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

Revised Closing Date: February 25, 2015, at 6:00 a.m. ET

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 Web site: 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 http://www.dodsbir.net/sitis. Specific questions pertaining to the Army SBIR Program should be submitted to:

John Smith
Program Manager, Army SBIR
army.sbir@us.army.mil
US Army Research, Development and Engineering Command (RDECOM)
6200 Guardian Gateway
Suite 145
Aberdeen Proving Ground, MD 21005-1322
TEL: (866) 570-7247

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 Henry Jackson Foundation, Geneva Corporation, Clinical Research Management, Inc., and Reg Richard Inc. who will provide Advisory and Assistance Services to the Army, providing technical analysis in the evaluation of proposals submitted against Army topic numbers:

- A15-058 - Multi-Mode Security Domain Software for Medic's EUD – Henry Jackson Foundation, Geneva Corporation
- A15-054 - High-throughput Bacteriophage Isolation and Characterization – Clinical Research Management, Inc.
- A15-055 - Modifiable Electronic Body Diagram Template to Accommodate Varying Body Shapes – Reg Richard, Inc.

Individuals from Henry Jackson Foundation, Geneva Corporation, Clinical Research Management, Inc., and Reg Richard Inc. 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. These firms are 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 process, the aforementioned firms may require access to proprietary information contained in the offerors' proposals. Therefore, pursuant to FAR 9.505-4, these firms 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. 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.**

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.

15.1 Phase I Key Dates

Solicitation closes, proposals due	25 Feb 2015
Phase I Evaluations	20 Feb – 23 Apr 2015
Phase I Selections	24 Apr 2015
Phase I Award Goal	18 Jun 2015

**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 (http://www.dodsbir.net/submission/). 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, please call the DoD SBIR/STTR Help Desk at [1-800-348-0787] or Help Desk email at [sbirhelp@bytecubed.com].

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/sbir/TechnicalAssistance.aspx.

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/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 15.1 Topic Index

Participating Organizations	PC	Phone
Aviation and Missile RD&E Center (AMRDEC-A)	Linda Taylor	256-876-2883
Aviation and Missle RD&E Center (AMRDEC-M)	Buddy Thomas	256-842-9227
Armaments RD&E Center (ARDEC)	Benjamin Call	973-724-6275
Army Research Lab (ARL)	Francis Rush Charles Ober	301-394-4961 301-394-1015
U.S. Army Test & Evaluation (ATEC)	Jessica Knight	443-861-9339
Communication-Electronics Research, Development and Engineering Center (CERDEC)	Joanne McBride	443-861-7654
Edgewood Chemical Biological Center (ECBC)	Dhirajlal Parekh Martha Weeks	410-436-8400 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 Aaron Sparks	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 Combat Support & Combat Service Support (CS&CSS)	Munira Tourner	586-282-4822
PEO Ground Combat Systems (GCS)	Rachel Dugan Aaron Hart	586-282-8940 586-282-0603
PEO Intelligence, Electronic Warfare & Sensor (IEW&S)	Jonathan Reiner	443-861-7823
PEO Missiles & Space	William Chenault	256-876-1250
PEO Simulation, Training and Instrumentation (STRI)	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 others 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 15.1 Topic Index

