difference between insurgent and friendly civilian/DoD personnel, 2) detection of buried landmines and IEDs, 3) detection of low observable targets that are obscured by camouflage and/or natural vegetation. This may include further modification and ruggedization depending on customer needs. Such evaluation will take place at an appropriate U.S. Army field-test facility. This will also include further maturation of the system in which reduction in size, weight and power (SWaP) will be examined. Contractor is expected to pursue civilian applications and additional commercialization opportunities, e.g., remote sensing of geological formations, enhanced surveillance for homeland/boarder security, and enhanced machine vision and inspection used in various manufacturing process.

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KEYWORDS: biometric sensing, facial recognition, polarimetric imaging, human identification, long-range surveillance, thermal imaging, polarimetric thermography, long-wave-infrared (LWIR)

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A16-025 TITLE: On-Demand Property Modification for Performance Enhancement of Adaptive Systems

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: To demonstrate on-demand dynamic property improvements in response to externally applied fields for real-time control and performance enhancement of adaptive systems in-theater.

DESCRIPTION: Energy Coupled to Matter (ECM) is an emerging technology that is focused on fundamental research to discover, explore, and exploit interactions between materials and intense energy fields (magnetic, electric, acoustic, etc.), and enable significant property enhancements or unique property combinations to overcome traditional engineering trade-offs. Current ECM applications are primarily focused on field-assisted processing and manufacturing techniques in which electromagnetic fields are applied to manipulate microstructures and improve properties by reducing temperatures and times required for fabricating fully dense parts. These include current state-of-the-art methods such as spark plasma sintering, microwave sintering, flash sintering, and magnetic field processing [1-4]. While these techniques have demonstrated the ability to enhance material properties, achieve faster throughput, and generate energy and cost savings, they are limited to processing and manufacturing environments. Future ECM applications will expand beyond the confines of laboratory and manufacturing settings, allowing for on-demand structure-property modifications to be realized in-theater, and placing field-enhanced technologies directly into the hands of the Soldiers. The real-time interactions between applied physics-based fields and materials, systems, or devices may result in dynamic changes for immediate exploitation of rapid enhancements in physical or mechanical properties, or access to structural modifications that could not otherwise be achieved. Pairing these capabilities with detection technologies that promote battlefield awareness by identifying immediate situational needs may allow for active or adaptive on-demand ECM responses to enable advanced protection and lethality capabilities in the field. Examples of phenomena in which an electromagnetic input can be directly converted into a mechanical or physical response include piezoelectric, magnetostrictive, electro-rheological, and magneto-rheological effects. However, these effects are often limited in magnitude, and utilized for low power applications

such as sensors, actuators, dampers, and transducers, etc. [5-8], which do not have the desired dynamic output requirements. Since the magnitude of these effects is insufficient for the Army applications targeted by this effort, a significant amplification or enhancement of these types of phenomena, or an entirely new concept for generating a dynamic change in response to the application of electromagnetic fields is desired. The field-material interactions should result in a property increase (strength, hardness, fracture toughness, etc.) that reflects a 1.5 to 5 times or higher improvements as compared to the baseline conditions. A permanent enhancement in properties is strongly desired, though a temporary increase in properties may be acceptable for limited applications if the duration is on the order of seconds. The resulting materials systems or devices should lead to commercialization of novel products, commercial licensing, and intellectual property developments for lethality and protection applications of interest to the Department of Defense (DoD) as well as industry.

PHASE I: Perform research and analysis that will enable real-time, on-demand, dynamic material property improvements in the presence of applied electromagnetic fields (i.e. electric, magnetic, microwave, etc.). A significant enhancement (i.e. 1.5 to 3 times improvement) in properties including strength, hardness, fracture toughness, and/or elastic properties of one or more Army materials of interest (i.e. metals, ceramics, composites, polymers, or multi-material hybrid systems) is required. The property improvements should be evaluated based on magnitude and response time to the field (on the order of milliseconds or microseconds), though sustained duration of the phase or property change may not be critical for all applications, as some may only require an active property enhancement on the order of seconds. Concept evaluation should include validation of property improvements via comprehensive characterization techniques (microscopy, property testing, nondestructive evaluation, etc.). Phase I deliverables should include physical models, demonstrations, or coupons (if property modification is permanent). Since understanding of fundamental mechanisms is required for ECM basic research, insight into the underlying physics of these property changes through experimental testing and/or modeling & simulation is also desirable.

PHASE II: Demonstrate active functional prototypes or devices that are capable of inducing significant property changes (i.e. 3 to 5 times or higher improvements) in response to the application of electromagnetic fields for each concept that is developed. Validation of the enhancement in properties (whether temporary or permanent) through the use of proper characterization, testing, and measurement techniques is required. Down-selection of ideal materials systems for maximizing property and performance enhancements is also required. This system will be assessed for protection applications by testing the impact response in the presence and absence of electromagnetic fields. High-velocity impact testing will be performed with the goal of utilizing the developed technology to provide one or more of the following: (1) a significantly lighter weight protection system (10% or higher weight reduction) to defeat the same level of threat compared to current state-of-the-art (2) an equal weight protection system capable of defeating incrementally more lethal threats (3 to 5 times or higher increase in yield strength) (3) enhanced multi-threat (i.e. kinetic energy and chemical energy) protection (3 to 5 times or higher increase in fracture toughness). Investigation and insight into the physics of interactions between the applied fields and materials, including development of the appropriate models for analyzing field-material interactions, is desired. Exploration of in-situ characterization capabilities for control and feedback of adaptive systems is also of great interest.

PHASE III DUAL USE APPLICATIONS: Develop a full-scale commercial system for accurately and reproducibly applying electromagnetic fields to actively control property and performance of materials systems in an adaptive manner. The interactions between applied fields and materials systems must be evaluated as they relate to scale-up from a prototype to a full-size system (power requirements, areal coverage, magnitude/duration of response, etc.). Commercialization of resulting technologies, including product development, marketing and sales, licensing of the technology, and intellectual property considerations, are required. Anticipated commercial and DoD applications may include advanced personnel and vehicle protection systems, electromagnetic equipment and devices, and modeling tools that accurately simulate the effects of applied electromagnetic fields on materials systems. Successful commercialization will further support Army interests in areas such as property control and tailoring, adaptive dynamic response, and small volume production, all of which will be valuable to both DoD and industry.

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KEYWORDS: Energy Coupled to Matter, On-Demand, Adaptive, Electromagnetic, Property Enhancement

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A16-026 TITLE: Optical Thin Film Technologies for High Energy Lasers

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: To develop a new integrated photonic technology with high thermal conductivity crystalline substrates and epitaxial thin films to demonstrate high power laser waveguide and phase control capabilities for directed energy. With the efficient coupling of off-chip lasers, photonic integrated circuit beam combining, beam steering, and routing could be achieved using active phase control, beam splitting, and switching to produce miniaturized high energy laser systems.

DESCRIPTION: High energy laser (HEL) systems currently face various challenges for miniaturization. In particular, limitations on beam diameter and bulk optics size inhibit compact integrated photonic systems from being developed where large high-power mirrors and beam directors are needed for laser beam combining, steering and adaptive optics functions. Integrated photonics presents a solution to the compactness problems given that their power handling capabilities can be improved upon. Thin film dielectrics such as glasses used in optical fibers are one approach but more difficult to manufacture for high power on a planar substrate where cylindrical symmetry with complex photonic crystal cross sections are needed to increase the mode size large enough to obviate nonlinear effects such as Stimulated Brillouin Scattering, Stimulated Raman Scattering, and Thermal Modal Instability. Crystalline materials on the other hand are often overlooked as potential materials because the most common ones such as silicon suffer from other nonlinearities such as two-photon absorption and four-wave mixing, or simply

absorption due to a narrow optical bandgap. On the other hand, wide-bandgap materials are becoming promising, on various fronts. In the RF and power electronics areas (as well as LEDs) progress is being made toward developing 4 and 6 inch substrates of sapphire, SiC, Ga2O3, GaN on SiC, etc. [1]. The development of integrated photonics including high power laser beam combining and phase modulation may thus be possible [2]. The critical advantages of wide-bandgap semiconductors in terms of high power optical waveguides include much higher thermal conductivities than even Si (as well as orders of magnitude over dielectrics), low thermo-optic coefficients (dn/dT), reduced two photon absorption over Si, much reduced surface recombination velocities- making ridge waveguides potentially transformative, and robustness to humidity and other contaminants [3]. This topic aims to explore such new waveguide architectures for HEL materials and potential revolutionary advances in compact HEL systems. For example, active and passive photonic integrated circuits (or PICs) could be designed to interface with off-chip fiber lasers or on-chip or butt coupled solid state lasers [4]. Once the power has been coupled from the lasers into the waveguides the high power PIC can be used for beam combining and even beam steering via phase modulation effects. First, though, development of low-loss high power waveguides needs to be developed. The correlation of power handling to defect density levels in the materials needs to be characterized to determine power limiting mechanisms. The need for high crystallinity, low-defect materials should be explored versus lower quality sputtered materials (that may be better utilized in certain waveguide designs with their strain relaxed interfaces). Advantages of particular materials should be discussed in terms of integrated photonics including electro-optical effects for phase-shifting applications for effective beam control.

PHASE I: Pursue epitaxial growth and possibly bulk substrate development of high thermal conductivity wide-bandgap crystalline materials that will be attractive for potential use as high power optical waveguides. Investigate materials growth and processing needs, and waveguide and phase modulation regimes with the proposed materials. An in depth consideration of the material quality needed to achieve useful components for HELs as well as etched surface quality should be characterized. Simulation and preliminary investigation of waveguides and surface sidewall roughness and waveguide loss should be carried out to achieve minimal losses and useful properties for power handling of a kW or more per single mode waveguide [5]. Estimates of power handling levels should be made for actual designs based on studies with more elementary waveguides made versus defect density and other critical parameters (sidewall roughness). Achievement of over 100 W power handling per waveguide is desired.

PHASE II: Continuation of phase I that builds on the results in terms of further advances in material quality, sidewall roughness and surface state reduction, etc. to achieve low-loss optical waveguides (< 1 dB/cm). Other characteristics include low insertion loss (< 1 dB) and ability to achieve < 1 dB loss from 90 degree bends. Design and characterize integrated photonic components such as electro-optical phase shifters that can modulate over MHz rates and resultant coherent beam combiners (multiple inputs, single output). Detailed bend induced loss vs. bend radius, propagation loss requirements, and input/output coupling loss need consideration for coupling to optical fiber and for beam combining of multiple waveguides. Power handling in excess of 1 kW with proper thermal management and optical scattering mitigation (input/output coupling, sidewall smoothness, and optical waveguide confinement considerations) are desired. A full implementation of optical phase modulation could also be pursued if resources are available with studies at various power levels. Prototype deliverables may be written into the award based upon coordination with Army customers- where high power testing capabilities are available and seen to be of use for progression to phase III. At least one straight and one 90 degree bend waveguide will be delivered for testing (if the contractor can demonstrate the functionality at their facilities this may suffice). Required deliverables will include a full disclosure of the high power waveguide technology to the government. The details of this technology will include etching recipes, materials used (including how to acquire materials of similar crystallinity, defect levels, etc.), waveguide designs – refractive index profiles to achieve kW power handling, a disclosure of all related technology used for phase modulation, achievement of routing –such as using waveguide bends, etc. Use of this high power waveguide technology by the government and its contractors will be expected with more detailed specific examples utilizing the developed technology being arranged during phase I and following (the technology readiness level achieved may exceed the minimum level desired).

PHASE III DUAL USE APPLICATIONS: Utilize new crystalline photonics technology for high energy laser applications with integrated photonic components used for beam combining, active phase control, beam steering, beam routing, etc. Extended work on how the laser light will be efficiently coupled into the high power PIC should be pursued to minimize loss. Planar waveguide or fiber to PIC coupler would need to be pursued upon successful development of low-loss, high power handling integrated photonic technology. Applications of this technology could then be explored in higher TRL (Technology Readiness Level) systems within DoD labs, contractors, etc. Commercialization would follow through advanced acquisitions programs.

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KEYWORDS: wide-bandgap semiconductors, high energy lasers, high power lasers, optical waveguides, thin film coatings, integrated photonics

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A16-027 TITLE: Cyber Battlefield Operating System Simulation Tools for LVC Simulations

TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: The objective is to develop innovative methods and software tools to provide the effects of cyber attack and defense in the Army’s current Live Virtual and Constructive (LVC) Simulation Systems. This functionality must be accomplished while maintaining the Information Assurance (IA) compliance requirements required by training systems which are typically compromised on cyber range events.

DESCRIPTION: As the Army continually develops a force capable of meeting the challenges of 2025 and beyond, the domain of Cyberspace is exponentially important. The U.S. Army Operating Concept states that “Enemies and adversaries collaborate as contests in space and cyberspace extend to and affect tactical operations.” The realization that Cyberspace is a warfighting domain has simulation and training program managers struggling to identify the best solution to implement cyber warfare effects into the training domain. Current training simulations among the Live, Virtual, Constructive, and Gaming domains lack a cyber implementation. The Combat Training Centers leverage Army Cyber expertise to execute cyber training pilots that integrate cyber effects into the operational environment, largely for and/or against Brigade Combat Teams. From an Opposing Force perspective, these exercises demonstrate, through actual effects, potential adversary mission command system compromise, while other emerging efforts provide friendly / Blue Force with cyber capabilities. These scenarios are groundbreaking, and force trainees to recognize system compromise while simultaneously planning offensive operations of their own. However, a simulated training environment is currently lacking at all echelons. The Test and Evaluation community has progressed in cyber simulation tools to support operational testing of cyber related systems. The computer models of networks and cyber events support operational testing of complex systems. Although these models and cyber test ranges have the complexity to simulate the devices under test and support fixed test goals, they lack the flexibility required by the training environment to provide the ability to create flexible training scenarios based on a unit’s training objectives. These training scenarios would generate cyber effects to trainees in a given simulation so

they can make correct decisions to identity attacks and practice response and recovery based on the scope of the attack. The focus of this SBIR topic is to research innovative approaches to best implement cyber effects in training simulations with the goal of being part of an overall architecture and strategy that the Army's various Live, Virtual, and Constructive (LVC) training simulations could follow. An initial starting point could be current work being done on operational system cyber testing and how these approaches could be made more flexible and scalable to accommodate different training missions in the architectures on the training systems. The potential scope of this research includes tactical cyber effects on Mission Command Systems, Kinetic effects of Computer Network Attacks, and cellular/satellite networks. Currently none of the Army's major Constructive and Virtual simulations have an approach or strategy to implement the Cyber Battlefield Operating Systems (BOS) across their systems. Another great challenge of the cyber simulation area is that the training requirements of different training audiences are either not defined or sketchy at best, making it impossible for the major LVC programs to move forward in adding the Cyber BOS. It is envisioned that the cyber learning requirements/goals will be very different by user; leaders in Constructive simulations may want to be trained to identify the basic effect of attacks and delegate orders to develop contingencies while Live operators may want to directly train on range equipment. The system should allow the detection, response, and recover processes to cyber attacks to be effectively practiced/rehearsed by the trainees. The goal of this SBIR's prototype is to provide a demonstration CyberOps training capability to the Army training community that shows them the potential methods to incorporate the injection of CyberOps effects into their training solutions so that the trainees can recognize cyber-attacks and make recovery decisions accordingly.

PHASE I: Conduct an analysis of current Army LVC simulations and architectures and determine innovative solutions to create the effects (both offensive and defensive) of cyber-attacks and as well as allow the trainees to make proper decisions to maximize the scenario's outcome. Select a LVC system to be the focus of your prototypes. Determine how cyber events can be effectively trained on the selected LVC systems you have selected to focus on. Develop a system design that includes requirements, specifications, training operational concept, interface designs, and graphical interfaces. Provide a report on design approach and overall system design.

PHASE II: Develop a prototype of the cyber simulation design. Test and verify its usability to add cyber training effects to the selected LVC simulation. Metrics include the system being able to simulate to a training audience a wide variety of possible cyber attacks (e.g. malware attack, jamming, hacking, social engineering, insider threat, etc.) and provide realistic effects to a training audience so they can determine the nature of the attack and react as appropriate. Show how the prototype design could have the ability to be a training architecture that would allow cyber effects to be simulated across the LVC training domains.

PHASE III DUAL USE APPLICATIONS: This research has enormous dual use potential. Many of the cyber simulations could potentially be used by commercial organizations that plan training of their cyber and management teams to protect from cyber attacks. Presently there is a large market for the cyber training of systems operators in the commercial sector. Depending on the approaches taken, the models and simulations generated by this effort have the potential to meet the needs of this market.

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KEYWORDS: Cyber, Cyber Warfare, Cyber Offense, Cyber Battlefield Operating Systems (BOS), Cyber Defense, Computer Network Attack (CAN, Training, Mission Command Systems (MCS), Live–Virtual-Constructive (LVC)

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A16-028 TITLE: Miniature, software-defined Man-Portable Doppler Radar (MPDR) for Atmospheric Measurement

TECHNOLOGY AREA(S): Battlespace

OBJECTIVE: Develop and demonstrate an innovative compact, man-portable, ruggedized software-defined Doppler RADAR (Radio Detection And Ranging) system for the measurement of atmospheric winds and adverse weather features (e.g. thunderstorms, cloud fronts, etc…) that will have advanced characteristics such as adjustable RF waveforms allowing for versatile radar adaptability.

DESCRIPTION: There has been considerable interest and development in the use of software-defined radios for use in adaptable, multi-mission, micro-Radar development. Software-defined radar is a versatile radar system, where most of the processing, like signal generation, filtering, up-and down conversion, demodulation is performed by software. Most of the current efforts have been research oriented and have not delivered systems that are robust for practical field measurement. Within the Department of Defense, the U.S. Air Force have existing programs for development of portable Doppler RADAR systems but are operationally targeted less for direct tactical use in a local environment than to larger areas, typically out to 180km and large systems (>2000 lbs). The US Army has the need for real-time, high-resolution, short range tactical weather sensing that is critical for military applications such as forward-area Precision Airdrop (PAD), aviation operations including landing zones and weather hazard warning. There have been recent development efforts for the miniaturization of Coherent Doppler LIDAR (Light detection and ranging) sensor systems that can measure atmospheric winds in clear air but these systems fail to perform in degraded visibility conditions. Also, the range of these systems is not adequate for providing useful warnings of impending weather-related hazards. Man-portable Doppler RADAR systems, especially via software-defined technology, can improve the overall situational awareness within a tactical scale volume and can improve operational performance for aviation systems and mobility. The Size, Weight, and Power (SWaP) required for man-portability into forward-areas will require systems with volumes less than 30L and weights less than 20kg to enable a single soldier to carry the system. This is the limiting size and weight for a single soldier to carry. Also, for these systems to gain practical use requires an efficient use of power for the sensor operation. Although the science involved in Doppler RADAR sensing is well developed, there still exists areas that pose barriers for successfully developing a man-portable RADAR. One of these barriers is in the use of novel waveforms that can allow for both detection of adverse weather and overcome potential problems with RF jamming. Also, as the overall RF power of the RADAR is reduced, novel methods will likely have to be employed for the efficient signal processing. There are complex technical barriers that will also have to be overcome for the successful development of a man-portable Doppler RADAR. As the size of Doppler RADAR decreases, the expected wavelength will also likely have to decrease due to the required size of the RADAR antenna to fit the man-portability requirement. This will likely force the system to operate in the X band of the RF spectrum. Also, most of the current Doppler RADAR's employ either a rotating antenna (single beam) or phased array for delivering the beam. Miniaturizing this component of the RADAR poses technical problems regarding both the optimal design to fit within the SWaP requirements and necessary functional constraints posed by the overall RF power and gain required for improving Signal to Noise(SNR). Another technical barrier is the development of compact signal processing/waveform generation electronics that ideally would be able to adapt to different sensing scenarios such as rapid update near field sensing, extended range sensing, and hard target detection.

PHASE I: Effort should be directed toward the development of initial design of the proposed miniature, software-defined MPDR system concept. Detailed algorithms for radar signal generation and processing should be evaluated, using a combination of real data and high fidelity simulation for effectiveness in wind and aerosol/cloud detection under various atmospheric conditions. Results should be documented. Strengths and deficiencies should be clearly identified. The preliminary design should be configured with optimized performance and ready to be implemented in hardware during Phase II. The man-portable design requirements are for the overall system to weigh less than 20Kg and have a volume less than 30L.The system should be designed to be capable of measuring atmospheric winds to 10km with adverse weather detected at 15km.

PHASE II: Develop a proof of concept breadboard prototype to demonstrate the technologies and capabilities identified and explored in Phase I. Upon completion and demonstration of proof of concept device, further develop

the system to a prototype to reduce the size, weight and power (SWAP) of the MPDR sensor such that it weighs less than 20kg and does not occupy a volume larger than 30 L. The system should be capable of measuring atmospheric winds to 10km with adverse weather detected at 15km. Demonstrate the capabilities of the system in a field study. Expected maturity level at completion of Phase II is TRL 5.

PHASE III DUAL USE APPLICATIONS: The prototype should be further refined toward commercialization. The offeror should work with Army scientists and engineers, along with potential industry partners, to identify and implement technology transition to military and civilian applications. Civilian applications include aviation hazard warning for airports. Some specific military objectives under phase III could be operational testing with US Army Pathfinders supporting forward area aviation operations (such as precision air drop and landing zone support) as well as testing with US ARMY aviation operations providing support during landing and takeoff phases of flight which represent the greatest hazard for flight operations.

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KEYWORDS: Atmospheric remote sensing, RADAR, Doppler, software-defined radio, Weather radar

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A16-029 TITLE: Computationally Driven Development of Energy Absorbing Materials and Manufacturing Processes for Rotorcraft

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Develop lightweight, energy absorbing materials, manufacturing processes, and subsequent methods to evaluate technologies that increase occupant survivability and airframe crashworthiness.

DESCRIPTION: The development of technologies to improve rotary wing aircraft is inhibited by both testing cost and the test devices that are currently utilized. Rotary wing aircraft testing frequently use a commercial automotive Anthropomorphic Test Devices (ATD) for crew injury assessment. These assessments include determining whether energy absorbing seats and restraint system changes will increase occupant survivability. This method limits the utility of the test because the ATDs were not designed to represent response of military personnel to the types of load paths and overall crash dynamics experienced in rotary wing aircraft. An additional limitation in developing new technologies is the high-cost of each test especially when instrumenting each crew location with an ATD. As responses in the airframe energy attenuation seats and floor technology, and crew are highly non-linear, this problem needs to be solved using a fully coupled and single simulation domain rather than relying on one-way coupling between locations in the aircraft and crew models. High fidelity meshed models should be developed to be compatible with a highly scalable physics solver to take full advantage of HPC resources. The constitutive models and simulation framework must be able to represent the interaction of each of the layers of the system and complex failure modes. The study of injury modes under these loads will necessitate the incorporation of recent injury biomechanics data being gathered for vertical loading similar to that seen in rotary wing crash events and should be considered in the analysis. As the demand for reduced development cycles and funding continues coupled with recent developments in high rate structural mechanics capabilities – a promising approach is emerging that leverages system level high-fidelity modeling to capture the response of ATDs when assessing the viability of new technology

and understanding the severity of the impulsive load on each crew location within a given airframe. The Army is interested in developing a state of the art high fidelity computational physics (HFCP) tool set for evaluating new technologies and reducing test costs and risks. Development of this capability involves three critical development paths: 1. Creation of representative high fidelity meshed models of armor and seating technology of interest to the aviation community for occupant survivability analysis with the resolution and material constitutive models to predict large deformations and failure. 2. Accurate crew injury prediction capability based on recent research into vertical acceleration-based injury biomechanics. 3. Development of energy attenuation technologies that are designed to mitigate crew injury and accurate characterization of their response to enable performance predictions via HFCP analysis.

PHASE I: Conduct a feasibility study of applying current crew injury evaluation capabilities as compared with those in other industries or for other DoD platforms. Determine an approach to develop a HFCP capability to simulate rotary wing aircraft impact into various surface conditions and subsequent crew survivability and demonstrate the capability with a representative structural model. Identify lightweight, energy absorbing materials and manufacturing processes to be further developed in Phase II.

PHASE II: Demonstrate an end-to-end HFCP capability to predict crew injury as compared to test data. Leverage this capability to develop and evaluate lightweight, energy absorbing materials, and manufacturing processes that improve crashworthiness. Conduct testing to validate the HFCP analysis tool that captures the evolution of the air frame response to impact and demonstrates the ability to evaluate technologies intended to improve crew survivability.

PHASE III DUAL USE APPLICATIONS: Partner with rotary wing program offices to integrate a validated HFCP analysis capability into the engineering, survivability, and test and evaluation teams to support materiel design and insertion for crew survivability. There are synergies between military and commercial aviation pursuits of technologies to increase occupant survivability and crashworthiness and establishing relationships on the military and civil aviation side will provide a path forward to commercialization.

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KEYWORDS: high performance computing, energy absorbing materials, injury biomechanics, rotary wing aircraft

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A16-030 TITLE: Mode 5 Identification Friend or Foe (IFF) simulation and subsequent RF injection

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Enhance an existing tactical network simulation in order to provide Mode 5 Identification Friend or Foe (IFF) simulation and subsequent Radio Frequency (RF) injection (1090 MHz) of up to 1000 simultaneous simulated tactical aircraft to passive air traffic control receiver hardware.

DESCRIPTION: The purpose of this research topic is to expand the capability of the Joint Scalable Tactical Emulated Network (JSTEN) to include Radio Frequency (RF) stimulation of passive Mode 5 receivers with simulated Identification Friend or Foe (IFF) air tracks. Joint Scalable Tactical Emulated Network (JSTEN) is a Government owned network environment that facilitates network emulation and the integration of those emulated networks with any live tactical networks that are based on Ethernet packaging protocols. The Mode 5 Identification Friend or Foe (IFF) interrogations and responses occur on 1030 MHz and 1090 MHz respectively. The response messages from multiple aircraft generate a complex, often interfering, Radio Frequency (RF) environment that cannot be cost-effectively generated using live aircraft. Army Test and Evaluation Command (ATEC) and other organizations, such as Product Manager (PM) Air Traffic Control (ATC), require a capability of combined live, virtual and constructive (LVC) simulations, which can be tailored to emulate a realistic combat environment for the test and evaluation of Mode 5 Identification Friend or Foe (IFF).

PHASE I: Investigate and define a technique(s) and concept(s) for stimulating different types of passive Mode 5 receivers utilizing the enhanced Joint Scalable Tactical Emulated Network (JSTEN). For example, some receivers have omnidirectional antennas that cover the entire 360 degree Field of View of the receiver. Other receivers take advantage of multiple directional antennas with overlapping Fields of View. This topic will create a unique capability that can stimulate multiple types of receiver configurations. Various implementation and fabrication approaches are to be investigated. Specific form factors and packaging concepts will be devised. Phase I will demonstrate design feasibility through analysis, modeling and/or breadboard hardware. Part of the analysis will include the scalability limitations of the simulation framework.

PHASE II: Conduct the design, fabrication, test, and delivery of a Mode 5 simulation and transmission prototype framework as defined in Phase I. The framework will require the integration of Government Furnished Equipment (GFE) Type I encryption hardware (KIV-77/KIV-78) compatible with existing passive receivers. The framework will also require compatibility with existing Government off the shelf software suites, including Joint Scalable Tactical Emulated Network (JSTEN) and One Semi-Automated Forces (OneSAF). This phase will determine the effectiveness of supplying overlapping Interrogation Friend or Foe (IFF) signals to receivers using the prototype hardware.

PHASE III DUAL USE APPLICATIONS: This technology will be utilized for the test and analysis of existing Mode 5 systems, such as those deployed by the Army, Navy, and Air Force. The technology will assist in the verification and certification of Mode 5 systems prior to delivery to the government. From a commercial perspective, the software and hardware from Phase I and II will stimulate hardware that utilizes the Federal Aviation Administration (FAA) Automatic Dependent Surveillance – Broadcast (ADS-B) technology. Automatic Dependent Surveillance – Broadcast (ADS-B) is a cooperative surveillance technology that allows commercial and military aircraft to broadcast their position to ground air traffic controllers and other aircraft. The tools developed could be modified for use in a wider range of applications in the radio frequency spectrum.

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3. DoD AIMS 04-900 - Interface Control Standard for Mode 4/5 Cryptographic Computer

KEYWORDS: Mode 5, Radio Frequency (RF), Air Traffic Control Radar Beacon System Identification Friend or Foe, Mark XII/XIIA System, AIMS, Automatic Dependent Surveillance – Broadcast (ADS-B), Passive Receiver, Software Virtual Network (SVN), Federal Aviation Administration (FAA), Encryption, Government Furnished

Equipment (GFE)

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A16-031 TITLE: Forest/Jungle Positioning Based on Geo-Registered Images from Foliage Penetrating Radar

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop and demonstrate the ability to resolve the pattern of trees in a forest/jungle environment and determine one's own position relative to a geo-registered map.

DESCRIPTION: The pattern of tree trunks in a forest/jungle appear spatially random and unique. By using algorithms similar to those used in stellar pattern matching, patterns of trees can be matched to imagery maps and used to identify a person's location. Maps could be generated from aerial imagery using foliage penetrating RADAR or other similar technologies to geo-register the environment and identify locations of tree trunks. If the tree locations can be identified with sufficient accuracy, methods such as Simultaneous Location and Mapping (SLAM) can be used on the ground to determine the location of individuals moving through the trees. This should allow dismounted soldiers to operate in forest and jungle environments where no GPS reception is available while maintaining accurate Position Location Information (PLI). This capability is extremely valuable to soldiers and UGV's and could rely on simple devices such as small cameras or LIDAR sensors. Soldiers and UGVs could conduct missions without interruption by this process (i.e. it is automatic and requires no action on their part). In a third phase it is assumed that this system would be integrated with the dismounted soldier's ensemble where it would employ the ensemble's camera, processor and memory (serving multiple purposes, not just navigation). However, in Phase II the prototype system would be stand alone and is not expected to weigh more than ten pounds and be less than 500 cu in, including batteries capable of running the system for six hours without a recharge.

PHASE I: The vendor will develop a system architecture and conduct necessary tradeoff studies proposed by the vendor that contributes to the architecture and prove feasibility of the proposed approach.

PHASE II: Design and build a prototype system which may be new, or may be modifications to an existing dismounted soldier navigation system performance. Demonstrations will be conducted in jungle, forested and other GPS degraded environments.

PHASE III DUAL USE APPLICATIONS: The vendor will commercialize the system. Military application of this topic is directly applicable to the dismounted soldier via the Assured PNT program, subprogram Dismounted PNT. Envisioned endstate is the ability of soldiers to conduct their missions in these environments, maintaining a high level of OPTEMPO, where the use of this technology is transparent to themselves (as if they had GPS in these environments). Commercial applications of this technology would be also directly applicable to First Responders that conduct their missions in jungle, forested and other GPS degraded environments (such as search and rescue, border/customs control and Drug Enforcement Agency).

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KEYWORDS: Dismounted, Soldier, Navigation, PNT, Foliage Penetrating Radar, GPS, Inertial

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A16-032 TITLE: Innovative X-Band Antenna Architecture for BFT 3

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: The objective of this SBIR topic is to design and develop an innovative phased array antenna architecture and feed system that promotes the development of low cost, full duplex, single aperture phased arrays at X-Band.

DESCRIPTION: Providing Situational Awareness (SA) is critical to effective battlefield command and control. The Army's recent experience in IRAQ and Afghanistan demonstrates that command and control of mobile and widely dispersed forces is very challenging (Ref: Force XXI Battle Command Brigade and Below-Blue Force Tracking (FBCB2-BFT). A Case Study in the Accelerated Acquisition of a Digital Command and Control System during Operations Enduring Freedom and Iraqi Freedom). Satellite communications are a critical component of the battlefield command and control communications strategy, as is evident by the Army's successful line of Blue Force Tracking (BFT) and Movement Tracking Systems (MTS). Project Manager (PM) Mission Command is investigating a fully owned and operated military SA system for the next generation BFT and MTS product lines. For the 10,000+ user terminals needed for Key Leader systems or the 100,000+ systems to fully populate the US Army/Marines (Ref: "Situational Awareness In Hand") with a ubiquitous capability, there remain some critical gaps in antenna technology. Existing satellite antenna technologies for mobile and On-The-Move (OTM) operations in military satellite bands continue to be limited in performance and/or very expensive, despite prior military R&D in this area (Ref: SBIR A07-134). In X-Band, a universal challenge with low cost phased arrays antenna systems arrives from the typical architectural convention of placing filters and Low Noise Amplifiers (LNA) in the unit cell behind each antenna element. While this architectural convention reduces the cost of the system (vs. more elaborate feed systems) and is successful at achieving a low system noise temperature, it physically limits the filter design to the area and medium directly behind each aperture (i.e the unit cell) ("Ref: Shared Aperture Technology Development"). The result is that these filters are not able to remove the transmit signal from the receive band, essentially creating a self-jamming situation for a substantial portion of the receive band. The new concept proposed by this SBIR topic is an investigation into the feed system technologies (e.g low cost, high performing unit cell materials, and manufacturing technologies, etc.) and architecture (e.g. where the filters, LNAs, Power Amplifiers (PA) and other components are located) of low cost phased array systems. Improvements in this area will allow full duplex single aperture phased array systems to be efficiently and effectively built in the X-Band frequency range. To fully demonstrate the objective of this SBIR, a low cost, full duplex, single aperture phased array X-Band antenna, along with a digital conversion system (DCS), shall be developed, designed and prototyped, using the innovative phased array antenna architecture and feed system, for a SATCOM On-The-Move Blue Force Tracking application. At a minimum, the proposed solutions should utilize electronic tracking in elevation in order to eliminate the need for mechanical mechanisms, which are less reliable, and require more power and maintenance support in this axis. However, in the azimuth axis, a mechanical solution is acceptable as it is less prone to mechanical failure and may reduce overall system cost. Improving satellite antenna technologies for mobile and On-The-Move (OTM)

operations in military X-band is one of the last major hurdles in a fully owned and operated military SA system, as the two other major hardware components, satellites and hubs, exist. The technology pursued in this SBIR will enable the Army, Homeland Defense, and other government organizations to realize this capability in the near future.