A15-001	Laser-based Acoustic Sensing for Noise Measurement in Wind Tunnel
A15-002	Development of Additive Manufacturing for Aerospace Gear Applications
A15-003	Durable, Non-Stick Coatings for Metallic and CMC Hot Section Components of Gas Turbine Engines
A15-004	W-band Beamforming Network
A15-005	Development of Fidelity Metrics for Image-based Missile Simulation Environments
A15-006	Estimating Emissive Signatures of Non-horizontal Terrain Morphologies for Simulation
A15-007	Cellular Architecture Optimization for Tailored Frequency Response in Missile Components and Structures
A15-008	Low Thermal Conductivity Fiber for Solid Rocket Nozzle Insulation
A15-009	Plenoptic Non-Intrusive Measurement for High Speed Ground Test Environments
A15-010	Manned/Unmanned Multi-platform Target Effects Teaming and Collaborative Engagement
A15-012	Counter-UAS Technologies for Swarming UAS's
A15-014	Nanoparticle Capacitors for Multi-Point Initiation
A15-016	True Double-clad Fully Crystalline Laser Fiber Development for DEW Applications
A15-017	Integrated High Temperature Sensors for Advanced Propulsion Materials
A15-018	Radioisotope Power Source for Long-Lived Sensors and Communications
A15-019	Very High Dynamic Range RF Two Tone Measurement Instrument and Sensor
A15-020	Wireless Networking Using Multiple Antenna Interference Alignment
A15-021	Health Conscious Structures for Zero-Maintenance Rotorcraft Platforms
A15-022	Front-end Application Specific Integrated Circuit for Navigation-Grade MEMS Gyroscope
A15-023	High Performance, Flexible, Silicon-Based Photovoltaic Devices
A15-024	High Operating Temperature Long Wave HgCdTe Focal Plane Arrays
A15-025	Compact Vehicle Transmission Concept with Large Reduction Ratio
A15-026	Real-Time Camera-Independent Image Processing System For Long-Range Tactical Imaging Applications
A15-027	Aerodynamic Interference Module Development for Rotorcraft Design
A15-028	Development of Broadband Nanostructured Antireflection Coatings for Improved Infrared Focal Plane Arrays (IRFPA) Performance
A15-029	Human Skin Simulant for Ballistic Testing
A15-030	Parachute Shape and Airflow Measurement During an Airdrop
A15-031	Open Air Virtual Partial Alcove Anechoic Chamber
A15-032	Mission Command of Autonomous Systems
A15-033	Technologies to Enable Screen Size Independent Software
A15-034	Managing Digital Communications via Virtual Staff
A15-035	Laser-based Wireless Power Transfer
A15-036	Cyber Ontology Development
A15-037	Cognitive Algorithm Development for Aircraft Survivability
A15-038	Multi-Mission Electro-Optical Sensor System
A15-039	Asynchronous Day/Night NIR-SWIR See-Spot Sensor Development
A15-040	Integrated Low Latency Integrated Video Decompression Micro-display
A15-041	Growth of III-V Antimonide (SB)-based Superlattice Material with Superior Performance
~~A15-042~~	(This topic has been removed from the solicitation.)
A15-043	Automated Explotability Reasoning
A15-044	Firmware Assurance
A15-045	Channel State Feedback for Closed-Loop Multi-User MIMO System
A15-046	Use of Social Cognitive Techniques to Enhance Communications at the Tactical Edge
A15-047	Broadband Plasmonic Meta Materials
A15-048	Chemical Biological Radiological Nuclear and Explosives (CBRNE) Reconnaissance Sampling Kit
A15-049	Development of Tactile (Haptic)
A15-050	Next Generation Sensors for Water Quality Testing and Fieldable Applications Using Traveling Wave Electrophoresis
A15-051	Next-Generation Adenovirus Vaccine
A15-052	Novel Adjuvants to Enhance the Immunogenicity of Dengue Vaccine

A15-053	Mucosal Immunity Stimulation Using Novel Vectors for Delivery of Proteins or Genes
A15-054	High-Throughput Bacteriophage Isolation and Characterization
A15-055	Modifiable Electronic Body Diagram Template to Accommodate Varying Body Shapes
A15-056	Temporary Ocular Device to Achieve Closure of Corneal Lacerations in Open Globe Injuries
A15-057	Analysis of Abnormal Vocal/Speech Patterns in Traumatic Brain Injury
A15-058	Multi-Mode Security Domain Software for Medic's EUD
A15-059	Cryopreservation for Regenerative Medical Applications
A15-060	Wearable Dosimeter for Personal Real-Time Assessment of Exposures to Occupational Chemicals
A15-061	Topical Therapeutic for Ocular Trauma
A15-062	Lightweight Radiation Shielding for Transportable Rigid Wall Shelters
A15-063	Conductive Network for Parachute Fabrics
A15-064	Single Process Multiplex Detection System for Food and Water Pathogens
A15-065	Technologies for Modular Refrigeration
A15-066	Radiant Floor Heating Technology for Expeditionary Shelters
A15-067	Soldier and Small Unit (SSU) Performance and Cognitive Models for Behavior and Decision Making in Constructive Simulation
A15-068	Innovative Non-GPS Geolocation Technologies for Hand and Remotely Emplaced Munitions
A15-069	Advanced Wireless Fuze Setter Technology for Medium and Large Caliber Rapid Fire Auto Loaders
A15-070	Locality Scanner for Helicopter Pilotage and Hazard Avoidance
A15-071	Enhanced Targeting Sensor Technology
A15-072	Advance Brake Fade Warning System and Test for Wheeled Vehicles
A15-073	Multi-Sensor Radar Processing for Unmanned Convoys
A15-074	Development of Nano-Reinforced 7075 Derivative Alloy For Structural Components
A15-075	LOw TRavel Isolated Floor (LOTRIF)
A15-076	New Mid-IR Laser Power Scaling Technology via Fiber Combiner
A15-077	Optical Aperture Synthesis for Airborne ISR Platforms
A15-078	See-through-the-Sensor Ballistic Wind Measurement
A15-079	Beam Director for Ultra Short Pulse Laser Long Range Target Acquisition, Targeting, and Engagement
A15-080	Variable Video Compression for Training Data Capture
A15-081	Non-Contact Hit Sensing
A15-082	Novel Sensors and Data Fusion Methods for an All Weather Tracker
A15-083	High Energy Density Solid State Batteries for Military Vehicle Applications
A15-084	Gallium Nitride (GaN) Bi-Directional Battery Isolator Unit
A15-085	In-Situ Thermal Properties Measurement Instrument
A15-086	Tactical Behavior Mining of a Soldier-Based Gaming Environment
A15-087	High Performance Switched Reluctance Generator Controller
A15-088	Energy Absorbing Seat For All Occupant Sizes and Blast Conditions
A15-089	Advanced, Robust, and Simple Pretreatment to Reverse Osmosis