PHASE I:
• Design notional architectural for phased array antenna architecture and feed system that promotes the development of low cost, full duplex, single aperture phased arrays in X-Band.
• Requirements decomposition of the following requirements into notional architecture and feed system.
• Full Duplex Communications
• Antenna Instantaneous BW: 1.15GHz
• Comms Rx BW: 2.4MHz (Threshold) 2 X 2.4 (Objective)
• Comms Tx BW: 2.4 MHz (Threshold)
• Operational Frequency: 7.25-7.75GHz (Rx), 7.9-8.4GHz (Tx)
• EIRP of 19 dBW; (over all FoR)
• G/T ~ -6 dBi/k (Threshold), Maximum Possible (Objective)
• Field of Regard (FoR): -5 to +90 Elevation, 0 to 360 Azimuth (Objective) +10 to +90 Elevation, 0 to 360 Azimuth (Threshold)
• Low Cost: Less than 8k/unit (Threshold) 5k/unit (Objective)
• Cost includes Antenna and Digital Conversion System taking RF to digital IF
• Size: L X W X H 8in x 8in x 6in (Threshold)
• WGS Certification Required (in production units): See MIL-STD-188-164B for tracking/pattern/polarization/axial ratio, etc.
• Systems must track while on the move. 40 mph (Threshold), 500 mph (Objective)
• Perform modeling of the design and detailed system budget to determine trade-offs for antenna performance vs. cost, and size.
• Simulation to verify and validate notional design.

PHASE II: Develop, design, prototype and demonstrate a low cost, full duplex, single aperture phased array X-Band antenna, along with a digital conversion system (DCS), using the innovative phased array antenna architecture and feed system, for a SATCOM OTM Blue Force Tracking application. The demonstration shall connect an existing BFT 2 capable transceiver to the prototype system via a the digital Intermediate Frequency (IF), and show full operation of the BFT 2 waveform and associated Joint Battle Command – Platform (JBC-P) software in the BFT 2 Network. The interface between the DCS and the BFT 2 capable transceiver shall be provided by the Government, such that the vendor can build their prototype unit to this interface. The prototype unit shall be integrated onto an Army test vehicle, and validate operation on the move over an X-Band satellite.

PHASE III DUAL USE APPLICATIONS: Commercial and Military X-Band phased arrays face the problem described in this SBIR topic ubiquitously. As a result, there are many transition opportunities for this technology. As a primary example, PM MC is seeking to augment commercial L-Band systems with a military X-Band system for next generation Blue Force Tracking (BFT) systems. However, with current antenna technology a X-Band user terminal antennas are too large to meet the platform size requirements. This technology approach will reduce the size of X-Band antennas by up to 67%, making X-Band user terminals a viable solution for this technology transition. Similarly, other military applications with size restrictions are USSOCOM, and the Marine Special Forces units. These are prime candidates for transition of this technology. In the commercial market, Movement and Tracking systems are widely deployed for logistics companies such as UPS, FEDEX, and long haul trucking. These systems currently operate in L-Band but similarly would like to augment or move to commercial X-Band for increased bandwidth and reduced form factor utilizing this technology.

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KEYWORDS: X-Band, Antenna, Phased Array, Blue Force Tracking, BFT, On-The-Move, Feed, Filter, Satellite, Communications, SATCOM

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A16-033 TITLE: Multi-Band Body Wearable Antenna

TECHNOLOGY AREA(S): Human Systems

OBJECTIVE: Develop body wearable antenna providing capability to fully integrate and operate with all current generation soldier radios (PRC-148,152,RT-1523); operating in multiple radio frequency bands, with multiple modulation techniques.

DESCRIPTION: Most soldiers today are issued either RT-1523, PRC-148 or PRC-152 radios that operate over the entire 30 MHz-512 MHz radio frequency band, which encompasses 6 distinct voice communications bands and several voice and data modulation techniques. The Army is seeking a new body wearable antenna design that is capable of operating effectively in multiple radio frequency bands and with various modulation techniques, which will provide a minimum range of 0.5 KM when both the transmitter and receiver are situated in horizontal positions on the ground. This body wearable antenna will need to operate effectively in the SINCGARS band (30 MHz-88 MHz), Air & Marine band (116 MHz–174 MHz), UHF band (225 MHz– 450 MHz), UHF-Public Safety band (450 MHz-512 MHz), UHF SATCOM band (225 MHz-318 MHz circularly polarized) and L-Band (Soldier Radio Waveform). The Army is seeking a new body wearable antenna design that is capable of operating effectively in multiple radio frequency bands and with various modulation techniques when both the transmitter and receiver are situated in horizontal positions on the ground. The Army is also seeking for this antenna design the ability to be able to be remoted from the radio and the soldier (i.e.: hoisted into a tree) to provide increased communications range in heavily forested or triple canopy jungle environments. Communications range is expected to increase up to 5 KM under these conditions.

PHASE I: The objective of phase I is to demonstrate a body wearable antenna design, which should be able to provide a clear communications link in all six of the radio frequency bands and is at the technology readiness level of 4 (TRL-4). Specific Absorption Rate (SAR) exposure evaluations will be accomplished, by either calculation or simulation techniques, in each of the six radio frequency bands of operation, to demonstrate to the government that this antenna design will be safe for the soldier to wear. The SAR evaluation shall consider the possibility of two body wearable antennas on the body separated by one foot transmitting simultaneously.

PHASE II: The objective of Phase II is to further develop and then package this body wearable antenna technology in a light weight and rugged format that will be at the TRL-7 level at the end of Phase II. Fifty (50) body wearable antennas will be produced and provided to the government at the end of the Phase II contract for further field testing by the government. Specific Absorption Rate (SAR) exposure evaluations will be accomplished by actual SAR measurements, in each of the six radio frequency bands of operation, to demonstrate to the government that this antenna design will be safe for the soldier to wear. The radio frequency (RF) radiation exposure levels due to this wearable technology, must be below the occupational limits set by the FCC and OSHA. The FCC has both occupational and general power density exposure limits outlined in C.F.R 47 1.1310 as well as occupational and

general specific absorption rate (SAR) exposure limits outlined in C.F.R 47 2.1093, both of which follow ANSI/IEEE guidelines. The SAR evaluation shall consider the possibility of two body wearable antennas on the body separated by one foot transmitting simultaneously. This antenna will be designed to operate effectively while on the soldier's body, as well as when remoted from the soldier by being suspended in a tree. The antenna will be constructed with an acceptable camouflage pattern so as to be invisible to an observer, especially when remoted from the soldier's body. Each antenna will terminate in a TNC-jack and include two short (30") RF coax cables, one of which terminates in a TNC male plug at one end and a BNC male plug at the other end, and the other cable which terminates in a TNC male plug at both ends. This will allow each antenna to interface with all the currently fielded soldier radios.

PHASE III DUAL USE APPLICATIONS: Obtain National Stock Number (NSN) designation for antenna and have discussions with PEO C3T and PEO Soldier to consider this antenna to replace existing soldier radio antennas. Environmentally harden antenna to meet the environmental requirements of MIL-STD-810 in order to replace AT-271A/PRC (8-foot metal foldable stick antenna) and the AS-3683/PRC (1-meter metal tape whip antenna) in the field. Provide about 12 each antennas to several field units, such as the 25th Infantry Division and Special Operations Forces units, for field evaluations under simulated combat conditions. This body wearable antenna would be applicable to commercial applications, such as for use with Home Land Security units, as well as with first responder units.

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4. https://sbirsource.com/sbir/awards/50570-MUOS-antennas-for-soldiers

KEYWORDS: Body-wearable antenna

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A16-034 TITLE: Open Architecture Antenna Controller for Directional MANET

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: To develop a generic Open Modular Antennae Controller Architecture that works for legacy, IP and futuristic waveforms as a turnkey solution.

DESCRIPTION: The DoD is shifting from the traditional omni-directional antenna to directional antennas for tactical MANET. Different antenna designs such as parasitic and sector antennas are considered. With the clear advantages of shaping the RF emission to decrease spectrum footprint, increase frequency reuse, increase throughput, enhance security in avoiding jammers and eavesdropping nodes, there is a need for an antenna controller that can shape the spectrum emission per-packet (fast shaping) for this new generation of cognitive radios. The Army is seeking a new antenna controller design that is generic enough to accept the download of different software versions for different antenna types. The Army seeks the ability to develop modulation algorithms that can adapt to the complex sensing techniques built into cognitive radios to include enemy and friendly node locations, sensed spectrum emission and higher layer information such as destination node of the IP packet. The modulation

techniques must work per each packet transmission. The new controller design is thought to accept different software downloads in order to work with the different antenna types such as parasitic or sectored antennas. This hardware/software design must have the ability to adapt to legacy radios where no new requirements shall be imposed in legacy waveforms to turn them from omni-directional to directional radios. The new hardware/software design must be able to intercept the signal going to the legacy antenna controller, use add-on sensing output, and shape emitted spectrum transparent to the legacy waveform. The topic will explore new FPGA design and software design to achieve the above mentioned goals. A demonstration is expected of the controllers' ability to include techniques for creating cognitive spectrum awareness of both friendly and enemy nodes to make RF beam formation, directionality and power control algorithms; and the ability to minimize spectrum footprint considering the destination node of the IP packet (that is tying spectrum emission to routing) per each packet transmission. Defining an API to exchange cross layer signaling with the upper layers, defining API to obtain sensing information, and defining modules specific for each legacy waveform are parts of the desired design.

PHASE I: The objective of Phase I is to determine the feasibility of an FPGA design, software partitions, API definitions and initial per-packet modulation ability for one specific antenna type. This preliminary design must have the ability to intercept one legacy waveform signal and turn an omnidirectional emission to a directional emission that meets the above mentioned requirements.

PHASE II: The objective of Phase II is to develop and deliver a prototype implementation of a hardware/software-defined controller that can work with any legacy or non-legacy waveform, ability to implement per-packet processing and work with different antenna types while avoid emitting spectrum in unwanted directions (pattern nulling), maximize spectrum reuse and minimize spectrum foot print. The contractor will support creating metrics that can measure the controller spectrum interference reduction, increased MANET subnet throughput, increased message completion rate. Deliverables include (1) a prototype hardware/software controller, (2) a detailed architecture diagram(s) of controller and associated hardware/software, and (3) detailed listing of metrics (with measurement implementation description) for testing RF/Network improvement by use of controller delivered in (1). The key military application of this technology is software-defined radios where antenna controller module is separated with a specific hardware design that can meet legacy, current and future software capabilities.

PHASE III DUAL USE APPLICATIONS: The objective of Phase III is to demonstrate the antenna controller module is separated with a specific hardware design, meeting legacy, current and future software capabilities, with any legacy or non-legacy waveform. The military application of this technology will be any/all software defined military radios (HMS Manpack, MNVR, etc.) and their associated waveforms (such as SRW, WNW, etc.) that currently use omni-directional antennas. This is currently the majority of ground-based military tactical (Non-SATCOM) waveforms used by the Army. The commercial application of this technology would likely be for use with Wifi hotspots, Cellular/LTE repeaters, or future commercial auto radio/communications. The most likely transition path for this SBIR to operational capability will be through existing programs of record in the Army (namely PM Tactical Radios). The technology may require additional maturation via 6.3 R&D or via inclusion in the Army Agile Process and NIE events. Specific Commercial Applications - Commercial Auto Radios (HD Radio, etc.), Wifi Hot-Spots, Cellular/LTE Repeaters.

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KEYWORDS: Open Architecture, Antennae Controller, MANET, Directional Networking, Sectored Antennae, Software Defined Radios, FPGA, Legacy Waveforms

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A16-035 TITLE: Multi Product UHF L-band System Extension (MPULSE)

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: The objective of this topic is to develop innovative and efficient methods for broadening the interfacing capability for Position Location Information (PLI) systems to transceiver across multiple wireless systems to enhance PLI reliability.

DESCRIPTION: The survival of any military is to have reliable knowledge of the battlefield. Today the DoD depends on many systems to establish and update position information of our forces. PLI is critical to systems such as Blue Force Tracking (BFT) system and Production Rifleman Radio (PRR). Low powered emissions are the only media feasible for the antenna signaling structures that remain in the realm of practicality with lightweight tactical units. The current forces are limited to a select few service providers. By adding flexibility to the RF media interface to these systems, the market of service providers increases dramatically thereby reducing price and providing greater value along with more dependability. Developing adjustable, low powered, paired digital analog converters and analog digital converters as an interface to an all new completely architected field programmable gate array (FPGA) mounted on an evaluation FPGA board that allows for low noise, as well as low frequency heterodyne mixing will extend interface capability of service throughout the world. The ideal solution will be programmable and capable of working in the digital domain with frequencies as low as 290 MHz and as high as 3 GHz in. Additionally, the same interface solution will be capable of converting higher narrowband frequencies via low powered heterodyne mixing of C, X, and Ku. The lower end frequency capability will extend these systems the agility to utilize the Mobile UHF Objective System (MUOS), Iridium Satellite, Inmarsat 3 and 4, and Thurya constellations while heterodyne mixing will allow interfacing with other higher band satellites.

PHASE I: Explore and provide a prototype design that will produce the most effective number of bits (ENOB) possible using low powered 5 MHz wide, low frequency ADC/DAC combination. The design will come with a programmable heterodyne mixer on that can also mix down a 16 GHz signal to the same narrowband front end of a tunable 5 MHz wide at 290 MHz. The design shall have the ability to pass samples to the parent FPGA board for processing. The design shall be delivered in the level of detail of a computer aided design working with assumption that it will mate to a highly capable generic off the shelf FPGA evaluation board. The design shall include the strategies and methods applied to arrive at a stable transparent input/output.

PHASE II: Develop and deliver a prototype that consists of the interface developed with the generic FPGA allows the direct connection to a standard evaluation board (exact FPGA model board to be specified prior to time of phase II proposal), The ADC shall allow direct sampling at 3 GHz and below to 290 MHz along with conversion of frequencies from 4 GHz to 12.5 GHz. The FPGA board should use 16 to 20 nm technology affording the ability to appear digitally transparent as to where the source is coming in from. The symmetrical transmission would be complimentary with the FPGA board receiver being identical in digital timing at UHF when compared with the same output at Ku band to the antenna.

PHASE III DUAL USE APPLICATIONS: Research proposed in this topic can be used to improve the performance of these systems by additively summing two sources or outputting two transmissions in parallel for enhanced reliability. Dual output and summing two inputs will serve as a survivable Multiple In Multiple Out (MIMO) like technique for reliable PLI in a contested or nuclear event using robust waveform techniques. This application can be used commercially for any mobile application transitioning between layers and bands while traversing different media availabilities. Any similar position location reporting commercial applications will be able to make use of this

product including specifically Blue Force Tracking systems.

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KEYWORDS: Iridium, Mobile UHF Objective System (MUOS), Blue Force Tracking (BFT), Production Rifleman Radio (PRR), Position Location Information (PLI).

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A16-036 TITLE: Mission Command of Micro-Robot Swarms: How to select individual agent actions so as to evoke a specific emergent swarm behavior

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Design and build a system that is capable of decomposing complex operational goals into individual behaviors for members of a micro-robotic swarm, and allowing those individuals the ability to modify their behaviors to accomplish the overall goal in changing situations.

DESCRIPTION: The use of very small low powered micro-robots that may be deployed in swarms is becoming a real future possibility. Each individual robot can have very simple actions, but when the actions are integrated over a large swarm of individuals, group behaviors emerge. As an example, termites are able to build large nests with spires based on a non-obvious small number of individual behaviors. The overall swarm behavior is not centrally directed so the swarm is difficult to destroy because the loss of individuals does not impact the collective behavior. The challenge is how to select the individual behaviors so that the emergent behavior of the swarm has the desired effect. The focus of this SBIR will be to develop the technology that permits the selection of a small number of simple individual agent actions so that the resulting collective swarm action achieves a specific effect. The research will address how to express the selected overall swarm goal, how to partition the goal into simpler individual behaviors that do not require centralized control, and an examination of the potential minimum number of agents required to achieve the desired goal behavior. The solution to the problem should require a swarm of heterogeneous robots that do not require a centralized controller. Interesting solutions may not require the robots to directly

communicate between themselves but rather communicate via changes in their environment.

PHASE I: Research existing work in this area, perform an analysis of alternatives and document the strengths and weaknesses of the approaches. Select or specify an approach and design a system that is able to accept typical Army operational goals, decompose those goals into a small number of simple robot actions, and show how the actions are necessary and sufficient to achieve the goal when executed by a swarm of heterogeneous robot agents. The Phase I deliverable will be the analysis of alternatives and the system design.

PHASE II: Build and demonstrate the system designed in Phase I by using a robotic simulator that simulates the operation of the swarm in an appropriate simulated environment. The demonstration should show how goals are specified, decomposed into simpler individual actions, and how the actions achieve the goal objectives when executed by the swarm. The simulation should show that the loss of individuals does not impact the overall goal achievement. The Phase II deliverables will be the demonstration, the software to perform the demonstration and an analysis of the demonstration results.

PHASE III DUAL USE APPLICATIONS: Build and demonstrate the solution using real robots. This technology in the Army could be used to support reconnaissance, location mapping, target acquisition, communications relay, etc. A likely transition path would be as part of the Communications Electronics Research Development and Engineering Center's (CERDEC's) Mission Command for Autonomous Systems program, which could leverage this technology to demonstrate increased situational awareness for the commander, more robust robotic capabilities, and a decreased need for direct operation of robotic assets. Commercially applications are similar with indoor mapping and aerial photography becoming more ubiquitous.

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KEYWORDS: swarming, mission command, emergent behaviors, micro-robotics

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A16-037 TITLE: Predicting, Prognosticating, and Diagnosing via Heuristics and Learned Patterns

TECHNOLOGY AREA(S): Battlespace

OBJECTIVE: Develop and demonstrate a system that can predict the needs of the warfighter in real time based on such quantities as tempo of operations and weather conditions.

DESCRIPTION: A military commander who is able to know what will happen in the future has an advantage over an adversary who must react to events. Mission command’s inherent data centricity can be used to enormous

advantage to not only monitor current operations but also predict actions of the operation's resources, anticipating not only potential problems but also predicting demands on the resources and optimizing their performance. This SBIR will devise a general extensible method of monitoring key resource parameters or state variables (combat power, position, munition rounds, goal achievement, fluid levels, charge, operating parameters such as working pressures, etc.) and provide a software framework permitting the introduction of heuristic and pattern-based prediction modules which are able to generate alerts and alarms based on mission objectives and the resource parameters. The modules will be trainable based on experience gained in specific mission locations. As a concrete application, the SBIR will devise a methodology to predict energy needs for systems based on forecasts of weather and tempo of operation. Enable a heuristic system to learn energy requirements based on prior events and to refine predictions to continuously correct any error in prediction.

PHASE I: Develop a methodology by which critical quantities (e.g. fuel, ammunition, water, food, medical supplies, repair parts, etc.) may be continuously assessed, immediate needs assessed over a range of time periods (e.g. next hour, next day, next week, etc.) and multiple means to replenish may be put forward in order to sustain the combat mission. Factors such as tempo of operations, by which consumption of critical quantities scale directly, and weather and other forecasting, which may increase consumption of certain quantities while decreasing others. The methodology would require that the system continuously monitor itself, compare predicted values with actual values, and then adjust predictive functions in order to mitigate any errors in the predictive values and produce more accurate future predictions.

PHASE II: Produce a prototype system to implement the methodology developed in Phase I. Emphasis should be on power and energy production and use, although other quantities defined under the description for Phase I being quantified and predicted would be a most welcome addition.

PHASE III DUAL USE APPLICATIONS: A system developed under Phase II would be most useful not only in military but also in commercial systems. Such a system developed for use in power and energy production and use would find ready application to the technology known as Smart Grid, which seeks to optimize the production and usage of electrical power for a wide range of users. Other users would be suppliers of goods similar to those supplied to the military, such as food products, medical supplies and services, machine components, etc.

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KEYWORDS: heuristic, predictive, cognizant, tempo of operations, forecasting, power and energy

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A16-038 TITLE: Superimposing Computer-Generated Imagery within Mission Command Environments.

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: To improve execution of Mission Command by establishing approaches for Commanders and Staff to acquire more detailed information of their external environment, through composite view technologies combined with computer-generated sensory input, and a natural means of interacting with information.

DESCRIPTION: Perceived as an emerging technology of the future, Augmented Reality (AR) is making its way into Smartphones and Tablets, as next generation image capturing and Heads-Up Display (HUD) technologies mature. However, Commanders and Staff lack the ability to acquire more detailed visual information of their external environment. Providing Commanders with relevant information, captured by computer-generated sensory data and ingested by their Mission Command system, has the potential to enhance Situational Awareness (SA) and subsequently improve the performance of Army leaders in planning, preparing and executing operations. Innovations are sought in composite view technologies and computer-generated sensory input technologies to improve Soldier, Leader, and Team Performance in bandwidth restricted environments anywhere on the battlefield. This SBIR addresses current Army gaps identified in the 2015 Army Warfighting Challenges (AWFCs 9 and 19). The first one is (AWFC 9) Improve Soldier, Leader, and Team Performance –How to develop resilient Soldiers, adaptive leaders, and cohesive teams committed to the Army professional ethic that are capable of accomplishing the mission in environments of uncertainty and persistent danger. With regards to this AWFC, enhanced visualization, sensory input, and natural Human Computer Interaction (HCI) technologies could improve the experiential learning of Soldiers, leaders and teams. The second one (AWFC 19) addresses the need for improved Mission Command Execution –How to understand, visualize, describe, and direct operations consistent with the philosophy of mission command to seize the initiative over the enemy and accomplish the mission across the range of military operations. Situational awareness (SA) is a foundational component to understanding, visualizing, describing and directing operations. An advanced visualization mission command system has the potential to improve SA and subsequently improving the performance of Army leaders in planning, preparing and executing operations.

PHASE I: The contractor shall perform an analysis of visualization, imaging, and Human Computer Interaction (HCI) technologies in commercial and DoD development, while documenting their readiness for commercialization and integration with Army mission command and training systems. This portion of the effort will also include a projection of the technologies continued development and maturity over time. Using the initial research, the SBIR will perform an assessment of the relevance of the most promising visualization, imaging, and HCI technologies to Army mission command and training. The written product will correlate the most promising technologies to mission command and training functions and/or processes (e.g., operations process, individual training, collective training) to determine their relevance in providing superimposed sound, video, graphics or GPS data within Army Mission Command environments.

PHASE II: Contractor shall pursue advanced technology development by constructing a prototype of the most promising visualization, imaging, and HCI capabilities demonstrated in a relevant Mission Command environment at a Technology Readiness Level of 6 at the end of this Phase II. This prototype should account for current and projected mission command systems development and identify potential transition paths and programs of record (PoR) partners.

PHASE III DUAL USE APPLICATIONS: Key to a successful Phase III is the projection of potential technology injection with established and projected Program of Records (PoRs). Goal is to transition SBIR to Army PoRs by substantially testing prototype system in relevant, operational environments with soldiers to receive operational feedback as to system's ability to improve execution of Mission Command. CERDEC will assist contractors in gaining access to C4ISR operational experiment fields. Enhanced visualization, sensory input, and natural Human Computer Interaction (HCI) technologies developed must have applicability to increase soldiers Situational Awareness (SA) at Squad level, while navigating through unfamiliar environments. The commercial gaming market could also benefit from these advanced visualization and interactive concepts, as well as law enforcement to protect fellow police officers and the general public. The medical field, for example, could also use the technologies to

assist children with mental disorders.

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5. ARI Research Note 2014-04, Augmented Reality Mentor for Training Maintenance Procedures: Interim Assessment (2014

6. Naval Research Laboratory Washington, D.C. 20375-5320, Advancing Human Centered Augmented Reality Research (2004).

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KEYWORDS: Mission Command, Augmented Reality, Human Computer Interaction, Training

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A16-039 TITLE: Thin Film High-k Dielectric Semiconductor Materials Development for IRFPAs

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Research, investigate growth techniques and processing methods to develop a semiconductor high-k dielectric material that is optimized to provide high charge capacitive density per unit area for IRFPA imaging applications. The goal is to develop a semiconductor material that exhibits properties of high k dielectric constant over a wide operating temperature range, low leakage current, high breakdown voltage, and provide very low 1/f noise and RTS noise characteristics for Readout Integrated Circuit (ROIC) capacitor implementation. In addition, the material should also be of good producibility, good reliability, and compatible with the current readout fabrication technology.

DESCRIPTION: Many emerging Army applications demand larger format, smaller pixel size IRFPAs to achieve higher resolution and wider fields of view (FOV), without sacrificing existing performance, which has presented a tremendous problem for today's ROIC technology. The challenge is how to implement sufficient well capacity in small pixel pitch to meet sensitivity and intra-scene dynamic range requirements. Current ROICs are analog with integration capacitor taking up most of pixel area. The ROIC designs are fabricated using the commercially available 250nm or 180nm CMOS foundry process. Capacitors are implemented by laying poly over diffusion, poly over poly, metal over poly or metal over metal with thin layer of oxide grown between the two plates. To achieve higher charge capacitance density, the method of implementing MOS capacitor (using the thinner MOSFET gate oxides) is commonly used. Some foundry processes have processing options to stack MIM (Metal Insulator Metal) capacitors and/or tolerate higher voltage operations (translating into larger voltage swings) which allow for

increased charge density. These standard foundry processes typically yield charge capacitive density of 4fF/um2-6fF/um2. As we drive to smaller pixels, SiO2 can no longer meet the ROIC charge storage requirements. This topic seeks to advance the Army's current IR imaging technology through innovative investigation and development of a suitable high-k dielectric semiconductor material for high performance, high sensitivity cooled IRFPAs. The goal of this effort is achieve charge density >80fF/um2 or >20X of current SiO2 based technology. Particular interest will be given to materials and material growth techniques that are compatible with deposition methods on a silicon readout; however a separate capacitive layer coupled to a readout via 3 dimensional (3D) integration approach that shows high yield potential, reasonable cost to fabricate will be considered.

PHASE I: Research, investigate growth techniques and processing methods, to develop a semiconductor high-k dielectric material that is optimized to provide high charge capacitive density per unit area for IRFPA imaging applications through the use of modeling, analysis, empirical testing or fabrication. Innovative materials or material growth techniques that are compatible with deposition methods on a silicon readout are highly desirable. Thin film growth of proposed material along with characterization results would also be highly desirable in phase I effort. Establish working relationship with IR detector vendor to acquire detector arrays for possible phase II effort.

PHASE II: Using results of the investigation of phase I, fabricate devices, structures of the proposed materials. Test, and characterize the material's properties. To show compatibility with current readout technology, design, develop and fabricate a readout with the proposed material. Demonstrate the performance of the high-k dielectric ROIC by mating to IR detector array. Develop and fabricate electronics for an imaging demonstration of the technology.

PHASE III DUAL USE APPLICATIONS: Transition the material growth techniques and processes to a production capable technology. The commercialization of this technology includes night driving aid, search and rescue, security, border patrol, firefighting, and a host of other low cost infrared imaging applications.

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2. Groner, M.D., George, S.M., "High-k dielectric grown by atomic layer deposition: capacitor and gate application", Interlayer Dielectrics for Semiconductor Technologies, chapter 10, 2003.

3. DiMeo, Frank, "BST Capacitors for Cryogenic Focal Plane Arrays", SBIR contract #: DAAL01-97-C-0079, Final Report, June 30, 2000.

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KEYWORDS: Infrared Focal Plane Array, ROIC, sensors, high- k dielectric, charge storage

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A16-040 TITLE: Digital Readout Integrated Circuits With Efficient, Low Power On-chip Data Compression Development

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Design and develop a digital Readout Integrated Circuits (ROIC) technology with on-chip data compression that will enable very fast readout rates. In addition the digital ROIC will be low noise, low power, provide >16 bits of dynamic range in large format, small pixel pitch.

DESCRIPTION: Current digital ROIC technology uses Low Voltage Differential Signal (LVDS) circuits to drive the digital signals from the IRFPA to outside the dewar and into the warm space electronics. Current LVDS technology is limited to ~1Gb/s. Another common digital driver circuit approach is the Current Mode Logic (CML) which is capable of ~3Gb/s but at the expense of ~3X the power dissipation compared to LVDS. There is a continuing push for very large format, very high dynamic range, very fast frame rates digital Infrared Focal Plane Arrays (IRFPAs) by the DOD community. Some of the emerging applications requires IRFPA data rates greater than 100 Gb/s. For LVDS, this would translate to 100 pairs of copper wire dewar feedthrough leading into un-manageable power and thermal dissipation. The optical interconnect technology may be a potential solution but not a practical one at this time due to associated costs and maturity level. In general, data compression reduces data by removing data redundancy. This topic seeks to develop efficient on-chip non-glossy, data compression techniques that will reduce the data to a manageable rate to be handled by current LVDS and CML digital driver technology. Elegant, innovative 2D digital readout with on-chip data compression solutions that utilize standard silicon foundry processes are preferred; however, a 3D approach that shows high yield potential, reasonable cost to fabricate will be considered.

PHASE I: Develop concepts, determine technical feasibility, simulate, analyze and model data compression techniques and algorithms optimized for efficient, real time, low power on-chip readout circuit implementation. Establish working relationship with SLS detector vendor to acquire SLS detector arrays for possible phase II effort. Actual circuit implementation via test chips or hardware demonstration are highly desirable in Phase I.

PHASE II: Using results of Phase I, research, design, and develop a low power, digital ROIC architecture with on-chip data compression. Demonstrate by fabrication of a digital ROIC that has on-chip data compression with an equivalent data rate of ~100Gb/s uncompressed using standard LVDS or CML digital driver technology. Demonstrate the performance of the digital ROIC by mating to SLS detector array. Develop and fabricate electronics for an imaging demonstration of the technology.

PHASE III DUAL USE APPLICATIONS: Transition the digital ROIC technology with on-chip data compression to the military and commercial infrared imaging industry. The commercialization of this technology includes night driving aid, search and rescue, security, border patrol, firefighting, and a host of other high performance infrared imaging applications. Military applications include Hostile Fire Indicator (HFI), bullet tracking, Improved Degraded Visual Environment, real-time persistent surveillance and others.

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KEYWORDS: Digital ROIC, Digital IRFPA, On-chip data compression, Sensors

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A16-041 TITLE: Use of Augmented Reality in Experimentation with New Equipment Training for Electro-Optic Infrared (EOIR) Sensors

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Provide an enhanced, real-world experimentation and training capability to Soldiers that are learning to use new EOIR sensor modalities.

DESCRIPTION: Augmented reality (AR) provides a live direct or indirect view of a physical, real-world environment, supplemented by virtual characters, features, and effects to allow direct control and better utilization of the sensors. Embedded training provides necessary environmental and system feedback to train individuals, crews and units, and enhances operational readiness using the EOIR sensor system. We seek an experimentation capability that provides AR in the context of target acquisition experimentation, with the goal of increasing Soldier performance, cognition and familiarization with new sensor modalities. The technologies could include, but are not limited to, lightweight, flexible displays or optics that can be integrated into protective eyewear or helmet-mounted displays, mobile electronics, game-based systems, intelligent tutoring, enhanced character behaviors, and the efficient use of terrain databases and models for target acquisition experimentation.

PHASE I: The goal of Phase I is to research and develop the experimental design and methodology for augmenting target acquisition performance measurement and experimentation. The phase will result in a study and report of augmented reality capability, the role of psychophysics in experimentation, and an experiment design for use in a perception testing laboratory.

PHASE II: The goal of Phase II is to conduct a statistically relevant set of experiments using the design and methodology for augmenting target acquisition performance measurement and experimentation developed in Phase I. The experimentation difficulty will vary from a novice level to an expert level of target acquisition, with the appropriate noise and blur applied to the imagery. Metrics will be developed and collected for evaluation of Soldier target acquisition performance under varying conditions, with and without augmented reality. The experiments will result in a study and report of augmented reality capability, the role of psychophysics in experimentation, and a repeatable experiment design for use in a perception testing laboratory.

PHASE III DUAL USE APPLICATIONS: The goal of Phase III will be to refine the real-time, augmented and repeatable experiment capability for use in target acquisition with EOIR sensors developed in Phase 2. The key objectives will be a set of repeatable tests and human perception results for modeling and simulation of EOIR sensors. Specific military applications include recognition of combatants – vehicle (ROC-V) training and the application of that knowledge to the identification of targets in varying operational conditions. The research will provide measurements of target acquisition difficulty and potential increases in human performance using augmented reality to mimic military operations. Commercial applications include, but are not limited to, realistic representation of EOIR sensors and performance in video games, methodology for assessing and developing general education techniques, and a training approach for recognizing an array of objects in a scene.

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KEYWORDS: augmented reality, embedded training, perception testing, target acquisition

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A16-042 TITLE: Extended Short-Wavelength Infrared (SWIR) Focal Plane Arrays (FPA) for Hyperspectral Imaging

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop short-wavelength infrared focal plane arrays (SWIR FPA) for hyperspectral imaging at an extended cutoff wavelength of 2.5 µm and an operating temperature above 200 Kelvin using III-V semiconductor materials.

DESCRIPTION: Hyperspectral imaging at full SWIR spectral band (0.9 – 2.5 µm) has important military applications. When used as an imager, a SWIR camera can operate at night using light reflected off the subject in the scene, generating high resolution images with details such as shadows and surface roughness. Compared to thermal infrared imaging, SWIR images look more like visible images and thus scene interpretation is much easier. Even on moonless nights, natural background radiation from the sky, called nightglow, provides useful illumination for imaging. Additional advantages include imaging through glass windows, some types of camouflage, smokes, fires, and haze with less attenuation than visible light. Many objects of military interest, such as explosives and chemicals, disturbed earth, terrain, and vegetation, contain rich and unique spectral features in the SWIR band. A hyperspectral or multispectral imager can fully explore these spectral features in combination with those contained in an image, thus enhancing many critical military applications such as target cueing and identification, mine field detection, and chemical and biological hazard mapping. High performance SWIR focal plane arrays are a critical component inside a hyperspectral imager. Currently, they are mostly made of bulk indium gallium arsenide (InGaAs) semiconductor material, with a nominal cutoff wavelength of 1.7 µm. Efforts have been made to extend the cutoff wavelength to 2.5 µm by using a high Indium-to-Gallium ratio compound. However, this causes crystal lattice structure mismatch to the indium phosphide (InP) substrate, and therefore leads to detector performance degradation, e.g., orders of magnitude increase in dark current and deterioration in detector array uniformity. Published studies have shown that a III-V Antimony (Sb)-based superlattice can be an excellent infrared sensing material. High-performance mid-wavelength infrared (MWIR) and long-wavelength infrared (LWIR) superlattice detectors have been demonstrated [1-2]. Furthermore, researchers at several institutions have successfully validated that such superlattice materials can

be designed to have extended SWIR cutoff wavelength of 2.35 µm and be operated under thermal-electric cooling [3-4]. These early results show great promise of a III-V superlattice as an innovative and viable new material to overcome technical difficulties associated with the bulk InGaAs material, therefore achieving hyperspectral imaging at full SWIR band. The goal of this solicitation is to develop and demonstrate III-V semiconductor detectors and FPAs that are highly sensitive over the full SWIR band with a cutoff wavelength of 2.5 µm. The detector performance goal is the following: quantum efficiency larger than 90% with anti-reflection coating, dark current density less than 7×10-8 A/cm2 at an operating temperature 200K or higher, or within 10-times of Rule 07 if measured at other temperatures [5]. In order to leverage the investment by US commercial semiconductor foundries and to achieve detector lifecycle cost reduction, the preferred detector material is III-V semiconductor. The use of large-diameter GaSb substrate is encouraged but not required. Either bulk semiconductor or superlattice can be exploited in designing the detector architecture. However, consideration should be given to this material selection so that additional detector layers can be integrated to create a multi-band (such as SWIR and MWIR) architecture design in the future. Once the detector performance is demonstrated, it is highly desirable to fabricate FPAs and demonstrate the same dark current and quantum efficiency performance on the array level, using an existing in-house or commercially-available read-out integrated circuit (ROIC). The ROIC read noise should be sufficiently low that detector dark current performance can be demonstrated at temperatures controlled with a thermal-electric cooler or a cryogenic cooler with small size, weight, power, and cost. An FPA format 640x480 or larger, and pixel pitch of 15 µm or less is preferred. Pixel operability performance goal is greater than 99.9% in both dark current and quantum efficiency.

PHASE I: Design a detector as described above. Demonstrate the feasibility of achieving dark current and quantum efficiency performance of 10 times of Rule 07 and 85% respectively. Identify suitable ROICs and collaborators for Phase II FPA demonstration.

PHASE II: Fabricate and fully characterize a focal plane array using the detector design from Phase I. This may involve optimization of detector design, detector array processing and hybridization to a suitable ROIC, passivation, and FPA packaging with a thermal-electric or a cryogenic cooler. In-house or commercially available ROICs, either analog or digital, can be used. An FPA format of 640x480 or larger, and pixel pitch of 15 µm or less is desired.

PHASE III DUAL USE APPLICATIONS: The contractor shall pursue technology transition and commercialization of full-band SWIR hyperspectral imaging technologies developed under this solicitation, potentially having a number of important military, homeland security, agricultural, and industrial applications. These include, but are not limited to, chemical biological hazard detection, soil properties determination, vegetation identification and low moisture stress level monitoring, disturbed earth and terrain analysis, wide-area mapping of distinct mineral deposit concentrations and locations, food processing and sorting, material processing such as semiconductor and solar cell processing, pharmaceutical processing, material recycling such as plastics sorting, vehicle navigation, and machine vision. Particular Army transition paths include Airborne Cueing and Exploitation System Hyperspectral (ACES Hy), Enhanced Medium Altitude Reconnaissance and Surveillance System (EMARSS), and Airborne Reconnaissance Low-Enhanced (ARL-E).

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KEYWORDS: Hyperspectral Imager, HSI, Multispectral Imager, SWIR Detector and FPAs with Extended Cutoff Wavelength, III-V Semiconductor Materials, Superlatttice, SWIR/MW Dual-band FPAs, Passive Infrared

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A16-043 TITLE: Enterprise Enabled Intelligent Agents to Optimize Intelligence, Surveillance, and Reconnaissance (ISR) Collection

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: The scope of this SBIR is to investigate the deployment of Intelligent Agents across the ISR collection enterprise to optimize and perform efficient ISR collection with limited or reduced resources.

DESCRIPTION: Current implementations of ISR Collection Management tools rely heavily upon the cognitive processing of the Collection Manager to determine the best placement and coverage of the best available sensors. Automated optimization of sensor placement to optimize coverage is not a new technique; however advancements in the usage of lightweight analytic agents that can be distributed across the enterprise can enable this problem to be addressed in new and innovative ways. Utilization of distributed computing can process data from multiple sites across the enterprise that the Analyst or Collection Manager may not have had access to. In addition, automated processing of normalcy can help with the identification of anomalies in the data feed to prompt the user to modify their ISR Collection Plan to investigate further. Finally, these distributed agents need to communicate with each other across realistic operational networks and need to account for operations across Disconnected, Intermittent, and Limited/Latent network connections.

PHASE I: Develop a system design that identifies the types of sensors, the types of data, the communication mechanisms, and an approach to algorithms that can utilize distributed processing to optimize collection of data against known gaps and/or anomalous data for further investigation.

PHASE II: Develop and demonstrate a prototype approach with representative (live or simulated) sensors across multiple nodes in a realistic network environment. Testing should be performed to validate distributed operations of the algorithms for addressing sensor gaps and/or anomalous data.

PHASE III DUAL USE APPLICATIONS: This system could be utilized to improve military data collection across the enterprise to include tactical-level systems by automatically identifying areas that require further scrutiny by the analyst. Specifically a military program could use the agents to analyze the sensors and data feeds that are being processed and what geographic areas are currently covered, to produce a report to the Collection Manager to improve the current allocation of sensors and assets. This could be integrated with existing Collection Management systems. This system could also be utilized in commercial roles to monitor and identify gaps or anomalies in data collection, e.g. monitoring product delivery chain, identifying security systems (identify gaps or anomalies in coverage), etc.

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KEYWORDS: Agents, ISR, Intelligence, Surveillance, Reconnaissance, Sensor, Collection, Gaps, Anomalies, Distributed Computing, Coverage, Disconnected, Limited, Intermittent, DIL

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A16-044 TITLE: Simple Cognitive Based Visualization

TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: The objective of this SBIR is to increase cognitive performance through novel visualization techniques to reduce overall cognitive load leading to a natural ability to function more effectively.

DESCRIPTION: User Interfaces in today's military are traditionally built upon basic frameworks that allow for the integration of multiple data types into a common environment. This is typically implemented using a Geospatial View (Map) as the main view with additional tools and viewers available to provide additional information. This approach allows for easy integration but does not account for the information overload that occurs when too much data is presented all at once, or the disconnect when data is presented in multiple, unattached viewers. This SBIR looks to address these issues by developing novel techniques to visualize data in a manner that allows the user to adequately process and analyze the data presented without becoming overwhelmed or confused by requiring the usage of multiple tools. For instance, this can be accomplished through Data Aggregation, Geospatial Overlays, Gradient Heat Maps, Annotation to the current Symbology and Iconology, New and Unique Symbology and Iconology, Pop-Up Messages, etc. An example would be the visualization of Battle Damage Assessment on an enemy Icon by applying a "Health Bar", similar to what is used in Video Gaming, to represent current strength of the Opposing Force. Another example would be the mash-up of relational networks with geospatial information by overlaying the "Links" on top of the Geospatial Display (Map). By changing the current visualization paradigm, users should be able to perform their mission with greater efficiency, which will allow for better operational effectiveness.

PHASE I: Develop a system design that identifies new methodologies for visualization through innovative methods and/or technological solutions that can optimize the user's ability to process large amounts of data in more effective

manners.

PHASE II: Develop and demonstrate a prototype system that represents the new methods and/or technologies. Testing should be performed to effectiveness of the Human Machine Interface against current designs.

PHASE III DUAL USE APPLICATIONS: This system could be utilized to improve the soldier's ability to visualize process and act upon large amounts of data from numerous domains to include Intelligence, Mission Command and Logistics. Specifically an Intelligence System deals with dozens of data feeds handling many different types of data represented in multiple ways through multiple tools. Incorporating the efforts from the SBIR into the military system User Interface should improve the performance of the Soldier in executing his mission. Commercially, this system could be used improve the end user's ability to visualize any large amounts of data such as social media, supply chain, or logistics data.

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4. The eyes have it: A task by data type taxonomy for information visualizations - http://drum.lib.umd.edu/bitstream/1903/5784/1/TR_96-66.pdf

5. The Command Post of the Future Experience - https://s3.amazonaws.com/edas.assets/cogsima2013/KeynoteFouse.pdf

KEYWORDS: User Interface, UI, Human Machine Interface, HMI, Visualization, Display, Workstation, Analysis

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A16-045 TITLE: Portable Ultraviolet Raman Imaging Spectrometer for Explosives Detection

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: To develop an ultraviolet (UV) imaging Raman spectroscopic system with an excitation wavelength of 262 nm or shorter. The spectrometer should be capable of imaging an area >4 cm2 in less than 30 seconds at a standoff distance of 1 meter. The objective is to develop a portable system capable of examining explosive particulate on surfaces.

DESCRIPTION: Fielded explosives detection capabilities rely on direct contact with or entrapment of the solid sample or the associated chemical vapor above the contaminated surface with the sensor. Although these techniques can be used for remote or robotic detection, they do not provide the desired man-portable capability for standoff detection. An ideal detector is one that can precisely identify a combination of chemical, biological, and explosives threats at operationally significant standoff ranges, however at this point in time, there is no deployable or affordable solution. Raman spectroscopy is a particularly attractive detection technique because it is nondestructive, requires no sample preparation, and gives a high degree of chemical specificity. The use of ultraviolet (UV) excitation provides

improved sensitivity over visible or near IR excitation because of the larger cross-sections, along with possible enhancement of the signal intensity if the excitation wavelength is near that of an electronic transition (resonance or pre-resonance Raman). In addition, for excitation wavelengths shorter than 250 nm the fluorescence emission is separated spectrally from the Raman scattered light.1,2 UV Raman systems have been built to detect and identify bulk, and in some cases, trace level explosive contamination on surfaces at ranges of 10 to over 100 meters sensitivities decreasing with increasing range to the target.3,4 While showing promise for standoff explosives detection, these systems tend to be large and use high laser powers in a point scanning mode. Because the small laser spot needs to be scanned over the surface while integrating the Raman signal for a sufficient amount of time to produce a suitable signal to noise ratio (SNR), the time required to interrogate a large area quickly becomes problematic. Our previous work on Raman chemical imaging for trace detection of explosives residue on fingerprints has shown that Raman imaging may have speed and sensitivity advantages over the traditional point scanning technique for relatively short range standoff detection of explosives on surfaces.5,6 The goal of this effort is the design and construct a UV Raman imaging instrument for detection of trace explosive residue at ranges of at least 1 meter. Excitation Wavelength 262 nm or shorter Imaging Area > 4 cm2 Spectral Resolution An average of 12 - 20 cm-1 between 300 – 2200 cm-1 Spatial Resolution Be capable of detecting explosives residue at an areal density of 1 µg/cm2 and particles between 5 – 10 µm in size. Standoff Distance = 1 m Size < 6000 in3 [Threshold]; < 600 in3 [Objective] Data Collection Time < 30 s

PHASE I: Phase I will demonstrate the technical feasibility of the approach and develop a plan for the construction of the portable UV Raman Imager. This effort should include sufficient modeling and experimental data to show feasibility to achieve the characteristics outlined in Table 1 prior to the start of Phase II.

PHASE II: Construct and deliver a portable UV Raman imaging spectrometer meeting the specifications outlined in Table 1.

PHASE III DUAL USE APPLICATIONS: In addition to use for the Department of Defense (DoD) explosive detection, the system has commercialization activity for Chemical or Biological detection and civilian uses for first responders and law enforcement. DoD uses could include sensitive site exploitation, explosives detection and treaty verification. The successful development of a UV Raman imaging system would meet the requirements of the Survey Detector element of the Next Generation Chemical Detector (NGCD) program. Civilian uses could include identification of illicit drugs, inspection of food and/or hazardous waste containers.

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KEYWORDS: Raman, Imaging, Explosives, Detection

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A16-046 TITLE: High Conductivity Carbon Microfibers for Infrared Obscuration

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: To develop a means to increase the electrical conductivity of carbon microfibers. Fiber diameters should be as small as possible within the constraint of fiber linearity. This may prove to be in the vicinity of 50 nm or might involve smaller nanostructures. There are three essential requirements for the fiber produced. The length requirement is vital to the electromagnetic properties; the distribution must be relatively narrow with a length of about 3 µm in order to produce a strong resonance within the FIR atmospheric transmission window (8 to 12 µm). Further, there must not be debris of smaller sizes resulting from any of the processes involved. Even small mass percentages of the latter will destroy the infrared optical efficiency. And, finally, the resulting fibers must be easily separable.

DESCRIPTION: Smoke and obscurants play a crucial role in protecting the Warfighter by decreasing the electromagnetic energy available for the functioning of sensors, seekers, trackers, optical enhancement devices and the human eye. Recent advances in materials science now enable the production of precisely engineered obscurants with nanometer level control over particle size and shape. Numerical modeling and many measured results on metal nanofibers affirm that more than order of magnitude increases over current performance levels are possible if high aspect-ratio conductive particles can be effectively disseminated as an unagglomerated aerosol cloud. In spite of numerous publications, no one has yet demonstrated the IR optical attenuation efficiencies that would result from high conductivity coatings that are continuous along any low or nonconductive nanofiber base having an appropriate narrow length distribution. A major issue with fiber samples investigated to date is the quantity of “fines” contained in a sample. Anything that is not a fiber of the correct length contributes to electromagnetic attenuation in another portion of the spectrum and therefore only reduces the performance. As an alternative to conductive coatings on carbon microfibers, the possibility exists for other means to achieve high conductivity, such as intercalation or heat treating

PHASE I: Demonstrate with samples an ability to produce carbon microfibers with ~50 nm diameter, 3 +/- 1 micron length and conductivity of iron or better (105 mho/cm). Sample should have less than 10% fines by weight, and fibers must be separable. Provide 5 1-gm samples to ECBC for evaluation.

PHASE II: Demonstrate that process is scalable by providing 5 1-kg samples with no loss in performance from that achieved with small samples. In Phase II, a design of a manufacturing process to commercialize the concept should be developed.

PHASE III DUAL USE APPLICATIONS: The techniques developed in this program can be integrated into current and future military obscurant applications. Improved grenades and other munitions are needed to reduce the current logistics burden of countermeasures to protect the soldier and his equipment. This technology could have application in other DoD interest areas including high explosives, fuel/air explosives and decontamination. Improved separation techniques can be beneficial for all powdered materials in the metallurgy, ceramic, pharmaceutical and fuel

industries. Industrial applications could include electronics, fuel cells/batteries, furnaces and others

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KEYWORDS: Carbon microfibers, narrow length distribution, intercalation, heat treating, infrared obscuration

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A16-047 TITLE: Leveraging Networked Mobile Devices to Improve Terrain Analysis and Intelligence Preparation of the Battlefield

TECHNOLOGY AREA(S): Battlespace

OBJECTIVE: Develop a scalable, mobile-based technology that enables Army mobile devices (or similar commercially available mobile devices) to operate as deployable environmental sensors, supporting improved terrain analysis, Intelligence Preparation of the Battlefield, and Commander's Situational Awareness.

DESCRIPTION: Accurate terrain assessments supporting mounted and dismounted movement/maneuver, soldier performance, and sensor reliability are enhanced with greater knowledge of terrain conditions across the area of operations. Characterizing environmental conditions for terrain analysis has traditionally been accomplished using Air Force Weather forecasts, which allow analyst to assess terrain conditions based on a 5 km grid and very few point observations across the battlespace. As the Army moves forward with Nett Warrior, mobile and wearable technology offer potential to enable the Soldier to serve as sensor, adding significant opportunities to increase the amount of mineable geospatial information used in terrain analysis while simultaneously providing the commander increased situational understanding of mission specific environmental intelligence for mission critical planning and decision making. Emerging technology has the potential to enable existing Army appliances (e.g. Nett Warrior's Android) as a dual use capability operating as mobile computing platforms and as environmental sensor, providing in situ sensing across the battlefield without any hardware changes or additions. This enormous increase of point source knowledge of the battlespace coupled with significant improvements in terrain modeling capabilities can provide greater fidelity assessments of environmental impacts to mission risk. Soldiers at the lower echelons including combat outposts or forward operating bases do not possess the necessary hardware or time to take the broad array of observations necessary to generate accurate, high resolution terrain analysis products. Currently, weather and climate services at forward locations are difficult to obtain due to limited network connectivity up to brigades, leaving Commanders to make decisions based on limited geospatial information of the operating environment. The ability to "crowd source" the operating environment, using services on handheld (of chest mounted) devices fed back to the forward base and evaluated in an Army Geospatial Enterprise system, supporting a

broad array of Army terrain analysis applications, provides a significant promise for increasing the amount of terrain data supporting Commanders' situational understanding. A number of decisions are directly influenced by the environmental conditions of the operating environment, including sensor placement (force protection), movement/maneuver, human performance criteria in extreme conditions, line of sight operations, to intelligence activities. Accurate terrain analysis supporting the commanders' situational awareness and intelligence preparation of the battlefield directly supports likelihood of mission success. A characteristic of all battlefield decisions is that they are decisions under uncertainty, with environmental considerations significantly contributing to operational uncertainty. Sparse data is a contributor to this critical uncertainty. Each Soldier will soon be outfit with a commercial mobile device to interact with the Army's Nett Warrior System. Technology enabling the Nett Warrior device to serve as sensor, enabling the soldier to 'be the sensor' would allow for a significant increase in sensing of environmental variables (air temperature, air pressure, precipitation, wind, snow depth and/or ice thickness), enabling quicker identification of environmental risks. Combining the information from each soldier together in a geospatial environment would enable the commander to have increased awareness of the operational environment. Integrating this capability with other wearable technology could also provide the commander with situational understanding of soldier stress due to environmental conditions.

PHASE I: Develop ability to sense environmental variables using Army Nett Warrior computing devices or similar mobile technology without increasing soldier load with additional environmental sensors. Develop technology to gather observations from multiple devices in remote locations ('crowd source' using soldier carried mobile computing devices or smart phones) into a geospatial system. Within the geospatial system, show the potential for using collected information to better describe the operating environment in terms of reference similar to existing Army terrain analysis products.

PHASE II: Develop and demonstrate system implementing technology developments achieved in Phase I, targeting implementation of sensing capability on Army Nett Warrior devices (or similar Army program mobile technology). Conduct field tests to evaluate and validate environmental measurements collected at central geospatial repository. Demonstrate system collecting crowd-sourced data, using data to populate a Open Geospatial Consortium-compliant geospatial system, and demonstrate the ability to generate improved Army terrain analysis products.

PHASE III DUAL USE APPLICATIONS: The contractor shall integrate the Phase II approach into one or more systems/software applications for eventual fielding. Deliver final developed system, including prototype and all software technology to Army for immediate use with current Army research-level forecast models. Commercial applications include use in municipalities for state and city emergency planners for weather risk mitigation and for assessing school districts determining closures due to inclement weather conditions.

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3. http://www.agc.army.mil/Media/FactSheets/FactSheetArticleView/tabid/11913/Article/480894/army-geospatial-enterprise-architecture.aspx

4. Army terrain analysis applications http://www.agc.army.mil/Missions/Terrain.aspx

KEYWORDS: Crowd source, Commander's situational awareness, mobile technology, environmental characterization, terrain analysis, geospatial, Weather, uncertainty, decision making, intelligence preparation of the battlefield, decision tool, feedback, high resolution

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A16-048 TITLE: Heuristic-based Prognostic and Diagnostic Method for Installations

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Establish an innovative approach for and demonstrate methodology and modeling tools to provide prognostics and diagnostics for installation based microgrid equipment.

DESCRIPTION: Through the Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) Joint Capabilities Technology Demonstration (JCTD), the Department of Defense (DOD) has repeatedly found that legacy infrastructure naturally degrades over time and often fails to perform as originally designed. The traditional approach of performing prognostics and diagnostics for mechanical plants and electrical systems has been to create a physics-based model based on first principles and known equipment characteristics. Such models are often created at the component level so that details of individual component performance can be captured. Physics-based component models can incorporate reliability from the material level up through components, sub-assemblies, and throughout the entire system. This type of approach has been very successful in the airline industry. The second method, which is in many ways a derivative of the first, is to create a model from observed values and performance. Once a model is developed, regardless of basis, actual performance can be compared to the predicted performance with some level of diagnostics being reported if there are differences between the two. Both of these methods are capable of capturing failures that are caused by fatigue, thermal stress, corrosion, erosion and other forms of degradation. They can also address issues of uncertainty or variability in manufacturing, materials, maintenance history and usage history. Unfortunately, the development of physics-based models to capture generator and electrical equipment performance is cost prohibitive and does not address the existing inventory of installation equipment. Additionally, unlike the airline industry, the acquisition cost for generators and power distribution equipment is relatively low, making it cost prohibitive to develop physics-based models for generators and power distribution equipment. Also, the diverse number equipment vendors are unlikely to invest into prognostics and diagnostics as it would raise the cost of their equipment, which is normally acquired based on low bid. Other industries, such as buildings, are faced with diversification that is found with generators and power distribution. Very few buildings have a common footprint and those that do almost never have similar mechanical plants or occupancy profiles. Even with such diversification, the building industry incorporates use of quantitative, reliable and accurate methods of diagnosing the performance of buildings. These techniques often provide a high rate of return on investments. Return on investment for buildings can be quantified in more than energy efficiency, but also in terms of reliability and human comfort. The goal of this SBIR is to develop innovative methods and modeling tools for predicting generator and power distribution performance and to provide a first order diagnostics and prognostics methodology. The diagnostics methodology may incorporate machine learning techniques and non-classical approaches. Creative diagnostics methodologies that consider a “top-down” approach are encouraged. The method should be able to identify long-term generator and power distribution performance degradation. The desired solution is an app that can reside on a commercially available controller and perform prognostics and diagnostics.

PHASE I: Design a concept for the required computational tools to accurately determine the reliability of generators. In addition, the phase one effort shall define and determine the feasibility of developing a methodology used to implement the identified tools to work in harmony with control systems, and consider the scalability of this methodology.

PHASE II: Develop, demonstrate and validate an app that can reside on a commercially available controller, and integrate the tools identified in Phase I to predict the reliability of a generator or sub-system. Demonstrate the completed methodology and tools for predicting reliability on examples ranging from components thru entire generator systems. In addition, validate that the methodology and tools can predict different failure modes for a wide range of generator fleets and power distribution equipment.

PHASE III DUAL USE APPLICATIONS: Implement the prognostics and diagnostics tool on military installations and commercial applications.

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KEYWORDS: reliability, scalability, prognostics, diagnostics, fault detection

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A16-049 TITLE: Conservation and Maintenance of Trauma Injured Tissues for Autologous Repair and Reconstruction

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Tissue salvage and maintenance using perfusion or equivalent approach to retain function

DESCRIPTION: A capability is sought to permit perfusion-based or equivalent salvage and maintenance of trauma-injured tissues with particular emphasis on limbs, hands, digits and composite facial tissues in order to enable delayed autologous orthotopic or non-orthotopic repair. The ability to salvage complex biological tissues in this manner will enable a wide range of medical interventions to treat trauma and restore function using both autologous and allogeneic tissues. Military as well as civilian trauma cases routinely demonstrate medicine's current limitations in healing critical damage such as traumatic limb damage, amputations, and composite facial injury. The results of those injuries are life-long disabilities with tremendous loss in quality of life, large patient care costs, high rates of chronic pain, physical inactivity, negative psychological impact, cardiovascular abnormalities [1] and in the case of craniofacial damage sometimes also a significantly increased incidence of complications leading to death. The number of service members impacted is large. For instance, approximately 1600 wounded service members have sustained amputations from the wars in Iraq and Afghanistan so far; close to 500 of those suffered amputations of more than one limb. Four thousand service members sustained facial injuries. And the number of civilians who suffer similar injuries is even larger. For instance, two million people are living with limb loss in the US [2]; 185,000 undergo amputations each year. Almost half of those amputations are due to trauma. At the same time, enormous progress has been made in vascularized composite (VC) tissue transplantation over the last 5-10 years, to a large extent due to DoD's Hand and Face Transplant Program (the largest in the world). These new capabilities provide a foundation to help repair the most complex injuries and address many of the needs discussed above. However, reconstructive surgical outcomes following acute trauma are severely limited by tissue ischemia following traumatic amputation or devascularization. Unfortunately, VC tissues can currently be conserved for only a few hours, typically degrading even faster than vital organs, and tissues that cannot be salvaged and maintained long enough are frequently discarded, regardless of tissue quality and viability. Outcomes could be greatly improved if viable tissues (non-ischemic as well as ischemic) could be salvaged and conserved long enough to reach advanced surgical facilities for repair and replantation. Enormous progress has been made in perfusion based conservation technologies [3] of vital organs such as the heart and lung. Companies have begun to form (e.g. TransMedics, XVIVO Perfusion AB, Perfusix USA Inc, XOR Laboratories Toronto, Vivoline Medical AB, Organ Recovery Systems) and clinical trials are showing first promising results (e.g. PROCEED II FDA pivotal trial; The European

Machine Preservation Trial (MPT)). Participating institutions are for example Brigham and Women's Hospital, Boston, UCLA Medical Center, Los Angeles, CA, The Cedars-Sinai Heart Institute, Los Angeles, CA, Columbia University Medical Center, New York, NY. And while to date little focus has been put on applying these technologies to vascularized composite tissues, proof of principle does exist in a swine forelimb amputation/replantation study that suggests immense potential to preserve limb allografts using ex vivo circulation [4].

Such perfusion based conservation methods can enable:
-Maintenance of physiological pressure and flow parameters
-Tissue protection by down-regulation of cellular metabolism, thus reducing oxidative stress and apoptosis and alleviation of hypothermic endothelial injury
-Reinitialization of metabolic activity, replenishment of ATP, mechanical priming of the vasculature for reperfusion and provision of oxygen and nutrition (e.g. glucose, pyruvate) to the tissue
-Avoiding depletion of cellular energy and accumulation of waste products
-Real-time evaluation of metabolic, vascular and other parameters (e.g. tissue ATP levels) to predict tissue quality and function, optimal planning and timing of transplantation and precise calculation of risk of primary organ failure Immunomodulation [5]
-Therapeutic interventions such as tissue repair using e.g. trophic factors, gene therapy, nanoparticles and/or mesenchymal stem cells
-A crucial enabler of long term VCA banking approaches by enabling pre- and postconditioning strategies -Increase of the number of VCA tissues that can be successfully harvested from the donor pool -Better national and importantly international
-VCA matching, which would improve graft-host-compatibility, decrease acute and chronic rejection and decrease the intensity of immunosuppressive medication regimens
-Culture and maintenance of bioartificial composite tissue grafts for ‘on-demand’ transplantation

Approaches that center directly on activating stress pathways and/or trigger metabolic depression or hibernation are also of interest. Such approaches have in previous studies produced significantly longer survival times for organ preservation. Methods that apply pressure (e.g. hyperbaric or isochoric) for tissue maintenance are also promising. Previous studies have shown the potential benefit of using isochoric preservation methods to preserve tissue by suppressing ice nucleation at sub-zero temperatures. Among the capabilities sought, the following are of particular interest:
-Salvage and maintenance of vascularized composite tissue (e.g. limbs and facial tissue) in order to be able to fully restore function following combat trauma (such as avoiding or reversing traumatic limb amputations) of military service members.
-As is currently possible with short-term solid organ perfusion-based preservation, conditioning and repair during perfusion can significantly increase reconditioning and salvage of marginal organs from deceased donors. Of interest are approaches that apply this concept to vascularized composite tissues that are on the edge of their ischemia time when perfusion-based preservation begins, thus permitting VCA tissue health evaluation, reconditioning, and repair before replantation.
-In cases where autologous use of tissues is not possible (such as the delayed death of the patient), the salvaged tissues, if not already replanted, and depending on the tissue donor status of the deceased patient, would be available for allograft to treat other injured patients. In these cases, preservation of tissues would enable better immunological matching of VCA tissues. From a medical and commercialization perspective it is likely that capabilities developed under this effort will not only be applicable to VC tissues, but also can be applied to capabilities for salvage, conservation, maintenance and repair of vital organs.

PHASE I: Demonstrate a normo-thermic (38-36oC), sub-normo-thermic (36-21oC) or hypothermic (below 21oC) perfusion-based, isochoric, or related tissue salvage approach in a suitable model of vascularized composite tissue (ideally containing skin, muscle, fat, vessels and nerve). Post-perfusion / isochoric salvage replantation demonstration is desirable but is not required during phase I. During this phase the demonstration of the feasibility of the perfusion method to extend the viability of a composite tissue can include ex vivo assays. Approaches that enable or set the stage for conditioning, treatment and/or repair of VCA tissues are encouraged as are approaches that enable real-time read of metabolic, vascular or other parameters to predict tissue viability and quality. The proposal must include a description of preliminary plans for commercialization.

PHASE II: Demonstrate the utility of the approach from Phase I in a biological setting using an animal model or potentially human vascularized composite tissue system. This phase requires the performer to conduct detailed

characterization of the approach in a suitable biological model and to demonstrate the ability to regain biological function post-perfusion. The model selected should clearly demonstrate the ability to place the tissues under extended perfusion / preservation for at least 24 hours and to return the perfused tissue to a functional biological state post-perfusion. Demonstration of functionality following replantation or transplantation should be appropriate to the model selected but should include metabolic, vascular, and neuromuscular parameters, as appropriate and should not depend on external perfusion or assistance. Proposers are encouraged to incorporate conditioning, revival, and/or repair strategies. The proposal must include a description of a mature commercialization plan

PHASE III DUAL USE APPLICATIONS: Extended perfusion of complex biological tissue is a highly limiting capability gap in replantation and transplantation of vascularized composite tissues. A large potential market exists for salvage and maintenance technologies that can extend viability of tissues ex vivo for 24-48 hours. Progress in developing methods for vascularized composite tissue preservation will also likely transform current tissue banking and organ preservation industries tapping into significant market value. The proposal must include a description of plans for the commercialization of the underlying technology. It must describe one or more specific Phase III military applications and/or supported S&T or acquisition programs as well as the most likely path for transition of the SBIR from research to operational capability. For example, the proposal might relate the use of the preservation solution, protocols or equipment to the potential use in the treatment of particular diseases or conditions of military interest. Additionally, the Phase III section must include (a) one or more potential commercial applications OR (b) one or more commercial technologies that could be potentially inserted into defense systems as a result of this particular SBIR project. It is envisioned that the performer or a suitable partner will pursue development of the approach to permit the preservation of successively larger tissues. This award mechanism will bridge the gap between laboratory-scale innovation and entry into a recognized Food and Drug Administration (FDA) regulatory pathway leading to commercialization.

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KEYWORDS: Trauma, preservation, repair, regenerative, tissue, combat, casualty, treatment

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A16-050 TITLE: On-Demand Cell and Tissue Biologics for Mass Casualty Response

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: A capability is sought to ensure off-the-shelf, large volumes of stockpiled cell and tissue biologics that would be in high demand following a mass casualty event in military theaters of operation, in humanitarian response operations, or events on the homeland.

DESCRIPTION: Mass casualty events place enormous logistical strain on medical infrastructure, overwhelming personnel and rapidly depleting available medical supplies. This necessitates the stockpiling of medical supplies and therapeutics for on-demand use in the event of a healthcare surge. Tissue transplantation and regenerative medicine hold tremendous potential to treat injuries common in mass casualty events, but limited capabilities for storage and transportation of many biological materials severely constrains their application to this area of public health need. On and off the battlefield, mass casualty events involving radiation exposure, chemical or biological agents, and explosive or incendiary devices can create a diverse range of injuries requiring both urgent and continuing care. Events involving explosive devices, incendiary devices, and exposure to radioactive materials frequently result in thermal burns [1][2], while blistering agents such as sulfur mustard can cause severe chemical burns requiring treatment by skin grafting. Exposure to radiation levels far exceeding 2 Gray (Gy) resulting from detonation of a nuclear device or exposure to radioactive materials in the environment typically causes Acute Radiation Syndrome, the severity of which depends on the dose of radiation. Exposure to doses as low as 2 Gy causes moderate to severe bone marrow damage and is life-threatening, while exposure to higher doses can result in neutropenia, thrombocytopenia, severe gastrointestinal damage, hematopoietic syndrome, multi-organ failure, and other symptoms, necessitating a range of treatments including cytokine therapy, blood transfusion, stem cell therapy, bone marrow transplant, and prophylactic antibiotics [2]. Explosive blasts commonly cause injury to major blood vessels in the extremities, requiring ligation, reconstruction, or grafting of a replacement vessel. Many injuries common in mass casualty events are amenable to tissue transplant and regenerative medicine treatments. A range of conditions caused by Acute Radiation Syndrome including hematopoietic syndrome, cytopenia, and direct damage to bone marrow [2] necessitate hematopoietic stem cell transfusion or bone marrow transplantation [3]. Severe thermal burns and chemical burns can be treated by skin grafting. Severe burns over more than 20% total body surface area preclude the use of skin autograft, as the need for transplant skin is greater than can be supplied by the unaffected area, but cadaveric skin can be used either as a temporary antimicrobial wound dressing or (under narrow circumstances) as a permanent transplant. And arterial damage caused by blast injuries, particularly to the extremities, often requires treatment involving grafting of a new blood vessel. Although some disagreement exists over the preference for blood vessel auto- or allografts, in many trauma cases a venous autograft is not feasible, necessitating the use of a blood vessel from a cadaveric donor. The tissues required for these treatments are subject to significant storage constraints that are exacerbated during mass casualty events. Cadaveric skin that is cryopreserved using glycerol or dimethyl sulfoxide can currently be used as a temporary wound dressing with many clinical benefits, but the loss of cell viability resulting from current cryopreservation methods prevents its use as a current skin transplant. Refrigerated cadaveric skin can be used for permanent transplantation but it expires within weeks precluding disease testing and preventing its banking for mass casualty events. Bioengineered skin substitutes can be used for permanent grafting, but the same post-thaw viability limitations prevent their stockpiling for use as a medical countermeasure during a mass casualty event. Allogeneic bone marrow transplantation and hematopoietic stem cell transfusion are achievable after long-term storage, creating the potential for stockpiling of these biologics for use during healthcare surges. Current methods relying on cryopreservation in dimethyl sulfoxide are associated with a large range of adverse events in patients that receive these treatments including hypotension, dyspnea, cardiac arrhythmia, and in some cases cardiac or respiratory arrest, transient blood vessel occlusion, neurotoxicity, and renal failure, with increased susceptibility in children. Post-thaw washout of dimethyl sulfoxide can reduce toxicity but causes significant cell loss and cell damage, reducing clinical efficacy. Thus non-toxic cryoprotectant solutions are needed that can enable safe and simple post-thaw protocols for bone marrow and stem cell treatments. Moreover, new methods allowing for storage at higher temperatures (-80C or above) would enable rapid, cost-effective deployment from stockpiles to sites of mass casualty events. Current storage capabilities limit the efficacy of blood vessel banking. Cryopreservation, the only solution currently available for long-term storage, results in loss of endothelial viability, contributing to graft failure, thrombosis, and aneurysmal degeneration [4]. Traditional freezing and thawing methods lead to fracturing of the vessel wall, limiting treatment efficacy. Some studies have reported impaired blood vessel functionality after cryopreservation, including smooth muscle contractility and collagen synthesis. Alternatives to traditional slow-freezing methods such as vitrification have shown potential to improve both the efficacy and the cost-effectiveness of banking transplantable vascular tissues [5]. Improvements over the current state of the art can lead to effective stockpiling of cadaveric blood vessels for mass trauma injury, as well as a large number of other clinical applications. Capabilities for effective stockpiling of skin, blood vessels, bone marrow and marrow-derived stem cells will enable rapid and flexible responses to mass casualty events, with many other high-value military and civilian applications. This topic seeks the development novel methods to bank biologics for use in mass casualty events. Preservation methods for indefinite storage of transplantable tissues or tissue substitutes for treatment of trauma, burns, and radiation injury are encouraged, although other proposals for mass casualty applications will be considered as well.

PHASE I: The performer will develop the capability to successfully store harvested or engineered tissues that are typically in high demand following a mass casualty event for extended periods, with demonstration of efficacy as medical countermeasure following in-vivo use. Examples include the development of methods to allow for the long-term storage of full thickness skin or blood vessels or less/non-toxic ways to stockpile bone marrow. Proof of principle in vitro demonstration of post-preservation cell/tissue survival and tissue-specific functionality is required. Demonstration of short preservation times are acceptable if indicative of the potential success under longer preservation durations. Preservation approaches minimizing potential for toxicity to cell/tissue recipients are required. Evaluation and testing on tissue derived from commercially available animal or human tissue donor or on commercial tissue-based engineered products should use sources that do not require new or separate review by an institutional review board due to time constrains during Phase I. In addition, preliminary evaluation and testing of non-traditional tissue harvesting methods (e.g. harvesting bone marrow from living and potentially even recently deceased donors) are encouraged using only model systems that do not require review by animal use or human protection offices. Also required in Phase I is a description of the Food and Drug Administration (FDA) regulatory requirements for the proposed approach along with a regulatory development strategy. The focus of this phase is on developing preservative formulations or protocols that are suitable for use in Phase II.

PHASE II: The performer will demonstrate in an animal model the effectiveness of the storage formulations or protocols from in Phase I. The approaches developed should clearly demonstrate the ability to store the tissues under preservation conditions of biological inactivity and to return the preserved cells/tissue to a functional state post-preservation, for instance by successfully storing viable full thickness skin, large blood vessels and large volumes of bone marrow. The method developed should show no or minimal toxicity to cell/tissue recipients. Approaches conceived for field use under triage situations are encouraged but not required. Demonstration of functionality and/or therapeutic efficacy (in cases of tissue engineering constructs) post-preservation and following transplantation/treatment should be appropriate to the tissue and to the animal model selected.

PHASE III DUAL USE APPLICATIONS: Long term functional storage of complex biological tissue is a limiting capability for stockpiling of tissue biologics in case of mass casualty events in military theaters of operation, in humanitarian response operations, or events in the homeland. Beyond this, a large potential market exists for preservation technologies that can extend the storage of functional tissues and cells ex vivo for months and years. Progress in developing methods for long term preservation able to provide a long shelf life to engineered and natural complex cell/tissue therapies can transform current wound healing, regenerative medicine and cell therapy industries. The proposal must include a description of plans for the commercialization of the underlying technology. It is envisioned that the performer or a suitable partner will pursue development of the approach to permit the long term stockpiling and shelf-life. This award mechanism will bridge the gap between laboratory-scale innovation and entry into a recognized FDA regulatory pathway leading to commercialization.

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KEYWORDS: Disaster, response, mass, casualty, biologics, preparedness, tissue, engineering

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A16-051 TITLE: Particulate delivery system for next-generation malaria vaccine

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Develop next generation particulate, virus-like particle (VLP) vaccine delivery systems to display antigenic and molecular immunomodulating elements that are capable of inducing long-lived sterile protection against malaria challenge.

DESCRIPTION: Development of efficacious vaccines against malaria has been slowed by - 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). In spite of these hurdles, an efficacious vaccine remains the most cost-effective means for the prevention of morbidity, mortality, and for the reduction of malaria transmission. Immunity can be modulated by incorporation of adjuvants, optimization of delivery systems and fine-tuning of vaccine particulates (3,4). Notably successes with the malaria vaccine, Plasmodium falciparum circumsporozoite surface protein (CSP) fusion - hepatitis B surface antigen protein vaccine (5), (RTS, S formulation); have demonstrated that efficacy of immune responses can be achieved through the use of viral-like particle (VLP)-linked immunogens. The protective responses to the pre-erythrocytic stage CSP antigen in homologous challenge studies in U.S. subjects represents an important first step toward the development of broadly, cross-reactive long-lived immune responses. Thus it is possible that superior vaccine formulations can be generated by empirically testing other VLP antigenic structural displays in conjunction with biological adjuvants. Furthermore, abrogating the blood-stages of malarial infection remains an important goal by limiting the extent of the disease in affected individuals. Therefore inclusion of other key malarial antigens in conjunction with CSP – may lead to sustained immunity and / or minimize morbidity in partially protected individuals from a single antigen target such as the CSP. Current approaches have focused on recombinant subunit proteins; DNA vectored and attenuated whole organism vaccine approaches. The goal of this solicitation is to evaluate the potential of recombinant particulate (self-assembling nanoparticles, capsid surface particles, bacteria membrane-coated nanoparticles, outer-membrane vesicles, VLPs, etc.) delivery systems capable of displaying malarial antigens while retaining their capacity to form self-assembling structures. For example, capsid proteins from several genera of virus are known to assemble into VLPs when expressed as recombinant proteins, including those from adenovirus, papillomavirus, and norovirus (6,7). Some of these recombinant VLPs induce immunity against the vector itself, which can carry both, advantages and disadvantages. To date, effective expression of VLPs 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 inclusion of different antigenic 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. The vector alone should not be immunodominant in order to allow repeated immunizations. The selected contractor should have extensive experience in the construction and expression of recombinant proteins, particularly derived from baculovirus and yeast systems, 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 required in vaccine development – these include the adherence to GMP guidelines, the historical requirements for FDA approval of materials for use in human vaccinees and the economic feasibility of production.

PHASE I: Demonstrate the capability to produce properly assembled VLPs that display specific malarial antigens and secondarily, can display heterologous adjuvant moiety on their surfaces. Preferably, the malarial antigen is a pre-erythrocytic stage antigen and expression can be demonstrated by using transfection of eukaryotic cells and probing for structures using western blotting and antigen specific monoclonal antibodies. Produce sufficient quantity and quality of Good Laboratory Practice (GLP) pilot scale particles (suitable for injection) for immunogenicity studies in mice.

PHASE II: Demonstrate VLPs immunogenicity and the induction of protective immune responses against parasite challenge in murine models of infection. For this reason, it is anticipated that the successful Phase I will include a

VLP for at least one pre-erythrocytic stage antigen, for which there is a homologous challenge model in mice, i.e., CSP. It may be necessary to evaluate combinations of different VLP-displayed antigens at pilot scale to determine optimal presentations and formulations that have the highest potential for immunogenicity and economic feasibility. Down-select to identify lead VLP candidates and complete scale-up process development for VLP-antigen preparation. Evaluate prototypic VLPs in GLP toxicity study in appropriate animal model for pre-IND meeting with the U.S Food and Drug Administration (FDA).

PHASE III DUAL USE APPLICATIONS: Extend VLP prototype process to a final Good Manufacturing Practice (GMP) product scale suitable for FDA approval for Phase I clinical investigations. Perform extensive analyses of VLPs for safety, purity and identity in support of IND enabling activities. The objective of Phase III is to demonstrate VLP vaccine efficacy (>80%) against Controlled Human Malaria Infection (CHMI) in naïve US subjects vaccinated.

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KEYWORDS: Malaria, Virus like particles, Vaccine, Cellular, Humoral, Immunity

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A16-052 TITLE: Semi-Autonomous Airway Management Device

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Develop, test and manufacture a novel sensor system for semi-autonomous endotracheal intubation and airway management in a combat casualty care environment.

DESCRIPTION: Airway compromise has been cited as the second most common cause of potentially survivable deaths on the battlefield within the past decade [1]. 5-10% of the total combat casualty population require emergency airway management before reaching a field hospital [2]. Effective airway management in pre-hospital trauma care is critical for survival. In addition to the skill required for successful airway intervention, the tactical

environment of battlefield conditions presents an additional level of situational complexity, often involving confined spaces, hostile action, or lack of airway visibility [2]. While the clinically preferred method for airway management in trauma care is endotracheal intubation (ETI), success rates for ETI have been noted to decrease to 50% when providers do not maintain continuous practice and training [3]. Due to the wide range of relative experience of attending battlefield providers compounded by the significant training and skill level required for correct ETI, cricothyroidotomy often becomes the go-to for definitive airway management on the battlefield [4]. This extreme procedure involves cutting directly into the trachea and consequently renders more long-term consequences and still requires a high level of skill and routine practice. This topic is intended to design and develop a novel device for airway management in a battlefield setting. As previously indicated, field medics or attending providers may not routinely practice ETI enough to maintain highly successful skill levels. Therefore, such a device would operate semi-autonomously to quickly and effectively secure a pathway for the patient's airway and allow for connection to ventilation. In addition, penetrating neck or face trauma has been documented as the most common type of injury necessitating airway intervention of late in Operation Iraqi Freedom (OIF) [5]; therefore, the device cannot assume normal physical appearance and must account for traumatic situations where standard landmarks (i.e. nose, mouth, teeth, tongue, etc) may be missing, deformed, or obstructed. The device must be lightweight, portable and easily operated by a single provider. The overall goal is to develop a device that will be used in combat casualty care to provide quick and effective airway management to increase the survival rate of pre-hospital traumas.

PHASE I: Within the first six months, the business shall establish conceptual approaches for the design of the semi-autonomous intubation sensor system based upon existing physiological research and technological innovations in other biomedical applications. The business shall also be required to demonstrate the technical feasibility of the approach(es). And their proposed business strategy and requirements for Food and Drug Administration (FDA) clearance. If the conceptual device design incorporates multimodal approaches, separate demonstrations may serve to support the validity of each individual approach; however, the developer should still demonstrate the viability of their cohesion.

PHASE II: The first year of the two year development cycle in Phase II shall involve the fabrication of proof-of-concept prototype based on the design approach(es) identified from Phase I. The prototype will be tested in simulated and/or animal model environments in order to determine their practical viability. The second year will involve the refinement and more rigorous testing of the chosen design with a sound pre-clinical engineering development plan for FDA clearance. Testing and refinement will involve the device's adherence to battlefield constraints (i.e. battery life, operational time and ease of use) as well as the device's continued performance in human trauma models, such as animal, cadaver or simulation. At the end of the 2 year Phase II period, a finalized device should be able to semi-autonomously perform endotracheal intubation in human trauma models and be ready for deployment in clinical trauma settings.

PHASE III DUAL USE APPLICATIONS: Given successful performance in Phase II testing, the resulting device will undergo FDA review and IDE application in order to test the device in a clinical setting. While the battlefield scenarios will involve more difficult airway management conditions, proper function in a civilian trauma setting is essential before battlefield testing and will also contribute to the device's potential application in civilian trauma settings. If successful in civilian/clinical settings, testing under military training environments will follow.

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KEYWORDS: Airway management, combat casualty care, medical device, trauma, sensor system

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A16-053 TITLE: Secure Wireless Disposable Pulse Oximeter Patch that Generates a PPG Waveform

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: The objective of this topic is to research, develop, and demonstrate a secure wireless disposable pulse oximeter patch/bandage sensor type device that uses skin reflection to generate a Photoplethysmogram (PPG) waveform. Fingertip, transmissive absorption pulse oximeters that just generate a Peripheral Capillary Oxygen Saturation (SPO2) number are becoming more common on the battlefield at the point of injury, but most of these devices are not disposable, do not generate PPG waveforms and medical information cannot be captured wirelessly on a Medic and Corpsman End User Devices (EUD), Smartphones. This research topic is looking to develop a disposable wireless small pulse oximeter adhesive bandage sensor type device that will wirelessly transmit a SPO2 number and a PPG waveform to a EUD. The medical data generated will be electronically entered into the Tactical Combat Casualty Care (TC3) card and a patient status algorithm developed by the US Army Institute of Surgical Research (USAISR) will use the PPG waveform to generate the Compensatory Reserve Index (CRI) (U.S. Food and Drug Administration (FDA) approval pending) for the casualty. This topic also has the potential of integrating with other military projects in larger open source architecture.

DESCRIPTION: This topic is designed to focus on research, development, and demonstration of a disposable secure wireless pulse oximeter patch/bandage type sensor that generates a Photoplethysmogram (PPG) waveform. Medics and Corpsmen will potentially be using End User Devices (EUD), Smartphones to capture electronic medical data on casualties treated at the point of injury and during en route casualty evacuation, then transmitting the data via military tactical networks to be uploaded in the casualty’s electronic health record. Most of the current SPO2 fingertip devices being used on the battlefield only provides a number and most are not disposable, so the medic needs to grab it before the casualty departs or has to do without for the next patient. The medic or corpsman need a better method, a disposable bandage sized pulse oximeter sensor type device that can be adhered to the casualty’s skin that can securely transmit medical data wirelessly to any EUD. The pulse oximeter bandage type sensor device also needs to be capable of generating PPG waveforms. The potential solution exist that if a U.S. Food and Drug Administration (FDA) cleared patient status algorithm program is installed on the medic or corpsman’s EUD, the patient status algorithm will use the PPG waveform data to generate a medical predictive algorithm. The theory is to have a secure wireless SPO2 patch sensor transmit PPG waveforms to a patient status algorithm program installed on a EUD and then the goal is to provide the medic or corpsman with a capability to have a window of opportunity/precursor to predict casualty medical outcomes and start corrective treatment on a casualty before decompensating and death. The wireless capability on the pulse oximeter needs to be received by multiple EUDs as a casualty is treated and transported, the medic and corpsman treating the casualty at each stage of care will need the capability to receive and distinguish each casualty’s medical data being generated. Having the capability of a disposable skin reflective wireless pulse oximeter that generates a PPG waveform to a EUD will enhance a medic or corpsman on the medical stability of the casualty being treated on the battlefield at the point of injury and during casualty evacuation. A wireless sensor enables a medic or corpsman to monitor multiple casualties from a single location during triage and casualty evacuation (transport). Also this capability addresses a current capability gap; the ability to electronically document patient injuries and treatment. It is now technically possible and operationally feasible to combine most of the physiological monitoring (sensors), medical information exchange (TC3 and Military Acute Concussion Evaluation (MACE) cards), and telemedicine technologies (EUD connected to the tactical network) already in use, undergoing evaluation, or still in development. This topic focuses down to

researching, developing, and demonstrating a prototype wireless skin reflective pulse oximeter patch/bandage sensor that generates a PPG waveform. The final demonstration is to demonstrate a proof-of-concept fieldable prototype on an Army Program of Record EUD that can be tested and evaluated in the field with soldiers engaged in operational exercises. Since the CRI capability could potentially be used by the medic in making medical decisions, the CRI algorithm as implemented on the Medic's EUD may require resubmitting to the FDA for review and approval. Plans for FDA coordination, review, and approval should be included in proposals. After Phase III development, the final production model of a disposable wireless pulse oximeter bandage sensor must be ruggedized for shock, dust, sand, and water resistance to enable reliable, uninterrupted operation in combat vehicles on the move, to include operation and storage at extreme temperatures, and the sensor must be able to be viewed on any EUD. Size and weight are important factors; the ultimate object of system would be patient medical stability assessment and alerting the first responder well before patient degrades so preemptive medical care can be performed to save the life of the patient. Maintain a secure wireless connection between patient continuous medical monitoring sensors. Ensure data bandwidth is small enough to transmit medical data over military tactical (networks) radios. Quantitative values for acceptable operational and storage temperatures and power requirements should be planned to comply with applicable U.S. Military Standards (MIL-SPECs) (available on line). To facilitate commercialization, the pulse oximeter sensor will integrate with a EUD connected to military tactical networks (tactical radios /4G LTE (Multi-Access Cellular Extension)).

PHASE I: Research solutions and design a prototype breadboard solution that can demonstrate the technical challenges on this topic as identified above for a capability that incorporates feasible solution for a disposable wireless skin reflective pulse oximeter bandage (sensor) that can integrate with a EUD, any mobile android EUD with a secure wireless connection. Ultra wideband, Tunable Narrowband, or Ultraviolet light communication protocols are acceptable wireless protocols. Bluetooth or Wi-Fi protocols are not acceptable. The PPG waveform data packages may need to be streamed over the military tactical network, the packets need to be small enough to transmit over a limited bandwidth using military tactical radio/4G LTE network. Flesh out commercialization plans that were developed in the Phase I proposal for elaboration or modification to be incorporated in the Phase II proposal. Explore commercialization potential with civilian emergency medical service systems development and manufacturing companies. Seek partnerships within government and private industry for transition and commercialization of the production version of the product.

PHASE II: From the Phase I design; develop a ruggedized skin reflective pulse oximeter patch/bandage prototype sensor that can be used on any mobile EUD with wireless connection (e.g. Ultra wideband, Tunable Narrowband, Ultraviolet communication). The prototype at minimum needs to be capable of demonstrating in a field environment: the capability of the sensor to transmit wirelessly to a mobile EUD the Heart Rate, SPO2 number and PPG waveform to the EUD. It may be possible to demonstrate of a field able prototype system with soldier medical attendants in a relevant environment; such as a C4ISR Ground Activity Events, CDID-ED Network Battle Lab, etc. Flesh out commercialization plans contained in the Phase II proposal for elaboration or modification in Phase III. Firm up collaborative relationships and establish agreements with military and civilian end users to conduct proof-of-concept evaluations in Phase III. Begin to execute transition to Phase III commercialization potential in accordance with the Phase II commercialization plan.

PHASE III DUAL USE APPLICATIONS: Refine and execute the commercialization plan included in the Phase II Proposal. Continue development and refinement of the prototype in Phase II to develop a production variant of the wireless adhesive sensor. The production variant may be evaluated in an operational field environment such as Marine Corps Limited Objective Experiment (LOE), Army Network Integration Exercise (NIE), etc. depending on operational commitments. The primary transition agent will be the USAMRMC PM Medical Support Systems. Present the prototype project, as a candidate for fielding, to applicable Army, Navy/Marine Corps, Air Force, Coast Guard, Department of Defense, Program Managers for Combat Casualty Care systems along with government and civilian program managers for emergency, remote, and wilderness medicine within state and civilian health care organizations, and the Departments of Justice, Homeland Security, Interior, and Veteran's Administration. Execute further commercialization and manufacturing through collaborative relationships.

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KEYWORDS: combat casualty care, predictive algorithms, combat medic, telemedicine, pulse oximtery, mobile device, Photoplethysmography, digital volume pulse, heart rate, pulse wave analysis

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A16-054 TITLE: Machine Learning & Medical Predictive Algorithm for Medical Applications on End User Devices

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: The objective of this topic is to research, develop, and demonstrate a Machine Learning & Medical Predictive Algorithm (MPA) application that is installed on a mobile End User Device by merging Tactical Combat Casualty Care Guidelines with information generated on site from the DD Form 1380 electronic Tactical Combat Casualty Care (TC3) card, from wireless physiological monitoring sensors, and from the Compensatory Reserve Index (CRI) predictive algorithm. This topic also has the potential of integrating with other military projects in larger open source architecture.

DESCRIPTION: Design and prototype a machine leaning and medical predictive algorithm that can run on the U.S. Army PEO Soldier NETT Warrior Android Smartphone/End User Device (EUD). The Army PM Medical Communications for Combat Casualty Care (MC4) in conjunction with the OSD (HA) PM Joint Operational Medical Information Systems (JOMIS) have developed an electronic version of the Tactical Combat Casualty Care (TC3) card, DD Form 1380 that runs on an Android device such as the Army NETT Warrior EUD. The eTC3 card supports automatic secure wireless upload of vital signs from soldier worn or medic places sensors. Development of the wireless acquisition of data is NOT PART of this topic but the data generated by such capabilities along with patient assessment data entered by the medic on to the NETT Warrior EUD will be used as input for generating alerts and advice for the medic by various algorithms running on the medic's EUD. The CRI is generated from algorithmic analysis of the Photoplethysmogram (PPG) waveform generated by a pulse oximeter. It is one an example of such an alert which provides the medic enough warning to conduct treatment prior to patient decompensation. Medic alerts need to be in simple understanding indications like Green, Yellow, and Red flashing lights on the EUD to indicate whether the casualty is stable, warning, or crashing. These alerts can be followed by generation of care guidance based on protocols from the published Joint Tactical Combat Casualty Care Guidelines, and the Special Operations and Ranger Medical handbooks. This capability will enhance a medic's capability to take preemptive treatment measures to save a patient's life and advance the state of the art in prolonged field care and En

route combat casualty care assessment, monitoring, and intervention at the Point of Injury (POI) and on attended casualty evacuation vehicles. While TC3 guidelines and references such as the Special Operations Forces (SOF) and 75th Ranger Regiment medical handbooks are available to combat medics in book or even electronic form, the information contained must be remembered or looked up by the medic to apply to care of combat casualties. Automatic generation of alerts followed by care guidelines and advice based on patient assessment information generated on site would greatly streamline and improve initial combat casualty care provided by combat medics at points of injury. Currently Army combat medics are being issued EUDs for Command and Control; Applicable Army program managers intend for these EUDs to be used by soldiers to generate electronic Tactical Combat Casualty Care (TC3) cards and/or capture vital signs data wirelessly from medical sensors; however there are no apparent plans for leveraging that data to help the medics with combat casualty care. When physiological data acquisition and electronic patient encounter documentation are combined with machine learning, medical predictive algorithms this research will incrementally advance the state of the art in Prolonged Field Care and En Route Combat Casualty care in providing an operational medic with immediate alerts and treatment guidelines that enhance care as well as the capability to assessment, monitoring, and intervention at the point of injury (POI) and during casualty evacuation. A key additional component of this topic is to be able to improve and update the alert and advice algorithms through use of machine learning. Machine Learning is a scientific discipline that explores the construction and study of algorithms that can learn from data. Such algorithms operate by building a model from example inputs and using that to make predictions or decisions, rather than following strictly static program instructions. Machine learning is closely related to and often overlaps with computational statistics; a discipline which also specializes in prediction-making. The proposed capability should be able to continually improve its recommendations based on analysis of previous cases and outcomes. The final demonstration is to demonstrate a proof-of-concept fieldable prototype on an Army Program of Record EUD that can be tested and evaluated in the field with soldiers engaged in operational exercises. Since this capability could potentially be used by the medic in making medical decisions, this algorithms and medic advice generated may require U.S. Food and Drug Administration (FDA) review and approval. Plans for FDA coordination, review, and approval should be included in proposals. After Phase III development, the final production model of the Machine Learning tool software on a EUD must be ruggedized for shock, dust, sand, and water resistance to enable reliable, uninterrupted operation in combat vehicles on the move, to include operation and storage at extreme temperatures, and the developer's kit must be able to install this capability on the devices. Size and weight are important factors; the ultimate object of system would be patient medical stability assessment and alerting the first responder well before patient degrades so preemptive medical care can be performed to save the life of the patient. Maintain a secure wireless connection between patient continuous medical monitoring sensors. Ensure data bandwidth is small enough to transmit medical data over military tactical (networks) radios. Quantitative values for acceptable operational and storage temperatures and power requirements should be planned to comply with applicable U.S. Military Standards (MIL-SPECs) (available on line). To facilitate commercialization, the developer's kit should enable embedding the medical predictive algorithm application capability within mobile Smart devices with wireless connectivity to medical sensors for use over military common-user networks (tactical radios /cellular) or ubiquitous civilian communications equivalents.

PHASE I: Research novel approaches and technical solutions for a Machine Learning & Medical Predictive Algorithm (MPA) application that is installed on a mobile End User Device (EUD) in order to produce alerts and provide guidance to a medic in providing treatment options for the care of the casualty by merging Tactical Combat Casualty Care Guidelines with information generated on site from the DD Form 1380 electronic Tactical Combat Casualty Care (TC3) card, from wireless physiological monitoring sensors, and from the Compensatory Reserve Index (CRI) predictive algorithm. Flesh out commercialization plans that were developed in the Phase I proposal for elaboration or modification to be incorporated in the Phase II proposal. Explore commercialization potential with civilian emergency medical service systems development and manufacturing companies. Seek partnerships within government and private industry for transition and commercialization of the production version of the product.

PHASE II: From the Phase I design, develop a ruggedized prototype research, develop, and demonstrate a Machine Learning & Medical Predictive Algorithm (MPA) application that is installed on a mobile End User Device (EUD) in order to produce alerts and provide guidance to a medic in providing treatment options for the care of the casualty by merging Tactical Combat Casualty Care Guidelines with information generated on site from the DD Form 1380 electronic Tactical Combat Casualty Care (TC3) card, from wireless physiological monitoring sensors, and from the Compensatory Reserve Index (CRI) predictive algorithm. At the end of Phase II, demonstrate a field testable prototype the Machine Learning tool on a EUD that can be taken to a C4ISR Ground Activity Event exercise and connected to a military tactical network. The prototype system will be evaluated by operational medics in a relevant operational field environment; such as at a USA Army TRADOC Battle Lab. Flesh out commercialization plans contained in the Phase II proposal for elaboration or modification in Phase III. Firm up collaborative relationships

and establish agreements with military and civilian end users to conduct proof-of-concept evaluations in Phase III. Begin to execute transition to Phase III commercialization potential in accordance with the Phase II commercialization plan.

PHASE III DUAL USE APPLICATIONS: Refine and execute the commercialization plan included in the Phase II Proposal. Continue development and refinement of the prototype in Phase II to develop a production variant of the application. The primary transition agent will be the USAMRMC PM Medical Support Systems. The production variant may be evaluated in an operational field environment such as Marine Corps Limited Objective Experiment (LOE), Army Network Integration Exercise (NIE), etc. depending on operational commitments. Present the prototype project, as a candidate for fielding, to applicable Army, Navy/Marine Corps, Air Force, Coast Guard, Department of Defense, Program Managers for Combat Casualty Care systems along with government and civilian program managers for emergency, remote, and wilderness medicine within state and civilian health care organizations, and the Departments of Justice, Homeland Security, Interior, and Veteran's Administration. Execute further commercialization and manufacturing through collaborative relationships.

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KEYWORDS: machine learning, combat casualty care, predictive, algorithms, combat medic, telemedicine, medical informatics, end user device

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A16-055 TITLE: Miniature, point-of-care device for establishing sterile connections in combat environments

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: To develop and field a miniature, point-of-care device for establishing clean and sterile catheter connections in combat environments.

DESCRIPTION: Providers are often required to insert lines (catheters) in patients to deliver lifesaving drugs and fluids during combat casualty care procedures. Because the catheter may be placed near the heart, any infection would represent a major complication. To avoid catheter related blood stream infections (CRBSIs), strict compliance to a disinfection protocol requires thorough hand scrubbing, use of specialized gloves and facemasks, a two minute alcohol scrub around the connection site between the catheter and the tube that connects or feeds into the infusate. Additionally, use of adjunct disinfectants on the connectors, and a gentamycin and citrate flush in the catheter line is required. In a battlefield environment, skipping, improper, or incomplete performance of just one of

the steps can lead to CRBSIs which can result in increased complications for the patient, including septic shock and death. Due to the golden hour initiative in Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) time to hospital averaging less than one hour for battlefield casualties, line placement was mostly done at combat support hospitals where sterile procedures could be better managed. However, for future conflicts in other theaters where complete air superiority may not be guaranteed or where longer distances will require more aggressive treatment of soldiers in the field, it may be necessary to hold wounded soldiers in a far forward facility for extended periods of time. With prolonged field care potentially requiring the placement of these lines in the field, infections become a much more likely and worrisome occurrence. A device that could guarantee the sterile connections of lines in the field by being less reliant on nurse compliance to existing rigorous disinfection protocols would be highly desired.

PHASE I: Develop an initial concept design that meets the intent of the SBIR topic for a miniature point-of-care device for making clean (sterile) catheter connections in the field. The device should have the following characteristics. The design should be small, lightweight, portable, easy-to-use and provide for a sterile connection in less than 2 minutes. The device would be reusable to reduce the requirement to have multiple units available or carried by medical personnel. Phase I deliverables will include: a technical report that outlines the mechanical design of the proposed device, preliminary proof-of-concept data demonstrating the feasibility of the approach and a detailed analysis that defines the predicted performance and demonstration success criteria of the end product. The device should weigh no more than 100g (approximately 0.2 lbs) and measure no more than 1000cm3 (approximately 10 cm per side or 4 inches per side) in volume.

PHASE II: Based on the Phase I design, develop, demonstrate and validate a functional prototype. Conduct benchtop antimicrobial studies and tests to validate the efficacy of the device. Produce a physical testing protocol to include life-cycle and environmental testing. At the end of PHASE II, it is envisioned that the contractor will have completed all the necessary preclinical studies required for moving the device into clinical studies en route to Food and Drug Administration (FDA) clearance.

PHASE III DUAL USE APPLICATIONS: The overall goal of this program will be to finalize all pre-clinical testing and validation of a device that can receive regulatory approval. Phase III of this program will consist of clinical trials designed to produce a product with the appropriate indications for use such that it can be used to sterilize catheter connections in a combat environment while providing infection control. Technology innovations developed through this SBIR would also have dual use application for catheter connection sterilization in the military and civilian sectors. The technology would provide for significantly improved capabilities that could also reduce the impact (cost, workload, etc) of providing associated clinical services both in military and non-military settings. The small business should have plans to secure funding from non-SBIR government sources and /or the private sector to develop or transition the prototype into a viable product for sale in the military and/or private sector markets.

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KEYWORDS: Prolonged Field Care, infection control, infection prevention, sepsis prevention, sterilization, antimicrobial, catheter, CVC, PICC

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A16-056 TITLE: Portable Occult Hemorrhage Detector and Resuscitation System

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Develop a device that is capable of detecting occult hemorrhage at its earliest stages without the need for arterial access or complex imaging technology. Upon detection of occult hemorrhage, the device must also be capable of guiding resuscitation to prevent fluid overload. The final system will be fully automated so that a caregiver and a medic could operate the system with similar care results while operating in a prolonged field care scenario. The final system will also continuously communicate intraabdominal pressure and urine output to the end user to guide fluid resuscitation.

DESCRIPTION: Uncontrolled post-traumatic bleeding is the leading cause of potentially preventable death among wounded warfighters. Continuous monitoring is critical to the early detection of occult hemorrhage and has been achieved through the application of a variety of sensors to the body and connecting these sensors to various monitors allowing for the acquisition of data including: heart rate, core temperature, blood pressure and pulse oximetry. While these data can be very useful in tracking the health of the wounded warfighter, they are late indicators of volume depletion and reduced cardiac output see with occult hemorrhage. What is needed, then, is a non-invasive or minimally invasive device that is capable of providing real-time tracking of physiologic parameters that provide earlier detection of occult hemorrhage. In addition, once hemorrhage has been detected, large volume resuscitation (LVR) is frequently required. In delivering LVR the goal is to provide sufficient volume to enable cardiac function while not delivering excessive volume. This is especially important in a delayed evacuation scenario that requires far forward patient management for extended periods of time. Urine output is a well-accepted marker of adequate volume and is considered an underutilized vital sign during resuscitation periods. A monitoring system that detects occult hemorrhage at its earliest stage and continuously trends intraabdominal pressure and urine output to guide resuscitation would be of great value in improving treatment for injured military personnel.

PHASE I: Develop an initial concept design for a potential occult hemorrhage detection and fluid resuscitation system which incorporates at least a relative stroke volume indicator and a monitor of urine output and intraabdominal pressure. Conceptualize approaches to automating caregiver cognitive and physical tasks, including approaches to 1) optimizing detecting and alerting of occult hemorrhage and 2) guiding resuscitation based on intraabdominal pressure and urine output. The contractor will conceptualize a graphical display that shows input variables and therapy settings in a meaningful way to caregivers. The contractor will identify a method for communicating data to a central location. The contractor will identify clinical and technological issues that would require further caregiver intervention. The contractor will determine an appropriate regulatory strategy to meet Food and Drug Administration (FDA) regulatory requirements for such a device.

PHASE II: The contractor will further develop the occult hemorrhage detection and fluid resuscitation system. The contractor will implement the best approaches from Phase I into hardware and software that optimizes and automates detection of occult hemorrhage and optimization of crystalloid resuscitation based on intraabdominal pressure and urine output. The contractor will demonstrate data export into a central location. The contractor will perform tests and simulation studies and provide data preclinical and clinical data to drive its occult hemorrhage detection and fluid resuscitation system. The contractor will demonstrate, pre-clinically, the ability to detect occult hemorrhage in an automated manner. The contractor will also demonstrate the optimization of fluid resuscitation without fluid overload by guiding fluid infusion using urine output (to achieve a minimum UO) and intraabdominal

pressure (with a not to exceed threshold for IAP).

PHASE III DUAL USE APPLICATIONS: The contractor will validate and produce a working occult hemorrhage detection and fluid resuscitation system that 1) will provide automatic occult hemorrhage alerts, 2) will provide accurate urine output to ensure adequate volume resuscitation, 3) will provide accurate intraabdominal pressure to prevent fluid overload, 4) will graphically display patient data and 5) will communicate data to a central location. The contractor will demonstrate, clinically, the ability to detect occult hemorrhage with 80% specificity and 80% sensitivity in an automated manner. The contractor will also demonstrate the optimization of fluid resuscitation without fluid overload by guiding fluid infusion using urine output and intraabdominal pressure. Such a system should prevent unnecessary deaths related to unrecognized occult hemorrhage. Such a system will also enable lesser trained caregivers to provide adequate care of patients, and will enable caregivers to effectively take care of more patients simultaneously. Such a system should save lives, improve the quality of life for military and civilian patients, improve the CASEVAC process and should be of great commercial interest for all branches of the U.S. armed services and civilian trauma care professionals. Validation of the system will be performed in accordance with FDA regulation related to development and validation of a multi-parameter monitor (per 21 CFR 870.1025). The contractor will submit the developed system for FDA clearance for eventual use in a clinical environment.

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KEYWORDS: hemorrhage detection, monitoring, fluid management, fluid resuscitation, automated urinary output measurement

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A16-057 TITLE: IND-Enabling Studies for Development of a Novel Therapeutic Agent for the Treatment of Combat-Related Posttraumatic Stress Disorder

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Perform Investigational New Drug (IND)-enabling studies to support commercial development of a novel therapeutic agent to reduce or resolve symptoms of combat-related posttraumatic stress disorder (PTSD).

DESCRIPTION: U.S. military forces are frequently deployed to operational regions where there is a significant risk of exposure to combat-related traumatic events. PTSD may subsequently develop, and is associated with emotional distress and impairment in social and occupational functioning. As defined by the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5), PTSD is characterized by exposure to a traumatic event followed by the persistence of four groups of symptoms for more than one month:

intrusion symptoms such as flashbacks or nightmares; persistent avoidance of stimuli associated with the traumatic event; negative alterations in cognitions or mood; and marked alterations in arousal and reactivity such as sleep disturbance and hypervigilance. PTSD is estimated to occur in 7–20% of the over 2.6 million military service members and veterans who deployed in support of Operation Enduring Freedom, Operation Iraqi Freedom, and Operation New Dawn. In 2012, DoD spent $294.1 million and VA over $3 billion on PTSD care. Pharmacologic interventions are an important component of most treatment plans for PTSD. Only two medications, both of the SSRI class, are FDA-approved for PTSD. These and other medications used off-label have limited efficacy for combat-related PTSD. This topic is intended to identify and commercially develop a novel medication or other therapeutic agent to reduce or resolve symptoms of PTSD and improve social and occupational functioning in service members and veterans with PTSD. The novel therapeutic agent may focus broadly on treating PTSD as a syndrome or it may address a specific subset of PTSD symptoms. The therapeutic agent will be used either in conjunction with an evidence-based psychotherapy for PTSD or as a primary treatment for PTSD. The therapeutic agents(s) selected will have strong preclinical evidence of efficacy for treating PTSD. They will also have a compelling theoretical rationale, with evidence of the ability to target and modify key pathophysiological mechanisms involved in PTSD. The therapeutic agent(s) should have a route of administration that is clinically feasible in typical outpatient and community settings (e.g., a route of administration other than intravenous is preferred). The performer should also describe preliminary evidence of commercial viability. Although this topic principally anticipates the testing of small molecules, the therapeutic agent may be a biologic or nutraceutical product. Building on existing evidence of safety, efficacy, and target engagement, the effort will (i) provide data on in vitro characteristics of the candidate therapeutic agent(s) and (ii) develop procedures and pharmacology data to support animal toxicology studies of the candidate therapeutic agent(s) under Good Laboratory Practices (GLP) conditions for an Investigational New Drug (IND) submission to the Food and Drug Administration (FDA). At a minimum, the performer will demonstrate on the basis of GLP animal pharmacokinetics data that the candidate therapeutic agent is viable for administration as a clinical treatment for PTSD. At the end of the performance period, the performer should be ready to proceed with GLP animal toxicology studies to support submission of an IND to the FDA with a goal of commercial development of the therapeutic agent. Throughout the performance period, performer will have access to collaborative consultation with subject matter experts from the Division of Regulated Activities and Compliance (DRAC), the Neurotrauma and Psychological Health Project Management Office (NPH PMO), and other departments that support FDA-regulated research at the U.S. Army Medical Materiel Development Activity (USAMMDA).

PHASE I: During Phase I, the performer will identify one or more promising therapeutic agents based on available preclinical safety and efficacy data, or on clinical trials involving a medication used off-label for PTSD that will undergo reformulation. Performer will provide a compelling mechanistic rationale for the selected therapeutic agent(s). Clinical experts with research experience in drug treatment for combat-related PTSD should be consulted during the selection and development of the candidate agent(s) for PTSD. The compound may be a drug licensed outside of the U.S. that does not have marketing approval from the FDA. A pre-IND meeting should be conducted during Phase I to obtain FDA feedback on the study plan for IND-enabling animal studies. The performer will assess the feasibility of development by performing activities to establish Chemistry, Manufacturing, and Control (CMC) characteristics. If not already available, in vitro characteristics of the therapeutic agent(s) will be described by examining one or more formulations of the candidate agent(s) and assessing feasibility of Good Laboratory Practices (GLP) manufacturing of the therapeutic agent for testing in GLP animal pharmacokinetics and toxicology studies to support an IND submission. Specifically, the performer will report test characteristics that address the feasibility of the proposed therapeutic agent as a treatment for PTSD. These characteristics should include: 1) preliminary evidence of stability when stored over a temperature range of approximately 15 - 30°C; 2) stability in solution over a range of physiological pH and ionic concentration; 3) in vitro dissolution data; 4) rate of degradation in solution; 5) any other relevant CMC features that will be needed for submission of an IND. Characteristics should support feasible and safe dosing in humans. Performer will protect the relevant intellectual property by filing patent disclosures and applications as appropriate. Performer will deliver a report summarizing the testing and planning completed in phase I and will propose a development plan for an IND submission to the FDA. The report will also describe a provisional development strategy for clinical testing and New Drug Application (NDA) submission. This report will include an itemized estimate of costs for Phase II studies and other activities leading to an IND submission, as well as a business assessment of the commercial viability of the product. Commercial viability may include the performer’s estimate of its ability to transfer the technology to a larger business entity for further preclinical or clinical development.

PHASE II: During Phase II, the performer will select one candidate therapeutic agent, and perform animal pharmacology studies, including pharmacokinetics studies under GLP conditions, and complete requisite tasks such

as model development for treatment delivery systems, if needed, and other method validation of analytic techniques in preparation for conducting GLP animal toxicology studies. Additionally, the performer may choose to conduct selected components of GLP toxicology (e.g., genotoxicity). Performer will protect the relevant intellectual property by filing patent disclosures and patent applications as appropriate. Clinical experts with research experience in drug treatment for combat-related PTSD should be consulted during the design and interpretation of the animal studies. Performer will deliver a report summarizing the testing completed in phase II and will propose an updated development plan for an IND submission to the FDA. In the report, the performer will also present the design of suitable GLP animal toxicology studies in two species, and propose an updated clinical development strategy. The clinical development strategy will include potential partners for clinical testing and commercialization, and describe potential sources of Phase III funding. This report will include an itemized estimate of costs for Phase III studies and other activities leading to an NDA submission, as well as an updated business assessment of the commercial viability of the product. Commercial viability may include the performer's estimate of its ability to transfer the technology to a larger business entity for further preclinical or clinical development.

PHASE III DUAL USE APPLICATIONS: The development goal of this topic is to obtain FDA approval for a novel therapeutic agent to treat PTSD in a clinical population of military service members and veterans, possibly using associated biomarkers to describe treatment response or to identify individuals who will respond to the pharmacotherapy. Clinical testing should take place in Department of Defense treatment facilities and/or healthcare systems within the Department of Veterans Affairs. The novel therapeutic agent will have demonstrated safety and efficacy in a military/veteran population for combat-related PTSD. Phase III work will sequentially examine GLP animal toxicology leading to submission of an IND to the FDA, followed by human studies for safety, proof of concept, and confirmatory testing in multi-site randomized clinical trials to support an NDA for the treatment of PTSD. Consultation support received by the performer from USAMMDA during Phases I and II may be extended into Phase III testing, as appropriate. The ability of the therapeutic agent to reduce or resolve PTSD symptoms will be evaluated, along with the therapeutic agent's impact on social and occupational functioning. The end result of a successful Phase III will be the FDA approval of a safe and effective new therapeutic agent to treat combat-related PTSD. Military applications include the use of the therapeutic agent in outpatient and inpatient clinical care settings at military treatment facilities and potential use by forward-deployed healthcare providers. Commercial applications include the demonstration of safety and efficacy for use of the therapeutic agent to treat PTSD in individuals exposed to traumatic events in the civilian sector.

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KEYWORDS: combat-related trauma; pharmacotherapy; posttraumatic stress disorder (PTSD); social and occupational functioning; treatment.

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A16-058 TITLE: Device Solution to Enhance Vascular Access by Reducing Pain and Simplifying Procedure

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Develop, design, demonstrate, and manufacture a medical device that enhances venous access by reducing pain and simplifying the procedure.

DESCRIPTION: One of the most common therapies administered to hospitalized patients is peripheral intravenous (IV) and arterial catheterization, performed on at least 85% of patients, but it can be painful. In addition, it can be a difficult process for a myriad of reasons (e.g., dehydration, collapsed vein, scarred vein) that can lead to serious complications1. Furthermore, failed attempts at vascular access can increase tissue damage that may cause other complications such as infections, thrombosis or even death2. Failure to achieve effective vascular access has resulted in complications, such as bloodstream infections. Intensive Care Units (ICU) have reported additional costs between $33k and $75k per incident of bloodstream infections and increasing the length of hospital stay3. If access to the vasculature is not achieved, the effectiveness of the administered fluids or other products can be diminished or negated, necessitating repeated attempts creating further patient discomfort and stress4. These issues are encountered in controlled environments by well-trained medical professionals, but even more so under high stress situations that Soldiers may encounter. It is a common technique taught to many in the Army that is a part of the Combat Lifesaver Program. Some of the most common complications, such as dehydration, vasospasms, collapsed and scarred veins occur at higher rates in austere environments and can lead to serious complications5. As IV therapies are common procedures affecting both the Soldier and civilian populations, a materiel solution is being sought to enhance venous access. This topic seeks a new materiel device solution to reduce pain and to simplify the process of venous access for procedures such as IV catheterization. This device should be flexible enough to be used by any medical provider trained to administer an IV.

PHASE I: Define, develop design plans, and demonstrate feasibility of an innovative device that reduces pain and enables simplified, controlled vascular access, while maintaining tactile feel for any tissue type. Electronic engineering plans should be generated that allow 3-dimensional, rotational views of all components of the proposed system. A document describing the proposed device, operation, and performance requirements of the system should also be generated. Furthermore, this phase should include a plan for development, verification and validation, and regulatory strategy for FDA clearance/approval, concept of the proposed device, and a literature search to support feasibility.

PHASE II: Produce prototypes and validate device performance requirements as defined in Phase I. Validation should include appropriate and relevant bench and preclinical studies. The proposal should provide a detailed plan for practical implementation and preparation for FDA submission.

PHASE III DUAL USE APPLICATIONS: Pending successful results of Phase II studies, the final prototype shall demonstrate the capability to enhance venous access and reduce associated pain and complications. At the conclusion of Phase III, all studies and necessary documents should be completed to achieve FDA clearance/approval for commercial marketing.

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KEYWORDS: Arterial, Art-line, Intravenous, IV, Peripheral intravenous therapy, Intravenous catheterization, Thrombosis

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A16-059 TITLE: Effective targeted treatment of peripheral neuropathy

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Design and develop a medical device or combination therapy to effectively treat targeted areas of peripheral neuropathy, avoiding large systemic doses and side effects of current treatment options.

DESCRIPTION: Peripheral Neuropathy (PN) is caused by a range of disorders resulting in damage to the somatosensory nervous system, of which there is no cure1. Some common causes of PN damage include, but are not limited to traumatic injuries, diabetes, infections, exposure to chemicals, poor nutrition, and hereditary disorders affecting up to 4.5 million patients2. In those diagnosed with PN, debilitating symptoms include tingling, abnormal pain sensation and muscle fatigue2. A recent study shows that Hereditary Neuropathy with liability to Pressure Palsies (HNPP) was triggered by carrying a heavy pack resulting in fatigue, muscle cramps, and difficulty standing3. HNPP is often unrecognized and can be exacerbated by some aspects of military training. Though a hereditary condition may be the cause of some PN; trauma, compression and exposure to chemicals are also contributors and are common in a military environment. Considering the time and length in which the warfighter has to carry a heavy pack, potential exposure to chemicals, and likeliness of trauma, PN could be widespread but unrecognized. With respect to the likelihood of the warfighter becoming exposed to any number of neuropathy causing factors, further treatment options must be explored. Current treatment options are limited and moderately effective with potential drawbacks. Common treatment options include topical analgesics, oral medications, transdermal treatments with oral medications, and localized subcutaneous injections of botulinum toxin-A. However, these options pose potential drawbacks, such as varying success rate, systemic effects, inefficient drug delivery, need for anesthetics to alleviate pain at injection site, and dependency issues2. This topic seeks a device (e.g., delivery device of existing medications) or combination solution to effectively treat targeted areas of peripheral neuropathy, while avoiding large systemic dose and harmful side effects. The novel solution proposed could facilitate or potentially replace current treatments.

PHASE I: For this phase of study, the team should identify concepts and methods to develop a device or combination therapy to effectively treat targeted areas of peripheral neuropathy, while avoiding or reducing current harmful side effects. Develop and demonstrate proof of concept, performing initial technical capability and feasibility analysis. This Phase will demonstrate the feasibility of producing the proposed therapy, develop performance requirements, and prepare a plan for FDA submission.

PHASE II: Using Phase I results and requirements, produce prototypes and validate performance requirements to treat targeted areas of peripheral neuropathy, while avoiding large systemic dose and harmful side effects. Validation should include appropriate and relevant bench and preclinical studies. The proposal should provide a detailed plan for practical implementation and preparation for FDA submission.

PHASE III DUAL USE APPLICATIONS: Pending successful results of Phase II studies, the final prototype shall demonstrate the capability to treat targeted areas of peripheral neuropathy avoiding large systemic doses and side effects of current treatment options. At the conclusion of Phase III, all studies and necessary documents should be completed to achieve FDA clearance/approval for commercial marketing.

REFERENCES:
1. Xu B, Descalzi G, Ye H-R, Zhuo M, Wang Y-W. Translational investigation and treatment of neuropathic pain. Molecular Pain. 2012;8:15.

2. The Foundation for Peripheral Neuropathy. 2012. at http://www.foundationforpn.org/.

3. Delacour, Hervé, et al. "Hereditary neuropathy with liability to pressure palsies occurring during military training." Journal of the Royal Army Medical Corps 158.1 (2012): 47-49.

KEYWORDS: Peripheral neuropathy, Targeted treatment, device, Combination therapy, somatosensory, Nerve damage, Diabetes, Traumatic injury

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A16-060 TITLE: Visual and Physical Footprint Reduction of Parachutes on the Ground

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Develop innovative materiel solutions for cargo and personnel parachutes that both reduce the footprint and signature of landed parachutes and have the ability to survive the challenging airdrop environment.

DESCRIPTION: During current cargo airdrop operations, payloads are dropped from aircraft at altitudes up to and exceeding 30,000 ft, fall for some period of time under one or more parachutes and contact the ground where the parachute is either released or remains connected to the payload. The parachute flapping on the ground (or remaining inflated for a short period of time in some conditions) becomes a large visual marker for enemy combatants to find the payload before friendly forces can reach it. This poses an inherent risk to friendly forces as enemy combatants may be able to sabotage or assume control of the payload. Also, one risk of airdropping Unmanned Vehicles is the parachute landing on top of the vehicle and entangling it or covering important sensors, impairing the vehicle's effectiveness or completely stopping the vehicle's mission. The intent of this SBIR solicitation is to identify or invent materials or devices that will significantly decrease the visual and physical footprint of parachute systems on the ground while reliably surviving the violent nature of parachute opening shock and the ensuing flight. High reliability of the material and/or device design is essential due to the criticality of materiel being delivered. The solution must be reliable in all environments, ranging from arctic to tropic to desert and cause the parachute to be invisible to the naked eye from 10-15 feet within 5-15 minutes including smoke or residuals. The cost of the solution in conjunction with the scalability and potential reusability (for devices only) of the material is also important. The cost of a new material should not exceed twice that of the current cost, while a production cost of a device should not exceed $3,000. The solution shall also be shelf stable for greater than two years. The two approaches that have been conceptualized to solve this issue are either a material to replace what the current parachutes are made of or a device (battery or otherwise powered) to recover the parachute. The material replacement could be either a material that rapidly dissolves, a material with a trigger that burns with little to no visible smoke, or other concepts that cause the material to become invisible to the naked eye. The device to recover the parachute could be a system that rapidly recovers the currently used parachute into a camouflaged container. The concern with using a device involves the potential for snagging of the parachute on items in the environment. The approach with the least material left on the ground would be most desirable.

PHASE I: Identify multiple solutions that reduce the visual signature (may include parachute recovery systems, dissolvable/degradable materials, etc.) If parachute materials foreign to aerial delivery applications are used, conduct stress/strain, porosity and yield testing on swatches of material to quantify vital material properties and must meet all performance requirements of PIA-C-7020 Type I. If a device is used, a CADD design of the full scale system must be produced as well as a small scale prototype for functionality checks (does not have to meet strength requirements). The weight of the full scale design must not exceed 5-10% of the total weight of the payload being delivered (500 lbs per parachute maximum for Phase II). Phase I deliverables include a report detailing all procedures employed in the research, all results of tests conducted, all potential technologies reviewed, samples of materials or small scale prototypes (dependent upon approach), and milestones to be accomplished in Phase II and a recommended path forward.

PHASE II: Design and construct prototype systems using the material and/or design identified in Phase I. If a new material solution is identified in Phase I, 20 parachutes, no larger than a T-10, will be constructed, otherwise 10 prototype devices that can withstand the forces associated with an airdrop of less than 500 lbs will be constructed and parachutes will be Government Furnished Equipment. Demonstrate operation of the prototype systems in a relevant environment. This would entail releasing the system from either a fixed or rotary wing aircraft to assess airworthiness in the airdrop environment and quantify usability and visual signature of the solution. Capture opening shock and aerodynamic performance data of the system and compare standard construction data to data using the reduced visual signature material/design. If device identified in Phase I is reusable repeat testing of the prototype systems to assess operational life of the system • Identify and repair, if deemed cost effective, any durability issues

with the system • Phase II deliverables include the prototype parachutes and/or device, a technical data package detailing the low visual signature material and/or device, a demonstration of the prototype parachutes and/or device to include dynamic airdrops of the system, and a report detailing all Phase II work and a recommended path forward.

PHASE III DUAL USE APPLICATIONS: Parachutes that have a reduced visual and physical footprint after landing have potential commercial application in foreign and domestic military and government as well as other areas where a material contaminant left in the environment is undesirable.

REFERENCES:
1. Unit and Direct Support (DS) Maintenance Manual for Parachutes, Personnel Type: 35-Foot Diameter, T-10C, Troop Back Parachute Assembly, TM 10-1670-293-23&P

2. Airdrop of Supplies and Equipment: Rigging Ammunition, FM 4-20.153

3. Designing For Internal Aerial Delivery In Fixed Wing Aircraft, MIL-STD-1791

4. Parachute Industry Association Specification, PIA-C-7020, CLOTH, PARACHUTE, NYLON - RIP-STOP AND TWILL WEAVE

KEYWORDS: low-visibility, reduced visual signature, airdrop, aerial delivery, guided airdrop, parachute, materials, dissolvable

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A16-061 TITLE: Continuous Mode Conveyor Cooking Appliance for Unitized Group Rations (UGR-A) for Military Field Feeding

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: Develop a reliable, continuous mode conveyor cooking system that prepares military Unitized Group Ration, A (UGR-A) rations without the need for an entire kitchen ensemble. This appliance will utilize not only convective and radiation heat transfer, but also microwave energy. Additional goals are to minimize weight, increase efficiency, enable operation from multiple power sources, and design to military purpose.

DESCRIPTION: An objective of modern military field kitchens is to provide cooks with high quality, effective appliances to maximize capability, throughput, and flexibility to prepare the entire family of operational rations. The Army's legacy JP-8 fired appliances fall short, relying on inefficient burner units that subject cooks to excessive heat, exhaust, and noise. This proposed effort seeks to deviate from the traditional method of preparing rations using standard military cooking appliances, and instead use one appliance to prepare all military rations. Using energy technologies, research and evaluate the possibility of combining microwave energy with hot air impingement utilizing conveyor transport for a singular, universal military field feeding appliance. The UGR-A is the Army’s highest quality group feeding operational ration in use today. This ration uses frozen entrees that are tempered and prepared within any one of several custom military appliances that include, but not limited to, griddles, skillets, stock pots, and ovens. Most items are pre-cooked and are packaged in 50 meal modules. This research proposal seeks to demonstrate proof of concept for a meal being placed on a conveyor belt in its own serving tray and transported through the appliance for rapid cooking with high quality results. Upon exit from the conveyor, the meal could simply be served to the soldier. No other appliances would be necessary, no boiling of water, no stock pots, little clean-up, and one appliance for all UGR-A rations. The combination of high heat transfer of hot air impingement and microwave energy will produce rapid results with high quality. This method of cooking currently exists in fast casual and fast food commercial restaurants in batch mode as a way to rapidly prepare low-cost, high quality meals to order. This topic seeks to find an innovative solution to enhance this technology by going from batch mode processing to continuous mode processing addressing the higher production capacity needs for military

field feeding operations using the UGR-A as the standard ration for development. Also, this system is also intended to be compatible with the UGR-H&S. Offeror will research technologies that combine microwave energy with hot air impingement within an open conveyor transport system to prepare meals rapidly. Alternate methods of preparing UGR-A rations in a 'ready to serve' tray at high capacity would also be acceptable. If heat transfer and production capacity are favorable, explore the opportunity to operate the conveyor transport as a 'pass through' appliance with both entry and exit ports open without microwave leakage. If viable, combine both microwave and hot air impingement technologies into one unit to test a unique, military appliance that can rapidly cook high quality rations in a continuous process. Reducing logistics both from an operational energy standpoint and an operations standpoint is addressed by this concept. One appliance that is compatible with UGR-A's without the need for boiling water to re-heat rations could save significant water from a cooking operation as well as reducing water used for clean-up.. Fuel reductions are also expected.

PHASE I: Establish the technical feasibility of a system concept that meets the operational requirements stated in the topic description by conducting research to demonstrate that the approach is scientifically valid and practicable. Mitigate risk by identifying and addressing the most challenging technical hurdles in order to establish viability of the technology or process. Perform proof-of-principle validation in a laboratory environment, and characterize performance (throughput, power requirements) through experimentation. Address supportability, safety, and human factors concerns, and provide credible projections of size, weight, cost, and performance of a system suitable for fielding. It is envisioned this appliance to be used in mobile military field kitchens that are restrictive in overall space. For sizing purposes, modular military appliances occupy approximately 4 – 5 ft3 of floor space and ideally it is preferred that this appliance will have a footprint of 22"W x 27"D x 50"H. A size of 44"W x 27" x 50"H would be considered acceptable as it would take up two floor positions instead of one. The appliance should weigh no more than 300lbs and cost no more than $7500 in production volumes of 100 or more. In particular, research, design, and develop a breadboard prototype that will not only operate as a continuous mode conveyor cooking appliance but also to demonstrate that it can meet future size, layout, and weight requirements. Comparisons should be made to existing tunnel oven technology, as well as to other similar applications. Cost and functionality are important characteristics that should also be featured in the design. Demonstrate the feasibility and practicality of this process for producing heated UGR-As as well as an initial analysis to demonstrate that there is no microwave leakage. Initial experiments and performance criteria must be performed according to military standards. Deliverables shall include a breadboard prototype as well as a final report specifying full-scale performance for Phase II. Conceptual design, performance, safety factors, risk mitigation measures, MANPRINT, and estimated production costs shall be included for consideration of this effort.

PHASE II: Optimize and refine the conveyor appliance and heating methods. Develop and produce a full scale prototype appliance to demonstrate technical capability that meets all Reliability, Maintainability, and Availability (RAM) requirements. In addition, this system should be sufficiently mature for technical and operational testing, limited field-testing, demonstration, and display. Define manufacturability issues related to full-scale production of the prototype system for military and commercial application. Identify and address safety and human factors associated with the production and use of the prototype. The attached metrics in Table 1 will be used to judge success of the technology as a heating unit for UGR-As.

PHASE III DUAL USE APPLICATIONS: During Phase III, the researcher is expected to perform final tasks necessary to perfect the technology and through advanced testing prove it is capable of fulfilling the requirements necessary for technology transition and commercialization. The transition from research to operational capability will involve technology demonstrations at representative sites, follow-on development work in coordination with the Army Product Manager - Force Sustainment Systems, and ultimately fielding on board one of the Army's field feeding platforms. The development of this appliance will benefit all users by reducing logistics, costs, and weight. Further, this technology may be applicable beyond military applications including commercial and industrial applications.

REFERENCES:
1. Cardello, A.V.,Schutz, H.G. and Wright, A.O. Consumer and sensory testing of rations. In: Military Food Engineering and Ration Technology, A. Barrett and A.V. Cardello (Eds.), Lancaster: DesTech Publishers, 2012, 349-406.

2. Sara R. Jaeger, Armand V. Cardello, "Direct and indirect hedonic scaling methods: A comparison of the labeled affective magnitude (LAM) scale and best–worst scaling." Food Quality and Preference, 2009.. 20, 249-258.

3. http://www.fishnick.com/publications//stm/Rapid_Cook_STM_Development.pdf

4. https://www.troopsupport.dla.mil/subs/rations/programs/ugr/uaabt.asp

5. http://nsrdec.natick.army.mil/media/print/FSE_3ED.pdf

6. http://www.natick.army.mil/about/pao/pubs/warrior/02/septoct/alltoget.htm

7. Performance Metrics Table provided by TPOC, uploaded in SITIS on 12/16/15.

KEYWORDS: Continuous mode conveyor, heat transfer modes, cooking appliance, group rations

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A16-062 TITLE: High Pressure Resistant, Non-Powered, Flexible Chemical/Biological Protective Closure System

TECHNOLOGY AREA(S): Chemical/Biological Defense

OBJECTIVE: The overall objective is to develop a flexible Chemical/Biological (CB) resistant closure system that does not leak liquid (goal of a 36 PSI dynamic load) (2), (3), (4) or air (goal of a 16 PSI static load) (2), (3), (4). This closure system will maintain an air tight seal while subjected to both positive and negative pressures on either side of the seal while providing a low life cycle cost (goal of less than $15 per foot).

DESCRIPTION: Improvements in closures and interfaces are needed to provide liquid, vapor and aerosol CB protection while meeting the strenuous mechanical demands encountered while fielded in COLPRO shelters and body bags that experience pressure differentials. A need currently exists to develop a vapor tight closure that can withstand pressures experienced during normal military air transportation methods(2), (3), (4) to include withstanding stresses experienced in the rapid loss of cabin pressure. The closure system should also be resistant to CB agents, able to be decontaminated by normal military decontamination techniques (bleach, HTH), operated with gloves by the 5% percentile female to the 95% male(6), not require power to operate and have the ability to be used in austere (UV, sand, wind, hot, cold, etc) environments (1). Ideally this closure system would be reusable (able to be opened and closed multiple times). This closure could be used in collective protection systems, inflatable structures, vestibule attachments, individual protection garments, packaging of human remains and air transportation of sick individuals. All materials must comply with Berry Amendment requirements (5). Current closures that are marketed as “air tight” will leak air when under pressure and/or are made of materials that are known to not be resistant to C/B agents. Current solutions are generally based on one of three technologies (or in some cases in a combination of several approaches). These systems suffer from several significant deficiencies that limit the overall utility of the collective protection system into which they are integrated: • zippers: • not decontaminable • not durable • low tolerance to structural load at useable sizes • no standardization • requires secondary closure at end of track • excessive air leakage • difficult to clean and keep serviceable • sewn to liner which creates further leak points • hook and pile/loop:• not decontaminable • not durable • excessive air leakage • edge alignment (therefore engagement area) at mercy of operator • difficult to clean and keep serviceable • joint weakens with use • sewn to base material which creates further leak points • zip-track: • tracks stretch and deform • difficult to use in field conditions • requires secondary closure at end of track • no standardization • takes permanent crease in storage • leaks water at deformations • difficult to install to liner Technical Goals: While the CB seals must be continuous, easy to use, and able to withstand heavy use, they must also provide the mechanical strength necessary to withstand continuous loading from the internal overpressure used with collective protection shelters. A comprehensive performance specification has not been completed, but in general the required system performance can be summarized as follows: • not leak liquid (goal of a 36 PSI dynamic load) (2), (3), (4) or air (goal of a 16 PSI static load) (2), (3), (4). • resist expected field stresses (fabric loads, twisting, pulling, etc.) • ease of use in all operational

scenarios (cold/wet, night, masked/gloved, etc.) • chemical resistant to included decontamination fluids • easily attached to base material • low life cycle cost, technical maturity, high field utility (ruggedness, etc), allows small radius curves (for corners of floor/wall etc), no support equipment required to maintain seal • no support equipment required to maintain seal (electrical power, compressed air, etc.) • minimal impact on storage volume

PHASE I: Design a concept for the high pressure resistant closure mechanism. Develop a test plan to evaluate the closure performance. Demonstrate how the proposed technology will meet the requirements. This can be done by technology demonstration, scale prototype or CAD. Demonstrate that the chosen materials are CB resistant. This can be done by white paper or by providing previous test results (7). Phase I deliverables will include monthly reports, a final report (including a cost feasibility study), and a draft test plan.

PHASE II: Optimization of concept from Phase I. Produce and test multiple iterations of design concept. Validate closure test plan. Demonstrate the chosen materials will perform in operationally relevant environments. Phase II deliverables at the end of year 1 will include monthly reports, a 6-8 foot long prototype, and a test report documenting closure performance in a lab setting. Phase II deliverables at the end of year 2 will include monthly reports, a report documenting performance installed in a representative application in an operationally relevant environment, a full scale prototype installed in a shelter or body bag, level 2 engineering CAD drawings and a Phase III scale up plan.

PHASE III DUAL USE APPLICATIONS: Commercial applications for this product include body bags, dry bags, dry suits, filter housings and hazmat collection. High pressure closures can take the place of chemical adhesives, textile heat welds and other permanent closure methods.

REFERENCES:
1. MIL-STD-810 Environmental Engineering Considerations and Laboratory Tests methods 500-520: http://www.atec.army.mil/publications/Mil-Std-810G/Mil-Std-810G.pdf

49 CFR Parts 105-180, collectively called the Hazardous Materials Regulations (HMR) specifically 173.196(d)(2). Http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title49/49tab_02.tpl

3. The Defense Transportation Regulations (DTR) 4500.9-R: http://www.transcom.mil/dtr/part-i/dtr_part_i_app_i.pdf#search=hazardous&zoom=100

4. Joint regulation AFMAN 24-204_IP, Preparing Hazardous Materials for Military Air Shipments: http://www.wpafb.af.mil/shared/media/document/AFD-121204-014.pdf

5. Berry Amendment: http://web.ita.doc.gov/tacgi/eamain.nsf/BerryAmendment/Berry%20Amendment?Opendocument

6. MIL-STD-1472 Human Engineering: http://www.public.navy.mil/comnavsafecen/Documents/acquisition/MIL-STD-1472G%5B1%5D.pdf

7. TOP 8-2-501: Permeation and Penetration Testing of Air-Permable, Semi-permeable,and Impermeable Materials with Chemical Agents or Simulants (Swatch Testing) http://www.nist.gov/national-security-standards/upload/global_docs_TECMIPT_TTOP_08-2-501.pdf

KEYWORDS: Zipper, closure, chemical, CBRN, hermetic, seal, shelter, air transportation, Ebola

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A16-063 TITLE: Adjustable Reusable Platform for Expeditionary Military Shelters

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: With the majority of Army shelters setup on non-reusable wooden platforms in order to prolong the shelters' lives and to reduce logistical demands while improving the Warfighters' quality of life, a reusable system that can adjust to a variety of terrain is preferred. With a few options emerging from leading manufacturers, we do not currently have the assets to properly compare them in order to make a recommendation on which designs are optimal when asked by those in the field. A reusable system would ideally reduce packaging waste, be modular in design, and improve the energy efficiency of the shelter. New designs, and modifications to existing platform systems are anticipated to meet military applications. Material selection and adjustability for varying terrain are the focal areas to be investigated under this topic. This topic addressed Army Warfighting Challenge 16 “Set the Theater, Sustain Operations, and maintain Freedom of Movement”.

DESCRIPTION: Adjustable Reusable Platform System (ARPS) primary task is to quickly provide a reusable, leveling platform for expeditionary shelters to be setup and placed upon. The system must be robust as to handle everyday use supporting a military soft-walled shelters in multiple environments - ranging from hot/wet and hot/dry to cold temperatures. A successful ARPS would act as a replacement to the current solution of “built-in-place”, constructed wooden platforms. These wooden platforms absorb water, take significant time to assemble and level by skilled workers, and can only be used once. The current flooring solution offers nothing more than a level ground for the setup of soft-walled shelters, where as an ARPS should more easily provide those abilities as well as extreme environmental durability 6, multiple redeployment ability, and possible insulation properties. The price target on an ARPS will be that of the current wooden system being deployed twice, which is approximately $7.50 per square foot. The modular platform must be lightweight, easy to assemble/interlock, and support a point load of up to 120 pounds per square inch and be capable of supporting a uniform load of 65 pounds per square foot (in accordance with section 7.25 of ASTM E1925). The maximum point load shall not cause any permanent deformation of the platform. An ideal system would require no special tools for deployment, assembly, or disassembly. Each module should be single-warfighter portable (under 42 pounds in accordance with MIL-STD-1472F, section 5.9.11.3 table XVII) and be able to pack efficiently into TRICON shipping containers 3. An installation rate of 6 square feet per min by 2 warfighters (or better) is required. The ARPS must comply with applicable floor and material (non-system) requirements outlined in ASTM E1925. The platform must not be prohibitive in allowing equipment to be rolled in or positioned correctly. The maximum height of the system at a shelter entry area for the proposed ARPS is 24 inches; this is to allow for variations in terrain at the set up location. Integration of insulative properties with an R value greater than 5 (R5) is required. The platform must also have “skirting” around it, the ability to enclose the platform as so wind cannot penetrate under the system. Access locations through the floor for cabling and maintenance to supports would greatly improve the functionality as well.

PHASE I: Develop a prototype modular ARPS that meets the requests presented in the description and deliver a number of prototype modules (single “tiles”, or smallest building unit) for durability testing and small scale system testing. These prototype deliverables should be capable of covering a 100 square foot area when integrated with multiple modules. The self-leveling capabilities of the platform (via supports, stacking, or other novel solutions) must be capable of leveling the platform (+/- 0.25”) on ground which does not vary more than 3 inches over 10 linear feet 4 (no shims or non-system materials can be used). The ARPS must be able to be extended up to 24 inches off grade when deployed.

PHASE II: Improve upon the first generation ARPS prototype designed in Phase I based on testing results and prototype usability analysis. Deliverables will include 2 full-scale ARPS prototype systems with drawings for use in early stage operational testing and evaluation in expeditionary military soft-walled shelter systems. The small business under contract will be responsible for a large portion of testing to ready the product for commercialization.

PHASE III DUAL USE APPLICATIONS: A commercialized, highly durable, lightweight ARPS would allow for commercial and industrial use in multiple applications, possibly by simply changing the top/visible surface to meet the need. An improved ARPS could be used in modular/temporary buildings, office space, outdoor event space (concerts, weddings, etc.), radiant heating base-layer, or in a number of other applications where hidden wiring is

desired for safety and organizational reasons.

REFERENCES:
1. ASTM E1925-04, Specification for Engineering and Design Criteria for Rigid Wall Relocatable Structures

2. MIL-STD-1472F, Design Criteria Standard: Human Engineering

3. TRICON Specifications Type I: http://www.cmci.com/Tricons-TriconI.aspx Type II: http://www.cmci.com/Tricons-TriconII.aspx Type III: http://www.cmci.com/Tricons-TriconIII.aspx Type IV: http://www.cmci.com/Tricons-TriconIV.aspx

4. MIL-PRF-44271C, Section 3.4.5 Varying Terrain

5. MIL-STD-882D, Standard Practice for System Safety

6. MIL-STD-810G, DoD Test Method Standard; Environmental Engineering Consideration and Laboratory Tests

KEYWORDS: military, shelter, floor, platform, light weight, reusable, expeditionary, leveling, adjustable

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A16-064 TITLE: Biofidelic Headform for Evaluation of Head Protection Against Blast, Sound and Blunt Trauma Threats

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: Design, fabricate and demonstrate a repeatable and accurate anatomical, biofidelic surrogate of the human head and neck for use in experimental evaluation of soldier protective equipment designed to mitigate injury from blast, acoustic and blunt impact threats.

DESCRIPTION: Traumatic brain injuries have become a signature wound of recent military conflicts and are a major public health problem in contact sports, cycling and accidents. In spite of improved protective equipment and medical care available during recent military conflicts, TBI is the most common neurological disorder among soldiers returning from combat. Head and neck injuries, account for more than 25% of the injuries of service members evacuated from Iraq and Afghanistan1. Each year more than 1 million new TBI cases, with ~50,000 deaths, are diagnosed in the general US population2. Further improvements in head protection equipment using advanced computational and experimental technologies may be the most effective TBI prevention strategy3,4. Experimental evaluation of novel head protection equipment against injurious loads cannot be performed on humans. Animal testing and cadaver testing are possible options, however these options are costly, time consuming, highly variable and do not necessarily provide direct correlations or analog to support injury prediction or assessment of the living human body. The most rational approach is to use a physical surrogate of a human head and neck with resolved anatomical structures required to mount the protection equipment including helmet, eyewear, ear plugs, neck collars, etc. In this way cost effective, repeatable and accurate assessments can made to ascertain the protection afforded of protective equipment ensembles. Over the years several human head surrogates have been developed for automotive, sports and military applications 5-9. Probably, the best known human head surrogate model is the Hybrid III, composed of aluminum skull and vinyl skin with removable skull cap for access to head instrumentation5. More biofidelic head phantom for testing in shock tubes has been fabricated with glass/epoxy mixture for cranial bone, silicone gel for the brain, and syntactic foam for facial structures6. Even more biofidelic head surrogate, using rehydrated human cadaver skull has been recently demonstrated for testing behind helmet blunt trauma9. For rapid, reproducible and cost effective testing of military head gear, the head surrogate should balance several requirements including: anatomic fidelity, modularity, ruggedness, material properties, instrumentation, and cost. In military applications it could be used to evaluate combat and pilot helmets for blast,

blunt and ballistic threats, eye and ear protection, neck protection, head/neck loads from helmet mounted equipment, fit and comfort tests, and others. When properly instrumented it could provide benchmark quality data for validation of computational models of helmeted head biomechanics and TBI.

PHASE I: Develop design specifications for a novel biofidelic physical surrogate of a single size human head/neck for evaluation of soldier protective equipment against blast, sound and blunt threats. Select a representative human head and neck anatomy and develop physical surrogate design and a complementary "virtual head" for high-fidelity computational models. The single size headform should be designed to accommodate a size large Advanced Combat Helmet (ACH) with the expectation to develop multiple sizes of headforms in follow-on phases. Evaluate and select materials for the skin/scalp, skull and intracranial structures. The head surrogate should provide flexibility for testing helmets, helmet retention and suspension systems, eye-wear, hearing protection devices and helmet mounted gear. A ruggedized design is desired for both laboratory and field testing. Deliver a report documenting the design of the physical surrogate and the computational model. If possible, fabricate a prototype head surrogate.

PHASE II: Finalize the design of a modular physical surrogate of a human head/neck. The design should accommodate instrumentation sites and sensors for blast, blunt and acoustic exposures. The head/neck test article should have a universal mounting for installation in shock tube tests, blunt impacts, head drop tests and free field blast waves. Fabricate and conduct pilot tests of blunt impact to a helmeted head and acoustic tests of head with and without mounted ear plugs. Demonstrate the complementary computational model of the helmeted human head exposed to a blast wave, blunt load and acoustic exposure. Perform parametric computational tests to recommend a matrix of experimental tests for model calibration and validation as well as for evaluation of helmet suspension and retention systems. Deliver the prototype head/neck surrogate to the Army for initial evaluation along with system architecture plans for multiple sized headforms.

PHASE III DUAL USE APPLICATIONS: Upon successful completion of the development and testing of the prototype head/neck surrogate, the final design will be fabricated, instrumented, tested and delivered to the Army for further testing and evaluation. The company should aim to establish a standard human head/neck fixture and test protocols for US military, Department of Justice, and other government and civilian users in US and NATO countries. Target cost of single size headform is not to exceed $50,000.

REFERENCES:
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KEYWORDS: Human head surrogate, Traumatic brain injury, military helmets, blast waves, blunt injury, ballistic injury, biomechanics, protective armor

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A16-065 TITLE: Nanostructured Metal Alloy for Individual Armor

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop and demonstrate a nanostructured metal alloy and fabrication process which produces components having high ballistic performance relative to their weight. It can be part of a hybrid material system.

DESCRIPTION: Protecting Soldiers from ballistic threats with very light weight Soldier-borne armor is a key ongoing technical challenge for the Army. In the past, this need has been addressed with metals, rigid and non-rigid fiber based composite materials, ceramic hard faced composite materials, and armor designs which combine multiple materials and material configurations into armor components. Ultrafine grained and nanostructured metal alloys, that is, metal alloys which have crystalline grain sizes that approach a nanometer order of magnitude, show promise for making components having extremely high specific strength (strength to density ratio). Specific strength, along with elastic modulus and strain to failure are key parameters for ballistic performance. In order to perform well, the new metal must have high mechanical properties not only under quasi-static conditions, but also at high (ballistic impact) strain rates. It is also highly desirable that it exhibit ductile, not brittle, behavior at low and high strain rates. A metal alloy which performs as well as fiber based composite armor materials are expected to have a number of advantages relative to composites, including: • Significantly reduced thickness and bulk for a given level of protection • Improved ability to blunt threats • Reduced back face deformation • Improved structural performance • Improved durability A nanostructured metal alloy may be used in various ways to make Soldier-borne armor components. Several examples are: • Metal alloy outer strike face layer with fiber based composite backing layer for helmets, torso protection, and/or extremity protection. • Crack-arresting and/or compressive stress-inducing layer(s) for ceramic hard face armor components • Monolithic metal alloy ballistic shells for helmets • Monolithic metal alloy plates for torso protection

PHASE I: Develop a nanostructured metal alloy having high specific strength and other desirable properties discussed above, and a process to make the alloy. Produce material specimens and test them for: • Tensile strength, elastic modulus, and strain to failure • Hardness • Flexural strength • Thermodynamic stability • Mechanical properties at high strain rates (if possible within time and budget constraints) • Subscale ballistic performance (if possible within time and budget constraints) In order to be competitive with current state of the art composite armor materials, it is estimated that a nanostructured metal alloy should have a specific strength of roughly 450 kN·m/kg or higher. The nanostructured metal alloy must also be thermodynamically stable; that is, its crystalline grains must not grow in size over time at room temperature (22°C / 72°F) or at elevated temperatures (up to 100°C / 212°F). Finally, the process for making the nanostructured metal alloy must be scalable for manufacturing at reasonable cost (rough order of magnitude estimate of unit parts cost less than $220 per kg / $100 per pound.)Phase I deliverables will include at least 10 material specimens for Government use, monthly progress reports, and draft and final versions of a final report. The final report shall document the technology developed and include descriptions and results of specimen testing.

PHASE II: Develop and demonstrate full scale prototype Soldier-borne armor components incorporating the nanostructured metal alloy. Examples of Soldier-borne armor components include helmets, small arms protective inserts (SAPIs), side ballistic inserts (SBIs), and extremity protection. The component(s) selected must demonstrate the capability to make nanostructured metal alloy parts having complex geometry. Prototype components will be tested for mechanical properties, thermodynamic stability, ballistic performance against selected threats, and possibly other parameters depending on the type of prototype components made. Required Phase II deliverables will include at least 20 prototype components for Government use, monthly reports, and draft and final versions of a final report. The final report shall include a description of the nanostructured metal alloy technical solution, and the methods by which it was fabricated. The final report shall also document prototype development and include descriptions and results of prototype testing.

PHASE III DUAL USE APPLICATIONS: Although the initial use of this technology is intended to be Soldier-borne ballistic protection, there are a number of other potential commercial and military uses for it. Other DOD uses include components for explosive ordnance disposal (bomb resistant) suits, rotary wing and fixed wing aircraft armor, and structural components for aerospace platforms. Potential commercial applications for the technology include: • Structural components for aerospace platforms. • Ballistic helmets for law enforcement.• Torso armor plates for ballistic and/or stab protection for law enforcement. • Ballistic and/or blunt impact protective knee and elbow pads for law enforcement. • Ballistic and/or blunt impact protection for extremities for law enforcement. • Components for explosive ordnance disposal (bomb resistant) suits for law enforcement.

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KEYWORDS: Nanostructured, metal, alloy, armor, ballistic, nanocrystalline, thermodynamically stable, Soldier protection.

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A16-066 TITLE: Solid State High Voltage Switching Device for Multi-Point Initiation

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: The objective of this effort is to develop a small, low cost, solid state, high voltage switching device for electronic fuzing applications. Emphasis during all phases of this project should be on developing a device that meets performance requirements with minimized cost and no larger than the size of the current prototypes (preferably smaller).

DESCRIPTION: A typical multi-point electronics design utilizes one or more high voltage switches. These switches are significant contributors to the cost and size of the multi-point system, making them non-starters for many munition applications. Current state of the art switches that are used in these applications cost $100-$200 per switch and are approximately 110mm^3 for a 1400V device. Two Army programs have investigated the use of electronic switching to increase reliability and performance, however it is currently cost prohibitive. Similarly, emerging warhead technologies will require multi-point initiation to achieve scalable lethality and focused effects, which would also have to be cost effective for implementation. Examples of new technologies that may enable the

development of the desired switch are Silicon Carbide (SiC) and Trench and Field Stop (TFS) Field Effect Transistors (FETs) or Insulated Gate Bipolar Transistors (IGBTs). Key requirements for this switching device are a volume of less than 100 cubic mm (smaller is better), turn on time of less than 150ns (+/- 10%), operating temperature range of -45º to +145ºF, ability to survive high G environments (up to 20,000G), standoff capability of 1000-1500 V, high rate of change of current capability greater than 25kA/µs, switching efficiency greater than 85%, and leakage current less than 5µA. The desired unit cost is $5 each in quantities of 10,000 or more (not a guaranteed production rate). The device packaging should be a standard surface mount package, with low inductance (

PHASE I: During Phase I, a feasibility study of the proposed switching concept shall be conducted to provide evidence that demonstrates the concept can meet the stated requirements. This study should identify the equipment and resources needed to prototype a device, as well as initial device designs and unit cost estimates, with sufficient rationale. The Phase 1 deliverable is a final report to include the plan to build and test the prototype in Phase II.

PHASE II: Phase II shall begin by prototyping the initial device design and evaluating its performance against the stated requirements. It is expected that one or more design iterations will occur during the 2nd phase. Phase II will end with a proof-of-concept prototype that demonstrates the performance and producibility of the device. Deliverables include quarterly progress reports, prototype hardware, a manufacturing plan, and a final report, including product cost data.

PHASE III DUAL USE APPLICATIONS: Phase III shall begin with the execution of the manufacturing plan developed in Phase II. Continued development of the device shall be pursued to increase yields and reduce manufacturing costs. Key military applications for these devices include fuzing, electronic safe and arm devices, and ignition safety devices.

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KEYWORDS: fuze, fuzing, switch, thyristor, solid state, high voltage, discharge, pulsed power, electronic, semiconductor, component manufacture, munition, initiation, armament, safe arm, transistor, field effect transistor, diode, multi-point

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A16-067 TITLE: Next Generation Materials for Armor Piercing (AP) Small Caliber Projectiles

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop novel material technologies to replace the current tungsten carbide solution that will meet density and hardness requirements with the objective of reducing the manufacturing cost of the small caliber armor piercing projectile.

DESCRIPTION: The current process of machining tungsten carbide rod stock takes 15 minutes per penetrator. Using current (mostly manual) machining methods, completed penetrators are forecasted to cost about $21 each which is an order of magnitude higher than desired. Current penetrators are typically composed of cemented tungsten carbide due to the material's high density and hardness. However, the metallic binder (traditionally cobalt) that cements the tungsten carbide together often reduces these properties of interest in the bulk component. This effort is seeking a materials solution to develop a high density, high hardness material replacement that can be fabricated into a cost-effective ammunition package. The proposed technology must be amenable to mass production in order to meet annual ammunition buys on the order of millions per year. Key material properties include a density greater than 15 g/cc and a minimum hardness of 2500 HVN, post machining. Envelope dimensions per item are 0.25" in diameter and 2.00" in length. Final per unit cost, post machining, should be no more than $1.00 per piece. Other metrics (such as a measure of toughness, grain size, binder composition, and dimensional tolerances) will depend on the proposed solution and will be addressed during Phase I and II of this SBIR

PHASE I: During Phase I, a feasibility study of the proposed material concept(s) shall be conducted to provide evidence that demonstrates they can meet the stated requirements. This study should identify the equipment and resources needed to prototype the proposed material(s), as well as initial material concept(s) and unit cost estimates, with sufficient rationale. The phase 1 deliverable is a final report and engineering analysis, to include the plan to build and test the prototype in Phase II.

PHASE II: Phase II shall begin by prototyping the material(s) and evaluating its performance against the stated requirements. It is expected that one or more design iterations will occur during the 2nd phase. Phase II will end with a proof-of-concept prototype tested to demonstrate the properties and producibility of the material(s). Deliverables include monthly progress reports, material samples, a manufacturing plan, and a final report, including product cost data.

PHASE III DUAL USE APPLICATIONS: Phase III shall begin with the execution of the manufacturing plan developed in Phase II. Continued development shall be pursued to increase yields and reduce manufacturing costs.

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KEYWORDS: super hard, tungsten carbide, tungsten heavy alloy, net shape, armor piercing, penetrator, bullet, small caliber

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A16-069 TITLE: Airborne Based Sense and Avoid (ABSAA) Sensor for Tracking Non-cooperative Aircraft for RQ-7 Shadow and Larger UAS

TECHNOLOGY AREA(S): Air Platform

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 5.4.c.(8) of the solicitation.

OBJECTIVE: To develop a low cost, low SWAP (size, weight and power) ABSAA sensor.

DESCRIPTION: Unmanned Aircraft Systems (UAS) lack an on-board pilot to "see and avoid other aircraft" as required by Federal Aviation Regulations (FAR). "Sense and Avoid" is an electronic means of satisfying the "see and avoid" requirement for UAS. In order to integrate unmanned aircraft into the National Airspace System (NAS) to meet training and other mission needs, the U.S. Army has developed a Ground Based Sense and Avoid (GBSAA) capability to support unmanned operations within a fixed GBSAA operational volume. GBSAA is especially adept for integration of unmanned aircraft operations in cluttered environments and in high dense airspace near airports. GBSAA is useful for enabling training operations in military operating areas, short transits to military restricted airspace, and general operations anywhere within the GBSAA operational volume. However, full airspace integration requires that operations occur beyond the limited range of local ground sensors. For this to occur, an Airborne Based Sense and Avoid (ABSAA) capability is needed that can be integrated with GBSAA to support the full spectrum of desired unmanned operations. Currently, the major technology gap for enabling an ABSAA solution is a low cost, size, weight, and power airborne sensor that can adequately track non-cooperative (non-transponder equipped) manned aircraft. It is envisioned that an initial ABSAA capability will only operate at altitudes greater than 4,000 feet above ground level where many of the challenges associated with ground clutter and ground tracks are less problematic. GBSAA will support the portion of a UAS flight near terminal airspace and ABSAA will support the portion of the flight outside the GBSAA operational volume. An ABSAA capability will enable automated collision avoidance during loss of link thereby improving the safety of UAS operations. Further, a fully qualified and automated ABSAA capability will enable the future vision of automated UAS operations in the National Airspace System to include operations where one operator controls multiple UAS. Sense and avoid automation will also allow UAS to dynamically and safely coordinate with other aircraft to enable formations and teaming to potentially include new types of manned-unmanned teaming. Future Sense and Avoid capabilities will allow UAS to fly with fewer operational restrictions to enable dynamic operations during emergency response and during military operations. In order to realize the full potential of UAS, an ABSAA capability integrated with GBSAA is needed. In order to integrate an ABSAA capability onto unmanned aircraft, an adequate ABSAA sensor is required. For optimizing the ability of UAS to self-separate from other aircraft and avoid collisions there is a large and complex trade space between sensors, maneuver algorithms, and UAS operator interactions. Many sensor

solutions may potentially exist that provide adequate performance for sense and avoid. Below is an example list of sensor performance attributes that when combined are likely to result in an adequate sensor solution. Other sensor solutions may also exist and the below attribute list is to be used as a guide for example purposes. Low cost, size, weight, and power sensor with high reliability and availability is desired. Sensor design should be modular and fault tolerant with graceful degradation to avoid complete sensor loss during a component failure. Sense and Avoid is a safety critical function. 3D tracking of manned aircraft with a desired 1.5 degree track accuracy (1-sigma) or better in both vertical and horizontal dimensions. Minimizing tracking error in both position and velocity is a key safety factor for assessing potential collision threats and determining optimum avoidance maneuvers. Sensor field of regard of 360 degrees horizontal and +/- 20 degrees vertical with respect to the unmanned aircraft. 360 degree coverage is needed for ABSAA operations on the Shadow RQ-7 aircraft as other pilots are not adequately able to see and avoid the Shadow RQ-7 aircraft. ABSAA sensors placed in dual wing pods or attached to the wings may be one configuration that provides adequate coverage. Sensor resource management with the ability to allocate a portion of search and/or track resources based on operator inputs and/or intruder priority as assessed by maneuver avoidance algorithms is desired. The ability to simultaneously track 4 targets with track updates of once per second while continuing to search the entire field of regard at least once every 5 seconds is also desired. Greater than 95% probability of track at ranges of 3 NM or greater against a wide variety of non-transponding manned aircraft on a collision or near-collision trajectory is desired. Example intruder aircraft include: Lancair Evolution, Cessna TTx, Cessna 150, ultralights, hang gliders, hot air balloons, and sail planes. Maximizing tracking range is a key safety factor for providing adequate response time to avoid other aircraft. Maximizing sensor tracking range is particularly important for avoiding small fast aircraft flying at speeds of up to 250 knots. Sensor tracking at ranges beyond typical on-board pilot visual acquisition is needed to accommodate UAS operator assessment of recommended avoidance maneuvers, mitigate the effects of tracking error by increasing separation distances, and account for the maneuverability limitations of some UAS platforms. A low probability of false track with no more than 1 false track per flight hour when operating at altitudes greater than 4,000' above ground level is desired. Frequent false tracks disrupt UAS missions and may create hazards and unnecessary avoidance maneuvers which lead to conflicts with actual aircraft. Existing technology that has been considered for an ABSAA sensor include Electro-optical camera tracking systems, infrared camera tracking systems, lightweight radar systems, LIDAR, and hybrid technologies that combine sensor technologies. Other sensor technologies that can meet the ABSAA sensor need may also exist. Currently no known sensor technology has been configured or matured adequately to serve as an adequate ABSAA sensor.

PHASE I: Currently, there is no known sensor that can meet the ABSAA mission without maturation and modification. Applicants should demonstrate that they have the ability to innovate, invent, mature, modify, and/or miniaturize sensor technology for integration with unmanned aircraft. Applicants should propose a sensor technology for investigation for the Phase 1 task with rationale on why they believe it to be the best technology for investigation and development. Applicants should provide rationale on why they are well suited for developing the proposed sensor technology. Phase 1 tasks will be to conduct technical analysis, trades, and development planning that provides a clear technical path for ABSAA prototype development in Phase 2 with a high likelihood of success. Phase 1 tasks should show that ABSAA sensor development is technically achievable and that production costs can be managed for eventual commercialization.

PHASE II: Further develop a prototype ABSAA sensor and demonstrate sensor performance in a test environment and on the ground tracking airborne aircraft. Transition from Phase 1 to Phase 2 should be based in part on the applicants understanding of the technical challenges, the plan to manage the technical risks, and a rough order of magnitude cost estimate of a commercialized end product. Phase 2 deliverables include a working prototype tested in a lab environment, ground demonstration of tracking aircraft, analysis of the technical capability, test report, a final report that documents the Phase 2 effort in detail, a plan for integration onto an unmanned aircraft (preferably a Shadow RQ-7 variant), and a plan for further sensor maturation and development that will lead to a successful Phase 3 effort.

PHASE III DUAL USE APPLICATIONS: Further development and maturation of the ABSAA sensor. Integration of the ABSAA sensor onto an aircraft for a flight demonstration of the technology. Transition from Phase 2 to Phase 3 should be based in part on the applicants understanding of the technical challenges and the plan to manage the technical risk. Phase 3 deliverables include a successful airborne flight test where other airborne aircraft are tracked, analysis of the technical capability, test report, a final report that documents the Phase 3 effort in detail, a rough order of magnitude cost estimate of the end commercialized product, and a plan for further development and commercialization. Development of an ABSAA sensor has commercial value as the technology should be low SWAP (size weight and power) to accommodate UAS integration. Technologies developed for military unmanned

aircraft can also be applied to civil unmanned aircraft as well as manned aviation. An ABSAA sensor has specific value in the areas of collision avoidance with other aircraft and bird avoidance. There may also be other multi-mission capabilities for an ABSAA sensor such as UAS navigation in complex urban environments, ground vehicle autonomy to include collision avoidance in the automotive industry, wildlife tracking, tracking of dismount personnel, perimeter security, air defense and tracking other UAS, as well as other applications in naval and space domains.

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KEYWORDS: UAS, Sense and Avoid, ABSAA Sensor, Low SWAP, National Airspace (NAS), RQ-7 SHADOW, Airspace Integration

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A16-070 TITLE: The Internet of Things for Body Area Networks

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: The objective of this call for proposal is to develop a technique and methodology to implement the Internet of Things (IoT) in a novel way to Body Area Networks (BAN)s for dismounted soldiers wearing health sensors, position location devices, etc. to collect, record and analyze data streams faster and more accurately.

DESCRIPTION: In recent years, the Internet of Things (IoT) has explored and built applications along with their attendant use-cases connecting Bluetooth “smart” sensors to the internet. This technology utilizes communications standard IPv6 enabling mobile devices as gateways attaining access to and from the cloud. We are proposing the application of an IoT to a Body Area Network (BON) for dismounted soldiers wearing health sensors, position location sensors, etc. to collect, record and analyze data faster resulting in improved near real-time battlefield

communication, control, planning and decision making. The IoT would provide near real-time soldier's health statistics monitoring on-the-fly and other challenges coincident with big data problems.

PHASE I: 1) Establish a state-of-the-art baseline exploring the idea of extending an IoT to a BAN for dismounted soldiers and proposed a technique or methodology addressing real-time communication and low latency. 2) Develop a methodology to access mobile devices as acting gateways making them accessible to and from the cloud using IPv6 protocol and show end-to end connectivity and control. 3) Analyze the proposed solution(s) addressing design characteristics for application support for body area networks.

PHASE II: Develop, demonstrate and validate Phase I selected candidate algorithms and protocols. Build a test environment to demonstrate the recommended solutions including the Internet of Things (IoT) to body area networks (BAN)s for dismounted soldiers collecting real-time data and analyzing for planning, management and decision making. The BAN will be interfaced with the SDR (Software Defined Radios) provided by the Army Program Office and test case scenario will be developed and exercised implementing design concept. Update the design prototype and algorithms based on testing if necessary at TRL 5.

PHASE III DUAL USE APPLICATIONS: Transition the implementation to the SDR (Software Defined Radio) environment, insert into Soldier Radio Waveform) SRW and perform development tests. Once completed Phase II, this effort has the potential to be considered as an ATO by Army program. A commercial application could be: Utilizing the IoT a cardiologist could provide this device to his critical patients for near real-time health statistics for monitoring on-the-fly problems in order to have quicker turnaround emergency care in urgent cases.

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KEYWORDS: Keywords: The Internet of Things, body area networks, Software Defined Radios, dismounted soldiers.

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A16-071 TITLE: Back Extraction Blast Seat

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop a seat that will protect and accommodate the Soldier in an event, and enable evacuation of an injured Soldier post-event without extraction from the seat.

DESCRIPTION: Ground vehicle interiors are decreasing in size making evacuation of an injured Soldier following an event without inducing further injury increasingly difficult. A new seat should be internally mounted, multifunctional, and detachable, equipped with a restraint harness that, as a system, shall mitigate blast related injuries (overloading of the spine, pelvis, etc.) to the Soldier from explosive hazards. The seat shall additionally accommodate the central 90th percentile Soldier population while fully encumbered and facilitate manual extraction and transport of an injured Soldier while stabilizing the head and spine without extracting them from the seat.

PHASE I: Define and determine the technical feasibility of developing a blast attenuating seat that is lightweight and easily removable from the vehicle without special tools while stabilizing the Soldier's head and spine. The seat must protect and accommodate the central 90th percentile Soldier population while fully encumbered and be durable enough to handle the rugged conditions encountered by ground vehicles.

PHASE II: Develop and test 5 prototype seats that can protect and accommodate the Soldiers while enabling extraction and stabilization post-event. Based on the findings in Phase I, refine the concept, develop a detailed design, and fabricate a simple prototype system for proof of concept. Identify steps necessary for fully developing a commercially viable seat system.

PHASE III DUAL USE APPLICATIONS: Commercialization to the Husky (VMMD), Buffalo/MPCV and MMPV Type 1 and Type II vehicles. Potential additional military applications include, but are not limited to other up-armored Tactical Wheeled Vehicles, Light Armored Vehicles, and Combat Vehicles.

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KEYWORDS: Blast Mitigation, Seat, Lightweight, Protection, Injury Mitigation

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A16-072 TITLE: In-Field Repair Procedure for Fiber-Reinforced Composite Structures

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: To develop and demonstrate an in-field process and procedure for repairing damaged fiber reinforced composite structures without removing it from service.

DESCRIPTION: Fiber reinforced composite materials have the potential to reduce the weight of Army vehicles and structures without degrading their performance. One of the barriers to the adoption of fiber reinforced composites for Army applications are the lack of methods to repair composites without the need to remove the vehicle or structure from service. Examples of in-service damage which may occur in fiber-reinforced composites include cracking due to local overload, impact damage, and delamination. [1] This results in a significant amount of downtime, which affects the unit's optempo. The Army has an urgent need for the development of an in-field process and procedure to repair composite structures while the structure is in place. Currently existing composite repair methods can be grouped into two categories: 1) external doublers and 2) bonded repairs. External doublers involve the bolting or bonding of additional material, such as a pre-cured composite laminate or metal, to cover the damaged area. For this method, bolt holes, if used, must be of close tolerance. Other factors which need to be considered for this method include overlap distance, fastener size, and edge distance. [2] The use of bolts and other external fasteners adds areas of stress concentration to the material and may further weaken the composite due to its low bearing strength. Bonding repairs involve the use of adhesives to place a material patch over the damaged area. [3] These types of repairs may require the removal of the damaged area prior to the addition of new material. This technique requires a clean repair surface to allow for a strong bond to be achieved and lessen the deterioration of the bond strength over time. More importantly, the materials and fiber orientations of the repair plies must match that of the original structure to ensure that the stiffness, strength, and weight of the repair match that of the original structure. These methods require adequate clearance to allow the repair to be performed. [4] Sufficient clearance is also needed to ensure full repair of the damage and transfer of the applied loads from the repair material to the original material. Because this access cannot be guaranteed during an in-field operation, removal of the structure from service may be necessary to ensure sufficient access is attained and bonding areas sufficiently cure. Removing a structure, such as a bridge or vehicle, from service places an additional burden on the remaining resources and increases the difficulty in completing the overall mission. An in-field methodology for repairing composite materials is required to resolve these issues. The repair procedure must include a procedure to produce the material required for the repair on-demand, when the need for the materials arises, as well as a procedure to clean and prepare the damaged structure prior to performance of the repair. The material must be customizable to accommodate variations in stiffness, strength, and shape from one structure to the next. The repair procedure will need to be performed while the structure is in service, while ensuring that the structural performance of the repaired structure is comparable to the original structure prior to being damaged. Full restoration of the structure to its original state is preferred, but restoration to within 90% of the original state is acceptable. Porosity of the repair material and repaired structure must not exceed 2 percent. The repair procedure must be capable of being performed in a variety of environments, to include city, desert, and jungle environments; hot and cold temperatures; high and low humidity; varying levels of wind speed; and varying levels and types of moisture (e.g. rain, snow). Special tools may be utilized as part of the repair process. However, it is preferred that the repair procedure utilize equipment currently issued to Army Soldiers, as specified on http://peosoldier.army.mil/portfolio, to the maximum extent possible. The goal of this project is to define a set of steps which will restore a damaged composite structure to a non-damaged state without any degradation in performance or extended downtime.

PHASE I: In the Phase I effort, studies will be performed to assess the viability of the proposed technical approach. These studies should include discussions with TARDEC to identify specific requirements for the application of this process to military structures. The Phase I effort should include a preliminary analysis of the required equipment/ materials and projected cost for the proposed approach. Small scale manufacturing and material characterization, and fit-up testing may be performed to demonstrate the viability and repeatability of the repair process and procedure on a variety of composite materials. Viability will be assessed based on a comparison of undamaged material properties and properties of the repaired material. For Phase 1, material properties for the repaired material should be within 75 percent of that of the undamaged material. Repeatability will be assessed based on the ability of the repair process to achieve the same material properties from one repair to the next. Up to 75 percent repeatability

should be achieved in Phase I.

PHASE II: In Phase II, the in-field repair process and procedure shall be further developed to scale up and optimize the process, and it shall also be tested and demonstrated. Larger scale manufacturing, materials, and structural testing should be performed to establish the viability of the process for large components and structures and performance of the repaired structure relative to the original structure. The process shall also be demonstrated in a field environment on composite structures of various sizes. The approach should be evaluated in terms of quality of the repair material being produced, time to complete the repair, strength and stiffness of the repair area compared to the original structure, and ability of the repaired structure to transfer applied load from the repaired area to the original component. The Phase II effort should also include the development of instructional tools which will guide the user on the processing of the material and performance of the repair. Phase II shall result in a final repair process and procedure and instructional tool that will be delivered to the Government for User evaluation.

PHASE III DUAL USE APPLICATIONS: The Phase III work will further demonstrate the repeatability and applicability of the repair method to different size composite structures, to include full-scale bridge structures such as the Advanced Modular Composite Bridge or prototype Composite Joint Assault Bridges. Reliability of the repair over time should be further evaluated through fatigue testing to ultimate failure. Potential commercial applications for the technology include automobile repair, as the use of composite materials in automobiles is becoming more prevalent. The technology can also be transitioned to the aerospace and commercial aircraft industries, where use of composites is prevalent, as well as to state departments of transportation for use on highway bridges utilizing fiber reinforced composites. Additionally, this new technology can be transitioned to military depots, providing them with a repair capability for composite parts. The technology may also be applicable to the repair of composite armor and joining of composites in manufacturing.

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KEYWORDS: composites, damage, repair, structures, in-field procedure

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A16-073 TITLE: Abrams Engine Stall Detection Sensor

TECHNOLOGY AREA(S): Ground/Sea Vehicles

OBJECTIVE: Develop a solution capable of detecting the onset of compressor stall or stall precursors in gas turbine engines for the purpose of enabling the suppression of rotating stall prior to a surge event.

DESCRIPTION: The Abrams engine (AGT-1500) is a 1500 hp turbine engine. It is currently suffering from a stalling issue in which the compressor stalls, creating a surge event that causes significant damage to the fourth stage of the low pressure compressor. This damage nearly always results in powerpack removal and a return to the depot to repair. The cost associated with the compressor repair can be up to $200k. While there are currently no other Army ground vehicles that use a turbine engine, there are applications to various aircraft and watercraft. In-depth explanation: There are two classes of compressor stall. The first, rotating stall, is a major limitation of modern turbine engines. In this case a small proportion of compressor blades experience flow separation, creating a region of stalled air which circulates around the engine at roughly half the speed of the rotor's revolution. Key impacts of rotating stall are loss of efficiency, reduction in engine output power, and excess mechanical loading on the compressor blades. Additionally, rotating stall can progress to initiate axi-symmetric stall ("surge"). In an axi-symmetric stall, the entire compressor stage loses the ability to operate, resulting in a local reversal of the air flow. This in turn can cause the stalling of the preceding stage, and allow the phenomenon to propagate forwards through the engine, resulting in compressor surge. In this case the engine completely loses compression, resulting in a reversal of flow through the engine. This, in turn, can cause engine wear, extreme vibration, and even total destruction of the engine. Often the conditions which create the surge remain in place for a period of several seconds, resulting in a repeated surging of the engine. The surge phenomena is common to all turbine engines most specifically those using axial flow turbomachinery and are caused by numerous sources. There are numerous causes of compressor stall and surge, ranging from attempting to increase the engine speed too rapidly, to ingestion of a foreign object, erosion of engine parts, or extreme maneuvering. Surge can also be caused by an engine ingesting hot gases. Solution: What is needed is viable system for measuring the early stages of rotating stall in real-time on an operational turbine engine. We are seeking a technical solution that can detect a surge event in order to take action through the control system to avoid structural damage to compressor blades. The challenge is to monitor the compressor operation without impact to performance in a timely fashion that can be incorporated into the harsh Abrams engine environment for temperature, dust, shock and vibration.

PHASE I: Provide analysis indicating optimal method for identifying/predicting compressor surge. Provide analysis showing maximum amount of time allowable to "move away" from the stall point before catastrophic damage occurs. Develop solution that will identify a compressor surge on the low pressure compressor operating at 25,000 to 33,000 rpm and move the compressor away from the failure point. Deliverables include the technical analysis data and final report. The government will provide design details of the AGT-1500 as needed.

PHASE II: Develop prototype system that includes new data analysis and analytical capabilities at engine relevant conditions. Fabricate 2 surge detection systems suitable for laboratory testing. Conduct laboratory testing on engine throughout engine operating range and during induced surge / stall event. Demonstrate identification and correction of surge / stall event with laboratory level equipment. Identify design changes suitable for vehicle level testing including integration into engine control system. Coordinate results and recommendations with engine OEM. Deliverables include the prototype hardware and software, technical data, test results, and final project report.

PHASE III DUAL USE APPLICATIONS: Following successful completion of Phase II and endorsement of PM Abrams, develop a suitable solution for installation into the Abrams. . Design, fabricate, acquire, and integrate hardware to be installed and tested on the vehicle. Demonstrate operational suitability, reliability, and safety of the prototype to adequately demonstrate a TRL 7 for acquisition. The contractor will be required to coordinate results and recommendations with the engine OEM. Besides applications to the Abrams AGT-1500 Turbine, this technology could be applied to other Turbine applications, such as commercial jet aircraft, larger seafaring vessels, and some trains.

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KEYWORDS: Abrams, AGT-1500, Turbine, Compressor, Stall

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A16-074 TITLE: Two-Speed Final Drive for Recovery Vehicle

TECHNOLOGY AREA(S): Ground/Sea Vehicles

OBJECTIVE: Develop a solution for heavy (70-80 ton) tracked vehicle to increase towing capacity while still maintaining the platform's maximum speed.

DESCRIPTION: As vehicle weights increase, the towing capacity of the recovery vehicles must compensate for this increased load. Heavy tracked vehicles (70-80 ton) require high tractive effort to perform towing maneuvers and it is increasingly difficult to maintain this pulling force as well as achieve the desired maximum vehicle speed when not towing. We are looking for an innovative solution to this dichotomy. The M88-A2 Hercules is a heavy tracked recovery vehicle. It currently has a modest 1050 hp diesel engine coupled to a 3-speed (plus torque converter) crossdrive transmission and a single speed final drive w/o a quick disconnect. The current solution to increase the towing capacity is to change the ratio of the final drive drive whereby increasing the torque to the sprocket. However, just changing the gear ratio will lower the vehicle's top speed even further. The challenge is to develop a solution to fit in the space claim of the vehicle, increases the towing capacity of the vehicle, increases the top speed of the vehicle, and at least maintains (or improves) the ability for the M88 itself to be towed.

Vehicle Performance Requirements [4]
Grade Secondary/Cross Country Terrain
Fine Grain, 250-300 Rating Cone Index (RCI)
10% grade 5 MPH
20% grade 3 MPH
25% grade (30% Objective)
Must be able to negotiate with continued, positive, forward speed

Current Transmission Data
Range Data:
1st Range 4.57:1
2nd Range 2.14:1
3rd Range 1.00:1
Reverse Range 4.95:1
Final Drive Gear Ratio 4.63:1
Total ratio: Combines transmission and output reduction gear assy.
1st Range 4.57 * 4.63 = 21.13:1
2nd Range 2.14 * 4.63 = 9.91:1
3rd Range 1.00 * 4.57 = 4.57 :1
Reverse Range 4.95 8 4.57 = 22.92:1
Torque Converter: Ratio at stall = 3.7:1

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The M88-A2 Hercules has a modest 1050 hp diesel engine coupled to a 3-speed plus torque converter crossdrive transmission. In responding to PM Recovery's desire for improved heavy weight towing capability TARDEC GVPM identified and evaluated several powerpack configurations and final drive combinations. A simple technique to improve low speed towing is to increase the constant ratio of the final drive whereby increasing the torque to the sprocket and subsequently reducing maximum vehicle speed (slow the vehicle down). While this approach appears the simplest and least costly it does negatively impact vehicle maximum speed. This was the basis of a proposed 2-speed final drive to accommodate both low speed tow requirements and maximum vehicle speed. This proposed concept could be fitted to the existing vehicle powerpack to provide improvement at increased vehicle weights in a cost effective manner. The challenge is to develop a concept to fit in the space claim of the vehicle and additionally provide an easy to use disconnect mechanism (similar to Abrams final drive) that allows for external disconnect for to be towed situations.

PHASE I: Analytically determine a conceptual design within space claim constraints. Conduct feasibility study to determine potential configurations and demonstrate through various models that the solution will meet the mobility requirements laid. Deliverables include the technical data, test results, and final project report.

PHASE II: Fabricate prototype solution and demonstrate on an M88-A2 Hercules powerpack provided as GFE. This will include performance test with engine hp ranges of 1050 to 1500 and vehicle weights of 70, 75, and 80 tons as well as durability tests under the same range of conditions. Objective is to demonstrate a TRL 6 suitable for transition to a PM for final development and acquisition. Deliverables include the prototype hardware and software, technical data, test results, and final project report.

PHASE III DUAL USE APPLICATIONS: Develop a solution suitable for installation into the M88-A2 Hercules. Design, fabricate, acquire, and integrate hardware to be installed and tested on the vehicle. Demonstrate operational suitability, reliability, and safety of the prototype to adequately demonstrate a TRL 7 for acquisition. Commercial applications would include commercial heavy construction equipment in the 70-80 ton range, such as bulldozers, cranes, shovels, and others.

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KEYWORDS: Hercules, Final Drive, Transmission, Drivetrain, Gear, Heavy Tracked Vehicle

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A16-075 TITLE: Synthetic Megacity Representation in Army Modeling and Simulation (M&S) Environments

TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop an innovative synthetic megacity representation to support future immersive Army enterprise M&S environments (test, training, acquisition, intelligence, experimentation, analysis). This representation must support multi-level, dense urban terrain, massive civilian populations, and their social, political, and economic interactions amidst Army operations.

DESCRIPTION: In 2014, the Army introduced the Army Operating Concept (AOC) that addressed the challenges to win in a complex world. Expeditionary Army operations will no doubt be essential to preventing conflicts and shaping security environments that have interdependent linkages to cultural, economic, military and political issues. These unique challenges are even more compounded and intertwined in dense urban terrain environments headlined by megacities. With population over 10 million, megacities are regionally and globally connected epicenters that can face multi-faceted challenges of population boom, infrastructure over extension, and economic inequalities, natural disasters, and increased security risks while offering threat actors/networks freedom of maneuver.

As the Army moves forward to better understand megacities, it will develop doctrine and training in these environments. The Army's simulation-based capabilities must reflect the complexities of such environments. To date, many Live-Virtual-Constructive (LVC) events include rather limited and abstracted representation of urban terrain (mostly geotypical building features and limited populations), but it does not adequately address the size, scope, scale, and interactivity of megacities.

Megacity representation within synthetic environments must consider their unique characteristics such as urban, multi-level terrain (high rises, ground, subterranean) and population density, global interconnectivity networks (internet), flow and competition of resources (energy, food, power, waste), and hostile threat actors conducted operations blended within a large civilian populace. All of these impact Army engagements within megacities as well as simulated operational environments, such as those provided by OneSAF, which must model accurate interactions, behaviors, and physical representation of large, complex urban terrain footprints.

The synthetic megacity representation should research and develop novel M&S approaches that will support future immersive training and M&S environments. Innovative solutions to depict simulation-based megacities and their M&S technology challenges with dense, multi-level physical terrain and complex, multi-million population sized interactions should leverage commercial technologies/tools and simulation interoperability standards as it will support Live-Virtual-Constructive environments across the Army M&S enterprise (test and evaluation, training, acquisition, analysis, intelligence, experimentation).

PHASE I: Phase 1 should perform a study to investigate concepts and approaches for representation of megacities and their potential inclusion within future Army M&S environments to support training and other LVC simulation-based activities. The initial megacity conceptual design should include enhanced representation and interaction of political, military, economic (i.e. natural resources), social (i.e. interaction with dense heterogeneous populations/cultures), infrastructure (i.e. communication networks, sewage, power, transportation), physical environments (multi-level terrain), and time (PMESII-PT) and their role, activities, and incorporation into synthetic operational environments with Army units.

PHASE II: Phase 2 extends the deliverable concepts and approaches of megacity representation in synthetic environments and implements a proof-of-concept prototype that could be leverage across the Army M&S enterprise. Potential prototypes could potentially be linked within commercial/government simulation tools such as constructive-virtual environments provided by OneSAF. The prototype should consider specific aspects from Phase 1 investigation and demonstrate a synthetic megacity prototype of a dense, large, multi-tiered urban landscape, millions of individual civilians, and their select interactions across cultural, social, political and economic lines of activities with neutral, threat, and Army military organizations. Such demonstration should consider linkages with future Army training or other simulation-based environments. Demonstration will be at a TRL 4 to subject matter experts to incorporate and refine feedback.

PHASE III DUAL USE APPLICATIONS: A synthetic megacity representation would have significant operational military applications and SBIR research transition prospects. First, the Army's Synthetic Environment Core (SE Core) program has the mission to rapidly generate correlated runtime terrain databases for the Integrated Training Environment (ITE). An ability to leverage processes, tools, and standards for developing megacities would increase physical megacity urban terrain representation fidelity. Next, the OneSAF program of record provides a composable, extensible high fidelity entity level constructive simulation. Megacity capabilities carried forward from this research would augment urban operation behavior/interaction as well as non-kinetic effects representation into the calculus of military operations across the Army's 6 M&S communities of interest. Finally, the future Synthetic Training Environment (STE) program has identified a One World Terrain capability that will feature a single global terrain database with support of megacities.

Commercial applications include gaming, augmented/virtual reality, law enforcement, homeland defense, and humanitarian relief.

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KEYWORDS: megacity, urban operations, terrain, modeling, simulation, synthetic environment, political, economic, social, live, virtual, constructive

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A16-076 TITLE: Augmented/Mixed Reality for Force-on-Force Combat Casualty Care Training

TECHNOLOGY AREA(S): Human Systems

OBJECTIVE: Develop an Augmented Reality protocol and prototype to create visual replication (with visual and haptic cues) of simulated wounds/injuries based on Force-on-Force combat casualty assessments and care. The research would focus on the development and modeling of various wounds and injuries, and couple with a motion sensing (hand tracking) and speech recognition technology to allow for Combat Life Savers and/or medic treatment (treatment actions) of the injuries while in out in the field conditions. The research and development would utilize the MILES detectors as AR fiducial markers for body positioning and visual overlays.

DESCRIPTION: TRADOC's FY15 Science and Technology (S&T) Technology Imperatives Information Paper, identifies the need for Enhanced Combat Casualty Care within the Medical Sciences Area. This topic will focus on the research and development focused on establishing Combat Life Savers and medic training during the "Golden

Hour" in levels of care that include care under fire, tactical field care and casualty evacuation.

Combat Life Savers and combat medics provide battlefield medical care under austere conditions therefore the training, objective assessment, certification, and maintenance of life saving skills used by soldiers and/or combat medics is of critical concern to the U.S. Military. This topic seeks to improve first responder and combat medic training via Augmented Reality (AR) technology with virtual haptic feedback, and gesture and speech recognition. The use of augmented reality is intended to enhance visualization of severe trauma and underlying physiological mechanisms and to support trainee performance (e.g., guide trainees, provide feedback, and assess actions).

More lives are saved on the battlefield by Soldiers (Combat Life Savers) than medics. Research shows that Soldiers are not trained well enough in the basics of Tactical Combat Casualty Care. The proposed research would have support Tactical Combat Casualty Care training as well as more in-depth medic training.

The proposed research and development will use AR technology to superimpose synthetic imagery onto real soldiers and/or medical mannequins instrumented with virtual haptic feedback devices. The proposed system will need to recognize and respond to user actions (e.g. chest compressions, or airway clearing). The proposed system will need to integrate with the Live Training Force-on-Force technology for obtainment of casualty information (type, location, and time of occurrence). The visual representation will need to be time based to align with injury escalation.

The proposed research and development will need to leverage/advance on-going work in dynamic occlusion reasoning, Optical-See-Through (OST) display overlays, and 6-DOF head and hand tracking. The proposed research will need to include speech recognition from the medic under training, and provide appropriate responses/sounds from the patients (based on queries or actions taken).

PHASE I: Determine the feasibility/approach for the development of an integrated augmented reality technologies to meet training requirements in support of US Army medical first responder training within live training domain (field, Force-on-Force) environment. The tasks include a cognitive task analysis to understand the competencies and knowledge requirements associated with combat medicine; a technology analysis to guide the application; and research conducted to evaluate the impact of augmented reality technologies on trainee understanding.

PHASE II: Develop a prototype augmented reality medic training capability that can be utilized within live domain (field) training environments, utilizes/interfaces with the Multiple Integrated Laser Engagement System (MILES) as fiducial markers and for wound identification. Prototype system will need to track injury timing, soldier/medic actions taken, and provide visual/haptic cues in response to the actions taken. Develop of prototype AR capability that can be utilized with medical mannequins for the visual display of injuries/wounds, haptic responses, etc. Demonstrations will be at TRL 6.

PHASE III DUAL USE APPLICATIONS: Refine design and continue technology investigation and integration into a prototype baseline, and implement basic modeling methods, algorithms and interfaces. Pursue fill integration within the Live Training Transformation (LT2) and Tactical Engagement Simulation Systems (TESS) product lines, to define an implementation solution. Continue to develop models, procedures, actions and reactions for injuries and medic actions, ensure complete traceability to medic training requirements. Ensure product line development between live domain and mannequin solutions. Focus on environmental stability and reliability enhancements.

Commercial applications include extending technology to other medical applications and EMT programs.

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KEYWORDS: Augmented Reality, Medic Live Training, Head Mounted Display, Haptic

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A16-077 TITLE: Micro-Electro-Mechanical Systems (MEMS) for Image Stabilization in Small Missiles

TECHNOLOGY AREA(S): Air Platform

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 5.4.c.(8) of the solicitation.

OBJECTIVE: Small missile seekers for applications such as Lethal Miniature Aerial Munitions System (LMAMS), lack functionality typically present in larger and more expensive missile seekers. The objective of this effort is to develop a Micro-Electro-Mechanical System (MEMS) image stabilization device with the MEMS components and the associated MEMS control electronics in one package, allowing implementation in these small systems.

DESCRIPTION: Some missile seekers size, weight, power and cost (SWPaC) requirements prevent the use of gimbals for stabilization, reducing the performance of the seeker. Existing commercial image stabilization technology cannot meet missile environment and performance requirements. One example is the LMAMS, where the current state-of-the-art seeker design consist of a sensor in a strapdown design without gimbals or optical stabilization. MEMS can address the SWPaC requirements but typical controls for modern MEMS devices consist of integrated circuit cards and can use 50 watts of power or more depending on the size of the device. This effort will seek to develop MEMS components that can be integrated with the MEMS control electronics in one small low power package that reduces the SWPaC for these missile seeker while providing full functionality and performance to the soldier. The goal is to develop a MEMS device for optical stabilization in a 1.5 cubic inch package and a weight of less than 0.1 pounds. The performance goal for the device is a slew rate of >100,000 degrees per second to allow deblurring of the seeker imagery. This performance goal should be achieved using a power draw of less than 5 watts. A device of this size could provide optical stabilization for small LMAMS type systems, while also enhancing performance.

PHASE I: Conduct a feasibility study for a MEMS optical stabilization device for a seeker that can be integrated with imbedded seeker electronics. The study should investigate several options that meet or exceed the minimum performance parameters for state-of-the-art gimbal components, while reducing the SWPaC of the combined MEMS and related electronic components. It should also address the risks and potential payoffs of the innovative technology options and recommend the option that best achieves the objective of the technology pursuit. The Phase 1 SBIR efforts are to conduct a thorough feasibility study using scientific experiments and laboratory studies as necessary. At the end of Phase 1 efforts, a technical report will be delivered stating the method used for achieving device, why the method was chosen, results, and recommendations for a path forward.

PHASE II: Deliver a prototype based on the Phase 1 results.

PHASE III DUAL USE APPLICATIONS: Based on results from Phase 2, create a new generation of the MEMS components compliant with military specifications. These products will be further developed for testing at a US Government location. Other applications include intelligence, surveillance and reconnaissance technologies for DoD, Law Enforcement, Homeland Security, Border Surveillance, and Private DoD and Aviation Contractors.

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KEYWORDS: Micro-Electro-Mechanical Sensors, MEMS, Optical Image Stabilization

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A16-078 TITLE: Repurposed Software Programmable Radio Technology to Support Flexible Missile Uplink/Downlink Implementations

TECHNOLOGY AREA(S): Air Platform

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 5.4.c.(8) of the solicitation.

OBJECTIVE: The Army has interest in innovative, flexible, and cost effective re-use of software programmable radio technology to support missile uplink/downlink (UL/DL) capabilities for multiple missiles.

DESCRIPTION: The technology should support multiple missile types. We wish to investigate the adaptation of software programmable radio technology as the basis for more flexible and affordable UL/DL equipment solutions than that yielded by traditional single missile centric UL/DL implementations. The initial technology insertion target would be the Army Indirect Fire Protection Capability phase II (IFPC-2), with potential to support additional missile systems. Frequency mixing to the specific missile UL/DL frequency bands (e.g., L, S, C and X-Bands) will be required, but is assumed to be secondary to the software reprogrammable radio technology. Frequency tuning and message processing across the radio's operational frequency bandwidth is of interest and is primary to the investigation.

Missile uplink/downlink (UL/DL) equipment must be able to support current and future missile systems. Therefore variable message length, encoding, transmission rates, and latency/timeline requirements must be supported. Current and future missiles operate on different frequency bands and require different power levels depending on environment, missile type, and mission range. Accordingly, it would be expected that a software programmable radio would be integrated with mixing and power amplifier circuitry and with a suitable antenna to ensure that communications with a missile are robust and reliable. It can be assumed that the data links for existing fielded missiles cannot be modified due to cost and readiness implications. Supported missiles should include, but are not limited to, the AIM-9X, the AIM-120, and the AI3. Candidate software programmable radios should be based on Army standard radios (programs of record). As background information: The Army Integrated Air and Missile Defense (IAMD) program is defining a Small Footprint Radio (SFR) to support the IFPC platoon network communications requirements.

PHASE I: Investigate and research software programmable radios and/or similar technology to provide affordable and reliable missile uplink/downlink (UL/DL) capabilities for current and future ground launched missile types. Integration, size-weight-and-power (SWAP), mixing circuitry, power amplification circuitry, and antenna technology must be addressed to yield suitable UL/DL concepts and alternatives with the potential for further development into a fielded UL/DL system, but these are second tier items for this investigation. SWAP Thresholds: Size - 1.5 cubic feet, Weight - 140 lbs, Power - 713 watts 28 VDC. Concepts must account for items that the software programmable radio technology would address, including message lengths, encoding, decoding, classified information processing (including possible encryption/decryption), in-band frequency tuning, transmission rates, and timelines/latency requirements for multiple missile types. Given viable technical concept(s), sufficient information to estimate development, test and production costs should be included with technical concept data.

PHASE II: Using the technology approach developed in Phase I, fabricate and validate a prototype to prove the concept of software programmable radios and/or similar technology to provide affordable and reliable missile uplink/downlink (UL/DL) capabilities for current and future ground launched missile types. Fully address integration, size-weight-and-power (SWAP), mixing circuitry, power amplification circuitry, and antenna

technology to yield suitable UL/DL performance with potential for further development into a fielded UL/DL system. Implement support for message lengths, encoding, decoding, classified information processing (including possible encryption/decryption), in-band frequency tuning, transmission rates, and timelines/latency requirements for multiple missile types. Given a viable technical approach and performance, sufficient information to refine estimated development, test and production costs should be included with technical concept data.

PHASE III DUAL USE APPLICATIONS: The commercial application would be within DoD acquisition programs. Transition the Phase II product into a prototype for detailed technical and operational testing. Following testing, perform cost/ performance optimization and prepare sufficient data products to support potential procurement and fielding with the Army Indirect Fire Protection Capability phase II (IFPC-2) or with other potential missile systems. The Army's IFPC-2 would be a potential customer. Other Army programs might follow.

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KEYWORDS: Missile, Uplink, Downlink, Software Programmable

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A16-079 TITLE: High Bandwidth Redundant Communication Links for Small Satellites

TECHNOLOGY AREA(S): Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop a transceiver payload that can provide high bandwidth downlink in Ka band and a backup moderately high bandwidth downlink in X band for small satellites in Low Earth Orbit.

DESCRIPTION: Small satellites [and constellations] in Low Earth Orbit (LEO) have increasingly shown military and commercial value for the sensors and data they can provide. Department of Defense use of small satellites for earth sensing is increasing (e.g. Kestrel Eye). Commercial companies are also interested in the data small satellites can provide (e.g. Skybox, Flock-1, Scout). However, as the sensor payload capability increases, the ability of currently available small satellite transmitters to transmit large amounts of data to the ground are strained. This problem is typically exacerbated by the short line of sight contact windows over ground stations. Additionally, if the main communications link is experiencing interference or an outage, these critical contact opportunities might be missed. A redundant high bandwidth communications link that could be easily adapted for commercial and government use is highly desired. Therefore, a redundant communications link (Transmit) that can provide 120MBPS (Threshold) and 300MBPS (Objective) in spectrum allocated for government use in Ka band and 50MBPS (Threshold) and 100MBPS (Objective) in spectrum allocated for government use in X band is desired. Advanced techniques for increasing the throughput are encouraged if they can be easily implemented in both space and ground transceivers. An uplink (receive) capability of 1MBPS (Threshold) and 5MBPS (Objective) in spectrum allocated for government use is desired. The proposed system must be capable of one (threshold) and three (Objective) continuous transmission events of at least eight minutes each per orbit. The proposed system must be capable of commanded (threshold) and automatic (Objective) Doppler compensation. The proposed system must provide sufficient RF power to establish communications with a 2.4m ground antenna from LEO. The transceiver size must be demonstrated to fit reasonably within the volume and mass constraints of a small satellite. The transceiver must be capable of dissipating the expected heat generated during operation.

Synopsis of requirements:

- Shall provide 120MBPS (Threshold) and 300MBPS (Objective) in spectrum allocated for government use in Ka band (Advanced techniques for increasing the throughput are encouraged if they can be easily implemented in both space and ground transceivers);

- Shall provide 50MBPS (Threshold) and 120MBPS (Objective) in spectrum allocated for government use in X band. Advanced techniques for increasing the throughput are encouraged if they can be easily implemented in both space and ground transceivers);

- Shall provide an uplink (receive) capability of 1MBPS (Threshold) and 5MBPS (Objective) in spectrum allocated for government use in S band (Advanced techniques for increasing the throughput are encouraged if they can be easily implemented in both space and ground transceivers);

- Shall be capable of one (threshold) and three (Objective) continuous transmission events of at least eight minutes each per orbit;

- Shall be capable of commanded (threshold) and automatic (Objective) Doppler compensation;

- Shall provide sufficient RF power to establish high data rate communications with a 2.4m ground antenna from LEO;

- The transceiver size shall be less than 10cmx10cmx20cm (Threshold) and less than 10cmx10cmx10cm (Objective);

- The transceiver must be capable to storing up to 1 TB of data;

- The transceiver must be capable of storing multiple waveforms;

- The transceiver must be capable of receiving new uplinked waveforms
and changing waveforms quickly on-orbit;

- The transceiver shall employ a minimum of 256-AES encryption

- The transceiver shall be capable of dissipating the expected heat generated during operation; and

- The transceiver mass shall be less than 2kg (Threshold) and less than 1kg (Objective).

PHASE I: Phase I is expected to produce an initial transceiver design that can be easily adapted for commercial and Government use. Technical feasibility and predicted performance will be determined through detailed analysis and modeling.

Phase I deliverables will include:

- Initial transceiver design;

- Definition of the requirements and how they will be verified in Phase II;

- Technical feasibility and predicted performance of the approach including thermal, input and RF power will be determined through detailed analysis and modeling;

- Selection of bands for commercial and Government variants will be identified;

- Definition and development of key component technological milestones related to the Phase II program; and

- All data required to support a Stage 1 “Conceptual” DD1494 frequency allocation request and the analogous FCC process.

PHASE II: Phase II is expected to culminate in a protoflight transceiver based on a detailed design. The proposed approach will verify requirements established in Phase I and validate analyses and modeling performed in Phase I. Operation of the protoflight transceiver will be demonstrated with a ground station. The demonstration will be configured to mimic the radio frequency channel expected for use in LEO.

Phase II deliverables will include:

- Matured transceiver design

- Transceiver prototype

- Verification of compliance of all requirements;

- Ground station design;

- Operational demonstration of the transceiver in a representative radio frequency channel; and

- All data required to support a Stage 3 “Developmental” DD1494 frequency allocation request and the analogous

FCC process.

PHASE III DUAL USE APPLICATIONS: The successful completion of this Phase II SBIR will result in a transceiver prototype that can be transitioned to a Phase III for commercial or Government use. This transceiver is attractive for many applications because of the small form factor and game changing capability afforded. There are numerous DoD small satellite programs, especially those sponsored by the U.S. Army Space and Missile Defense Command, and numerous and varied small satellite constellations for remote earth sensing, like those mentioned above, that would benefit from this innovation. Specific military applications include ISR missions requiring color imaging, infrared imaging, Synthetic Aperture Radar, and hyperspectral imaging will require these very high data rate downlinks. SMDC works closely with the USA PEO Missiles and Space Transition Manager and leader for Space Initiatives who will be engaged with this effort beginning with Phase I SBIR activities.

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KEYWORDS: satellite, constellation, space, low earth orbit, transceiver, transmitter, receiver, radio, frequency, wideband, Ka-Band, X-Band, S-Band, communications, downlink, uplink

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A16-080 TITLE: High Power Direct Diode Laser

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: The U.S. Army has a need for a high power diode laser array that will generate upwards of 50kW of output power and can be focused over multiple kilometers to a near diffraction limited spot. Smaller scale proof-of-concept experiments for developing a high power 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. Approaches of interest include coherently beam combining, spectrally beam combining, and other innovative methods that increase output power and beam quality of standard diode lasers. The diode laser array must have a long coherence length or be capable of propagating over kilometer type distances and focusing in a near diffraction limited spot. Diffraction limited spot requirements assume propagation in a vacuum and not in atmosphere. Propagation through atmosphere will cause additional beam degradations that are not expected to be addressed in this SBIR.

DESCRIPTION: The U.S. Army has a need for a high power diode laser array that will generate upwards of 50kW of output power and can be focused over multiple kilometers to a near diffraction limited spot. Smaller scale proof-of-concept experiments for developing a high power 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. Approaches of interest include coherently beam combining, spectrally beam combining, and other innovative methods that increase output power and beam quality of standard diode lasers. The diode laser array must have a long coherence length or be capable of propagating over kilometer type distances and focusing in a near diffraction limited spot. Diffraction limited spot requirements assume propagation in a vacuum and not in atmosphere. Propagation through atmosphere will cause additional beam degradations that are not expected to be addressed in this SBIR.

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 electrically powered high energy lasers for directed energy systems require an additional gain media, such as Nd:YAG, pumped with a diode to achieve necessary coherence lengths capable of long propagation distances. Pumping an additional gain media reduces efficiency and therefore increases the total power requirements necessary to generate desired laser output power. It is desirable to remove the additional laser gain media and use the diode laser output directly. A direct diode approach would eliminate efficiency losses in the external gain media and improve the overall power requirements of a directed energy weapon system.

Current issues with using the output of a diode laser array for directed energy weapon applications include a short coherence length, multiple modes, high divergence angles, and the inability to propagate over a long distance. High energy lasers for directed energy applications require a significant amount of energy propagated a long distance and focused on a target.

PHASE I: Conduct research, analysis, and studies on the selected laser diode array architecture, develop measures of expected performance, and document results in a final report. Provide analysis supporting the method of efficient diode beam combination and expected output beam quality. The phase I effort should include modeling and simulation results supporting performance claims. A preliminary concept and draft testing methodologies that can be used demonstrate the laser diode array system proposed during the phase II effort shall also be produced.

PHASE II: During Phase II, a laser diode array system concept design will be completed. Selected components will be developed and tested to help verify the design concept. A subscale demonstration is desired. Parameters to be verified include wall plug to photon output power conversion efficiency, beam quality, and propagation capability. The data, reports, and tested hardware will be delivered to the government upon the completion of the phase II effort.

PHASE III DUAL USE APPLICATIONS: 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 shall demonstrate scalability 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, diode laser beam combining, high energy laser, highly efficient laser diode, coherent beam combining, on-chip laser diode beam combining

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A16-081 TITLE: Advanced Reverse Osmosis Elements

TECHNOLOGY AREA(S): Ground/Sea Vehicles

OBJECTIVE: Under this topic, the Government invites proposals for the development and demonstration of a new state of the art spiral wound reverse osmosis (RO) element where the active membrane surface area has been modified using a physical process to print/overlay a nanoscale pattern directly onto the standard thin film composite polyamide RO membrane currently used by the Army for desalination to improve membrane life therefore reducing logistics on the battlefield.

DESCRIPTION: The Army requires the capability to purify water at the extra small contingency base (

The proposals should identify a cutting edge scalable process that can print/overlay different nanoscale patterns/geometries/structures onto a standard thin film composite polyamide RO membrane. The technique should be able to be integrated into the current standard industrial process for manufacturing spiral wound elements. The process shall not damage the membrane or decrease the current manufactures specifications of rejection, flux, and membrane life. The patterns/geometries/structures on the membrane surface shall maintain structural integrity when rolled into a spiral wound element configuration. The pattern shall be modeled to show increased mixing and increased velocity at the membrane surface or other characteristic micro scale fluid flow properties correlated to reduced fouling and reduced concentration polarization at the membrane surface.

PHASE I: Demonstrate feasibility of the core technology on a 2.5 inch by 12 inch spiral wound element in a laboratory setting. Verify the element can produce to the minimum manufacturer specification of rejection and flux under the same test conditions prior to modification. Verify through direct comparison biofouling tests that the modified membrane has forty percent reduced fouling properties.

PHASE II: Based on the design parameters elucidated in Phase I, design, fabricate and demonstrate feasibility of the core technology on a 2.5 inch by 40 and 8 inch by 40 inch spiral wound element in a laboratory setting. Fabrication technique should demonstrate ability to integrate into current standard industrial process for manufacturing spiral wound elements. Provide a cost analysis of the developed technology to existing technology. Verify the elements can produce to the minimum manufacturer specification of rejection and flux under the same test conditions prior to modification. Verify through direct comparison biofouling tests that the modified membrane has ninety percent reduced fouling properties. Deliver twelve, 2.5 inch 40 inch length elements for use in the military's light weight water purifier system which can be used by various military and other defense and support organizations for military, humanitarian assistance, and disaster relief operations. The delivered prototypes should be suitable for laboratory and field demonstration but the design does not need to be ready for manufacture, nor is military standard durability required.

PHASE III DUAL USE APPLICATIONS: Technology developed under this SBIR could have an impact on military water purification with the intended transition path being into the planned Man Portable Water Purification System development effort. The development of this technology may also find application in the commercial water treatment industry and possibly in municipal water treatment applications.

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KEYWORDS: Nano, Reverse Osmosis (RO), fouling

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A16-082 TITLE: Structural Battery Development for Military Vehicle Applications

TECHNOLOGY AREA(S): Ground/Sea Vehicles

OBJECTIVE: Structural battery design engineered and embedded in the vehicle structure and/or armor for integrated on-board and increased power and energy for ground vehicles.

DESCRIPTION: The military requires batteries to provide energy and power for starting, lighting, ignition (SLI), Silent Watch, and Hybrid Applications. The demand for battery power and energy, especially for Silent Watch, continues to grow as more sophisticated electronics are developed and added to the military's fleet. One approach to meet this need is to add more batteries to the platforms but assigned space claims are small and limited. Accordingly, an innovative approach is needed to incorporate additional energy storage into the vehicle by integrating batteries into the vehicle structure or armor without affecting personnel/platform survivability, safety, or operational performance and minimizing weight gain. Such a battery will be an integral part of the vehicle structure without encroaching into existing space claims. The design shall not merely package into existing unused space. The vehicle exterior is by far the largest available area to incorporate batteries. Challenges include battery cycle life, replaceability at end of life, extreme temperature conditions exposure, flexibility, modularity, ideal electrochemistry identification, and safety. Battery cycle life should be >2000 cycles. Proposal shall address how the methodology of the energy extraction shall be achieved and distributed within the vehicle.

PHASE I: Identify and determine the engineering, technology, and electrochemistry needed to develop this concept. Drawings showing realistic designs based on engineering studies as well as identification of suitable electrochemistries are expected deliverables. This phase also needs to address the challenges identified in the above description.

PHASE II: Develop prototype structural cells (>3Ah) for evaluation. Cells shall be integrated into a 24V battery system with an installed energy of at least 500Whr to demonstrate an understanding of the technical design problems. There must be sufficient testing to demonstrate that the expected battery cycle life will meet >2000 cycles and that the structural battery will survive field conditions.

PHASE III DUAL USE APPLICATIONS: This phase will begin installation of the structural battery on a selected vehicle platform (military, commercial EV/HEV, etc.) and will also focus on production aspects of the structural batteries.

REFERENCES:
1. J. P. Thomas, M.A. Qidwai, "The design and application of multifunctional structure-battery materials systems," Journal of the Minerals, Metals and Materials Society, 57, 3, 18-24

2. J.F. Snyder, R.H. Carter, E.L. Wong, P.-A. Nguyen, K. Xu, E.H. Ngo, and E.D. Wetzel, "MULTIFUNCTIONAL STRUCTURAL COMPOSITE BATTERIES," http://www.dtic.mil/cgi-

bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA472085

3. S. Xu et al, "Stretchable batteries with self-similar serpentine interconnects and integrated wireless recharging systems", Nat. Commun. 2013, 4, 1543.

KEYWORDS: armor, integrated, batteries, structural, power, energy

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A16-083 TITLE: Laser Protection for Day Cameras

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop technology approaches to protect vehicle vision system day cameras from being damaged significantly by pulsed lasers with wavelengths in the visible spectrum.

DESCRIPTION: The proliferation of multiple laser wavelengths may present a significant danger to ground vehicle vision systems, including day camera sensors. One way to protect viewing systems against fixed frequency lasers is to use narrow band spectral line rejection filters at the known laser wavelengths, attenuating incident laser energy at these wavelengths, thus preventing laser radiation from damaging the sensor. As the number of possible laser wavelengths increases, this approach becomes less practical. Another approach relies on nonlinear optical materials (nonlinear absorbing dyes, nonlinear scattering suspensions, etc.) which must be located at the focus of an optical system in order to obtain the high fluence necessary to trigger the nonlinear mechanism. This SBIR topic solicits new, innovative approaches to provide protection against pulsed lasers operating at wavelengths throughout the visible spectrum for day camera sensors. The protection material within the protection system shall be a stable solid material and no powered electro-optics are allowed within the protection system. The protection material/system can be integrated in any location within the optical system. However, techniques for integration of the protection technology into optical systems which limit the growth of the optical system space claim and minimize integration cost are preferred. The proposed technology should allow ample transmission of ambient visible light and be of high optical quality (including low haze) so as not to significantly degrade vision system performance. It should have a fast response time when exposed to dangerous fluence levels, sufficient to react to and block incident laser pulses to a high optical density. The technology must have a broadband response; blocking any visible wavelength (i.e. 400-700 nanometers) which has sufficient irradiance to damage sensors significantly. The concept should be capable of changing from a high transmission state to a very low transmission state within sufficiently short time to block nearly all of the light contained in a light pulse emitted from a (non Q-switched or Q-switched) pulsed laser. The dynamic range (the range between the minimum and maximum input pulse energies over which the protection is provided) shall span several orders of magnitude. Protection from multiple pulses at commercially available repetition rates is desired. The laser-induced damage threshold of the protection material or system components and the localized laser damage site's impact on sensor performance shall be discussed. The proposal should discuss in detail the spectral transmittance in the transmissive and attenuating states, the activation threshold, the response time, the optical density in the attenuating state, and the recovery time of the technology, as well as any other important technical details. If at all possible, the proposal should show preliminary optical limiting data taken in an

optical system with the material at an f/5 intermediate focal plane.

PHASE I: Develop a laser protection concept designed to meet the requirements stated. Identify critical technologies for realizing this concept. Conduct theoretical analysis and limited laboratory testing (including optical limiting performance testing and optical characterization testing) on sample materials or devices to prove the feasibility of the concept. Phase I deliverables shall be test data, monthly progress reports, a final technical report, a final review meeting (including presentation materials) and sample materials or devices.

PHASE II: Develop and demonstrate a laser protected prototype system. The prototype should be built in the form, fit and function of, or integrated for use in conjunction with, a camera system to be proposed by the contractor during Phase I and approved by the government. This prototype shall be tested for laser protection performance and degradation to optical system performance in a laboratory environment. Factors to be considered include, but are not limited to, optical density upon laser illumination, response time, recovery time, linear optical properties under normal daylight illumination, ease of manufacture, and environmental stability. Optical density and response time upon laser illumination should be sufficient to protect the sensor from common class IV visible pulsed lasers. The recovery time should be on the order of a frame of video, commonly 1/30th or 1/60th of a second. The linear optical transmission properties under normal daylight should be higher than 40%. The proposed technology should be stable over military operating environmental conditions as specified in Mil-STD-810 E, specifically the operation and storage temperature requirements. The method of manufacture should be described. Phase II deliverables shall include a prototype laser protected camera system, interim sample materials (if applicable), test data, monthly progress reports, semi-annual progress reviews, a final review, a final report, and a Phase II project summary.

PHASE III DUAL USE APPLICATIONS: The most likely Phase III transition path is integration of this technology into ground combat vehicles via vehicle system prime contractors.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This technology could be applied to other military platforms

REFERENCES:
1. Standards for Hardening U.S. Army Sensors Against Antisensor Lasers, 27 April 2008.

2. Filter, Laser Hazard Protection, MIL-DTL-62422D(AT), 17 Aug 2010.

3. American National Standard for Safe Use of Lasers, ANSI Z136.1—2014, American National Standards Institute, Inc., 2014.

4. Spiricon Corporation, Camera Selection Guide, Spiricon Inc., Logan Utah, 84341-5740, 2003.

5. Zhang, C., Blarre, L., Walser, R.M., and Becker, M.F., “Mechanisms for laser-induced functional damage to silicon charge-coupled imaging sensors,” Applied Optics, Vol. 32, No. 27, Sep 1993.

6. Teppo, E., “GE TN2505 CID Array Camera Characteristics as a Function of Incident Laser Fluence at 532 nm and 1064 nm,” Big Sky Corporation, P.O. Box 3220, Boseman, MT 59772 May 1986.

7. Lu, J., Ni, X., Lin, Z., and He, A., “Measurement of threshold of damage to a charge-couple device caused by a Q-switched laser,” Microwave and Optical technology Letters, Vol., 11, No. 4, March 1996.

8. Janesick, J., Scientific Charge-Couple Devices, SPIE Press, P.O. Box 10 Bellingham, Washington, 98227, 2000.

KEYWORDS: Lasers, wavelengths, energy, frequency, hazardous, optics, cameras, CCD, CMOS

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A16-084 TITLE: High Power Density Diesel Engine Piston Temperature Measurement System

TECHNOLOGY AREA(S): Ground/Sea Vehicles

OBJECTIVE: Develop a laboratory measurement system capable of capturing and recording transient temperatures on a piston in a diesel engine during engine operation. This capability is sought to address the problems associated with traditional piston temperature systems which include: difficulty of implementation, durability, recorded signal quality, and dynamic temperature response.

DESCRIPTION: Anticipated future low rejection, high output vehicle diesel engines operating above 90 BHP power per liter of engine displacement at extreme desert like operating conditions will introduce new engine design limits; one of which is engine piston surface temperature. Temperatures above critical material property limits can result in reduced engine life and piston failure. Optimization of piston design for such low rejection, high power density engines while maintaining acceptable piston surface temperature is a critical step in the engine development process.

Acquiring piston temperature measurements in an operating engine has always been an arduous task. Difficulty results from high speed reciprocating motion of the piston which does not allow simple physical connections to be made to instrumentation mounted in the piston. Additionally, traditional thermocouples temperature measurements have conflicting design parameters of response time and durability due to the physics associated with the thermocouple junction. Other methods involve measuring changes in chemical properties of a known material and inferring a steady-state temperature which lacks accuracy and transient temperature response needed.

The Army is looking for enhancing the capability of a laboratory measurement of piston temperature during diesel engine operation with the ultimate of objective of utilizing such a tool for the design of low rejection, high power density diesel engine pistons. The goal of this topic is to develop a measurement system that is easy to implement into a piston of a diesel engine for use in a dynamometer laboratory environment. The system should be designed to withstand in-cylinder pressure up to 250bar, mean piston surface temperatures of 600°C, and engine speeds of 3500RPM. The transient temperature response time of 1 microsecond is desired with a useful system life of 200 engine hours.

PHASE I: The objective of Phase I is to demonstrate the feasibility of gathering temperature measurements at relevant diesel engine conditions. A preliminary design of the system shall be proposed that includes all necessary software (controller, signal processing etc.) and hardware. The design should demonstrate that high quality, real-time data can be obtained that meets the requirements stated above. A proof of concept test is recommended to validate key design specifications.

PHASE II: The objective of Phase II is to develop and implement a breadboard measurement system, and its associated signal processing methods, that can be used to measure real-time transient temperature in a laboratory diesel engine. Improved system design will be refined based upon the data gathered in Phase I. The complete system will be operationally tested and evaluated on a relevant military diesel engine in a laboratory dynamometer facility to assess measurement system accuracy, reliability, and durability.

PHASE III DUAL USE APPLICATIONS: Further development of the above temperature measurement system to become a “turn-key” system is the primary objective of Phase III. The final design will hard-wire and package all sub-systems so that the complete system is a stand-alone unit that has the ability to interface with other key laboratory data acquisition equipment. Detailed system design, operation manual (including safety requirements / procedures and troubleshooting logic) and software (for both data acquisition and acoustics post-processing/mapping) shall be provided in the overall measurement system. A final evaluation and demonstration of the resulting system will be performed by the contractor.

The resulting measurement technology and hardware is applicable to both military and commercial engines. The ability to measure piston surface temperature enables the further refinement of piston design of low heat rejection, high power density military diesel engines and commercial light and heavy-duty engines. This improved

measurement capability unit will also provide the missing temperature data (at locations in the engine) needed to validate and improve engine heat transfer models which can subsequently improve the piston design process by allowing designers a more accurate representation of piston cooling requirements. The data and their associated/validated mathematical models will be useful in the engine design cycle, reducing the cost and time to design an engine.

REFERENCES:
1. Raffa, C., Schwarz, E., and Tasdemir, J., "Combat Vehicle Engine Selection Methodology Based On Vehicle Integration Considerations," SAE Technical Paper 2005-01-1545, 2005, doi:10.4271/2005-01-1545.

2. Research Needed for More Compact Intermittent Combustion Propulsion Systems for Army Combat Vehicles, Blue Ribbon Committee Report, November 1995, DTIC accession number: ADA301691, http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA301691

3. Schwarz, E., Reid, M., Bryzik, W., and Danielson, E., "Combustion and Performance Characteristics of a Low Heat Rejection Engine," SAE Technical Paper 930988, 1993, doi:10.4271/930988.

KEYWORDS: diesel engines, temperature measurement, compression ignition, combustion, propulsion system, power density, specific power

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A16-085 TITLE: Lifecycle Test Optimization

TECHNOLOGY AREA(S): Ground/Sea Vehicles

OBJECTIVE: Develop and deploy a system reliability testing and optimization tool which will concretely describe the value of subsystem level tests and incorporate the results into system-level evaluations.

DESCRIPTION: The Program Managers (PMs), Program Executive Offices (PEOs), Research Development and Engineering Centers (RDECS), and Original Equipment Manufacturers (OEMs) and suppliers who develop and integrate technology into ground vehicles all perform tests on subsystems and components. However, the Army depends on a system-level test to validate OEM compliance with reliability requirements. The automotive industry uses laboratory testing to great efficiency and effect, reducing cost, saving time, minimizing risk and elevating performance. The PM/PEO and test community all desire to be more efficient with respect to testing but currently lack the analytical tools to help them fit early subsystem level testing into a framework which allows them to perform assessments at the system level. OEMs, suppliers, RDECS, and other government and private labs are available and are used (at contractor discretion) to improve reliability and discover failure modes. However, the Army lacks the tools needed to determine which subsystems should be tested in the lab in terms of a tangible return on investment of reduced cost, time and/or risk. Furthermore, as subsystem testing is performed, we do not currently have tools which allow us to include subsystem test results into system-level reliability metrics. This SBIR seeks to develop a software analytical tool which will:
1. Relate component and subsystem tests to system-level reliability needed for incorporation into system-level assessments. (e.g. how should results from an engine test or a suspension test be used in the Mean Miles Between Failure metric at the system level?)
2. Optimize the amount subsystem level testing to reduce overall time, cost and risk. In this context we assert that a trade exists between component and subsystem level testing and system level testing. Subsystem and component testing help discover failure modes earlier in the design but add cost, system testing is needed to discover integration

issues but discovers failure modes very late, thus adding time and cost in corrective actions. By this we are attempting to quantify this trade in an analytical and rigorous way.
3. Develop test plans that utilize a Design of Experiments (DOE) approach to most effectively test the right variants of vehicles in the most productive terrains.
We envision that that output of this tool (i.e. software) will be a rank ordering of recommended subsystem tests and an identified set of subsystem tests deemed 'optimal' with respect to overall test time, cost and program risk.

PHASE I: Perform a study and develop an analytical framework for the optimization tool. Major deliverables should be the description of optimization parameters, targets and constraints. It should also include a preliminary mathematical analysis of feasibility. It must include linkages of inputs (i.e. FMEA, test cost, corrective action cost, risk) and outputs (failure data) to programmatic information (i.e. required or given in a contractual relationship). It should include a flow chart and/or pseudo code of the process proposed. It should also provide a walkthrough of the process with a real or notional case study.

PHASE II: Leveraging the products from phase I, finish the analytical framework development and implement the framework in software targeting a Microsoft Windows platform around a real or notional case study. Implement the case study in the framework and demonstrate its feasibility. The product should include a thorough description of the inputs required. It should also include a manual and training for up to 12 associates.

PHASE III DUAL USE APPLICATIONS: This tool will help the PM and Evaluation communities ascribe value to their choices of test approaches. It has direct application to Army Ground Vehicle PMs/PEOs. Commercial application is software which can be used by PMs, ATEC and military OEMs.

REFERENCES:
1.
http://www.ndia.org/Divisions/IndustrialWorkingGroups/IndustrialCommitteeOnTestAndEvaluation/Documents/Jun_2013_STAT1_Raytheon.pdf

2. http://www.dtic.mil/ndia/2012TEST/13958_Rogers.pdf

3. http://www.nt.ntnu.no/users/skoge/prost/proceedings/cdc-ecc-2011/data/papers/1823.pdf

KEYWORDS: Testing, optimization, M&S, laboratory testing, subsystem, component, risk, cost

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A16-086 TITLE: High Fidelity Simulator for Hardware-in-the-Loop Testing

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: To develop a high spatial fidelity electro-optical (EO) simulator for hardware-in-the-loop testing applications.

DESCRIPTION: Hardware-in-the-loop (HWIL) simulators are playing an increasingly important role in performance evaluation, as well as risk and cost reduction associated with development of high complexity electro-optical systems, including the next generation of EWCM and IRCM systems. Dynamic infrared projection systems serve as key EO simulation components of several HWIL systems [1-5]. While significant progress was made in this area, the existing HWIL projection systems are fundamentally limited in the achievable spectral composition, the output radiance levels, and the achievable scene dynamic range, constrained by the projection frame rates and the gray-scale digitalization [1, 3]. At the same time, generation of high fidelity spatial and spectral signatures during the HWIL testing is highly important for performance verification and validation of several key components of the systems under test.

PHASE I: Provide the feasibility analysis as well as the top-level system design of the high fidelity EO simulator for HWIL testing. The feasibility analysis should identify the major technical risks that need to be addressed during the development. The top-level design should focus on selection of the key components required for successful fabrication of the system prototype during the following phase. The phase I deliverables will include a complete feasibility study incorporating details of the system-level design alternatives, selection of the optimum design approach, and the expected system performance based on the choice of the key simulator components.

PHASE II: Based on the concept developed during the Phase I effort, produce detailed design and tolerance analysis of the high fidelity EO simulator module for HWIL testing, including design of optical, electrical, mechanical, and software components and sub-systems necessary for the module prototype demonstration. Develop and build the functional prototype. Evaluate operational performance of the simulator, including static and dynamic performance, spatial and spectral characteristics, field of regard, and the output radiance. Identify any practical limitations, as applied to the key operational characteristics, and define optimum trade-offs between these characteristics. The Phase II deliverables will include system's design, fabrication and assembly of the high fidelity EO simulator prototype, performance evaluation, as well as the final report.

PHASE III DUAL USE APPLICATIONS: Commercialize the developed EO simulator by transitioning the developed solution to the Government laboratories, and industry, making it available to system integrators involved in development and testing of the electro-optical systems and components for the next generation of EWCM and IRCM systems.

REFERENCES:
1. J. R. Dupuis and D. Mansur, "Contrast Analysis for DMD-Based IR Scene Projector", Proc. SPIE, Vol. 8015, Technologies for Synthetic Environments: Hardware-in-the-Loop XVI, 801505(2011).

2. A. M. Carstens and R. G. Stockbridge, "Wideband Infrared Scene Projector (WISP)", Proc. SPIE, Vol. 2474, 132-138 (1995).

3. O. M. Williams, "Dynamic infrared projection: frame rate requirements", Proc. SPIE, Vol. 2223, pp. 87-99 (1994).

4. T. M. Cantey, et. al, "Hybrid infrared scene projector (HIRSP): a high dynamic range infrared scene projector", Proc. SPIE, Vol. 6544, Technologies for Synthetic Environments: Hardware-in-the-Loop Testing XII, 654409 (2007).

5. T. M. Cantey, et. al, "Hybrid infrared scene projector (HIRSP): A high dynamic range infrared scene projector, Part II", Proc. SPIE, Vol. 6942, Technologies for Synthetic Environments: Hardware-in-the-Loop Testing XIII, 69420J (2008).

KEYWORDS: Hardware-in-the-loop (HWIL), electro-optical (EO) simulator, high dynamic range, high output radiance, multi-spectral

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A16-087 TITLE: Gallium Nitride (GaN) based 28 VDC Circuit Protection and Distribution

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Design a 28VDC, 32-channel gallium nitride (GaN) based power distribution box capable of operating across on all military ground vehicles. As compared to silicon based designs, using GaN materials should reduce size, weight, and cooling requirements while increasing maximum current throughput.

DESCRIPTION: Advanced GaN solid state technology is necessary for future military vehicle systems with increased power demand. Vehicle electrical power requirements are growing and without technological advances, trade-offs will have to be made on payload vs. capability. The electrical power distribution devices must account for safety, efficiency, scalability, configurability, CAN control, integration, and robust stable operation. The solution will have the processing power necessary for fault detection and handling capabilities, built-in diagnostics, and stand alone and remote control in a compact device suitable for use in military ground vehicle applications. The use of wide bandgap power electronics that can operate in a 71C ambient environment is required. The use of input power lugs is allowed to minimize size, as long as provisions are present to prevent accidental short circuits between terminals or to ground. Topic proposals should focus on power units capable of distributing up to 300 amps 28VDC from a single 32 channel unit. Each channel within the unit should use no larger than 12 gauge terminals, be capable of handling a minimum of 20 amps, and be capable of being paralleled in groups up to 300 amps of circuit protection to a single device. Each channel or group of channels should have an individually configurable I2t trip curve.

PHASE I: Develop a proof of concept circuit for an advanced, intelligent, 28VDC GaN power module that addresses the features and functionality described above. This preliminary design will also include a packaging plan with SWaP, thermal analysis and considerations for meeting MIL-STD-1275E, MIL-STD-810G, MIL-STD-461 supported by modeling, analysis, and/or brassboard proofs of concept, all to be provided.

PHASE II: Electrical, thermal, mechanical, and functional aspects of a 28VDC solid state 32 channel GaN power control solution will be designed, developed, and built. Demonstration and technology evaluation will take place in a relevant laboratory environment or on a military ground vehicle system. Phase II will reach at least TRL 5 and commercial viability will be quantified.

PHASE III DUAL USE APPLICATIONS: Mechanical packaging and integration of the solution into a vehicle with low voltage 28VDC power buses will be achieved (TRL6) and a technology transition will occur so the device can be used in military ground vehicle applications.

REFERENCES:
1. MIL-STD-1275E (CHARACTERISTICS OF 28 VOLT DC INPUT POWER TO UTILIZATION EQUIPMENT IN MILITARY VEHICLES)

2. MIL-STD-810G (DEPARTMENT OF DEFENSE TEST METHOD STANDARD)

3. MIL-STD-461F (REQUIREMENTS FOR THE CONTROL OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS OF SUBSYSTEMS AND EQUIPMENT)

KEYWORDS: Power Control Modules, Intelligent Power Distribution, Solid State Power Electronics, Gallium Nitride, GaN

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A16-088 TITLE: Gallium Nitride (GaN) based 28 VDC to 120 VAC Inverter

TECHNOLOGY AREA(S): 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 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop hardware to demonstrate the application of commercially available GaN electronic switching devices to reduce the size, weight and power (SWaP) loss of low voltage power conversion hardware within the Combat Vehicle Prototype (CVP) Next Generation Power Architecture.

DESCRIPTION: Current vehicles use Commercial Off-The-Shelf (COTS) power inverters to power 120VAC loads. These inverters are large and inefficient. They rely on active cooling, which is indicative of the inherent inefficiencies and relatively low operating temperatures of the silicon switching devices used in them. What is more, the power used by their active cooling exacerbates their overall inefficiency, while contributing to reliability concerns. GaN switching devices have the potential to greatly reduce the SWaP of such converters by minimizing or eliminating the reliance on active cooling by virtue of their low on-state resistance and low switching losses. The low thermal resistance of GaN further reduces the need for active cooling by allowing these devices to dissipate heat much better than their silicon counter parts. Another benefit GaN devices offer is higher speed switching capability which makes it possible to reduce the size and weight of other typically large devices used in power converters, i.e., transformers and inductors.

Finally, the COTS power inverters currently used do not meet many of the typical requirements for military grade electronics leading to a high rate of failure. Phase III of this effort will result in a solution that addresses this.

PHASE I: Develop a proof of concept circuit for a device that produces 2.5kW rms of sine wave electrical power at 120V/60Hz with less than 3% thd, converted from 28VDC input power as specified in MIL-STD-1275E. A successful effort will utilize GaN power electronics to minimize size, with weight and overall efficiency secondary design considerations. Cooling options for this phase include active and passive air cooling that allow the device to operate at an ambient temperature of 71°C. This preliminary design will also include a packaging plan with SWaP, thermal analysis and considerations for meeting MIL-STD-1275E, MIL-STD-810G, MIL-STD-461 supported by modeling, analysis, and/or brassboard proofs of concept, all to be provided.

PHASE II: Electrical, thermal, mechanical, and functional aspects of a 2.5kW GaN inverter will be designed, developed, and built. Demonstration and technology evaluation will take place in a relevant laboratory environment or on a military ground vehicle system. Phase II will reach at least TRL 5 and commercial viability will be quantified.

PHASE III DUAL USE APPLICATIONS: Provide a military grade version of the hardware provided in Phase II which can be used in current military vehicles. Militarization includes meeting standards for shock, vibration, environment, reliability, and maintainability. A reduced-cost version of this hardware, which may not meet some of

the above mentioned military standards, could be offered to the commercial truck, recreational vehicle and construction industries.

REFERENCES:
1. Data sheets and publications available from Efficient Power Conversion Corporation (EPC) & GaN Systems

2. MIL-STD-1275E (CHARACTERISTICS OF 28 VOLT DC INPUT POWER TO UTILIZATION EQUIPMENT IN MILITARY VEHICLES)

3. MIL-STD-810G (DEPARTMENT OF DEFENSE TEST METHOD STANDARD)

4. MIL-STD-461F (REQUIREMENTS FOR THE CONTROL OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS OF SUBSYSTEMS AND EQUIPMENT)

KEYWORDS: Power conversion, inverter, GaN, gallium nitride, energy efficiency

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A16-089 TITLE: Robotic/Automated Occupant Assist of Unmanned Ground Vehicles

TECHNOLOGY AREA(S): Ground/Sea Vehicles

OBJECTIVE: The objective is to develop a robotic/automated occupant ingress/egress or loading/unloading assist system for use on a mobile ground robot.

DESCRIPTION: There is a need to develop robotic and automated devices that can be utilized on the lightweight, electrically operated vehicles to provide assistance to passengers with severely reduced mobility. The envisioned system could encompass an advanced manipulation, rigging, paired autonomous systems (autonomy enabled wheel chairs or similar devices) and specialized supporting devices (i.e., custom wheel chairs, walkers, crutches, etc.). The envisioned form factor design is compact, lightweight, with low power consumption in order to be integrated onto the lightweight electric Applied Robotics for Installation and Base Operations (ARIBO) vehicles. The occupant assist system should be as automated as possible and take less than 45 seconds to load/unload a passenger. The system shall be compatible with the vehicle, its power system, and should be efficient to not hinder the electric vehicle's range and operating capabilities by more than 15-20%. The system shall only require assistance from another passenger/aid/bystander to load/unload a passenger if the passenger does not have use of both their arms. The system shall not require any fixed apparatus at the pick-up/drop-off points.

This technology with directly benefit the ARIBO pilot project at Ft. Bragg, NC. This project is focused on accelerating automated vehicle technology transition through long-term use in real-world environments. It will provide automated, on-demand transportation to wounded warriors traveling between the Warrior Transition Battalion barracks and the Womack Army Medical Center. The Ft. Bragg project will utilize Cushman 6T electric vehicles, inter-operability profile (IOP) compliant interfaces, and an army-developed behavior engine. These vehicles are currently incapable of independently providing service for soldiers with severely reduced mobility who require assistance loading/unloading the vehicle. System improvements identified through ARIBO will impact technical reliability for hardware, software, and integration processes and techniques; human-machine interaction; and maintainability.

Lessons learned from this SBIR may influence future projects involving two or more automated systems physically

loading/unloading and organizing themselves in a marsupial transport vehicle or the physical recovery of wounded personnel on the battlefield. Investigation of human factors issues regarding the passenger interaction and the effective use of the system is also important. Approaches will be compared on the quality of the concept, required user/passenger interaction, weight and ruggedness of the design, human factors analysis, autonomous capability, power consumption, operational efficiency and cost.

PHASE I: The first phase consists of the initial system design, investigation of system components, human factors analysis, recommendations of the command set for use with occupant assist/safety, and the demonstration of feasibility. Documentation of design, such as size and weight (both as a payload to the vehicle and assisted occupant), power requirements, and cost, as well as projected system performance, shall be required in the final report.

PHASE II: The second phase consists of a final design and full implementation of the system, including vehicle integration (hardware, power, control, etc.), communications software and hardware, and non-vehicle hardware components/systems (if applicable). At the end of the contract, successful operation of the prototype system integrated onto a GFE ARIBO vehicle conducting the assist operations shall be demonstrated in a realistic outdoor environment. Deliverables shall include the prototype system and a final report, which shall contain documentation of all activities in the project and a user's guide and technical specifications for the prototype system.

PHASE III DUAL USE APPLICATIONS: Military applications include all those that entail automated unmanned vehicle transportation capabilities for military personnel are desired, such as CONUS military post. Civilian applications include inter-transportation systems of occupants requiring ingress/egress or loading/unloading assistance.

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