Army SBIR 15.1 Topic Descriptions

A15-001 TITLE: Laser-based Acoustic Sensing for Noise Measurement in Wind Tunnel

TECHNOLOGY AREAS: 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 non-intrusive, low self-noise, laser-based optical techniques for quantitative acoustics measurement (i.e. pulse shapes and amplitudes) of rotors/propellers testing in wind tunnels. This new capability is sought to address many problems associated with the use of traditional microphones mounted on tall bulky struts in front of the test vehicle; typically resulting in high self-noise, undesirable aerodynamic flow interactions on the test vehicle, strut instabilities and installation complexities, particularly when testing at high speeds at 150 knots and above.

DESCRIPTION: Acoustics measurement in wind tunnel has always been an arduous task. For the Army that is primarily concern with in-/near-horizon noise measurement forward of the test vehicle, the use of microphones mounted on one or more tall tower struts1 pose a significant challenge in obtaining high-quality, scientific data. This is mainly due to "dirty" airflow, shedding off the bluff-body tower strut, which impinges on the test vehicle and alters the local inflow to the rotor/propeller. The tower struts and the microphone probe holders also generate significant amount of self-noise, particularly at high speeds, that limits their usability because of compromised signal-to-noise ratio levels. The need to design tower struts to sustain wind speeds of 150 knots and above is also challenging – often resulting in heavy and bulky towers that are costly to build, difficult to install and to re-locate. Conventional setup as such also prohibits efficient area/volume-mapping of the external forward noise radiation of the test vehicle.

Recent development in non-invasive, laser-based optical techniques[2-5] for acoustics measurement is sought after to alleviate many of the problems stated above. Laser-based techniques rely on subtle changes in the frequency of light caused by the change in air's refractive index due to the passage of sound waves. When coupled with state-of-the-art post-processing numerical methods, it is becoming possible to extract acoustic particle velocities that are of much smaller amplitudes and higher frequencies compared to typical aerodynamics-generated velocities in the fluid medium. To-date, this type of sound extraction technique has only been successfully demonstrated in a stationary/low ambient flow medium.

The Army is looking for enhancement to this capability for applications to real-time acoustics measurement in wind tunnels where the fluid medium is non-stationary, and at speeds of 150 knots and above. The new acoustics measurement technique must account for wall enclosures lined with sound absorbing treatment and must take into consideration any corrections associated with passage through shear layers in open-jet configuration, and boundary layers in closed configuration. Preference is for techniques making use of natural dust particles in air, rather than methods that require seeding of the fluid medium. Operational frequency bandwidth from 15 Hz to 5000 Hz is desired within 100 feet from the test vehicle (sound source). Measurement technique must also be capable of efficiently mapping the sound radiation field forward (±45° port/starboard from centerline and ±45° above/below horizon).

PHASE I: The objective of Phase I is to demonstrate the feasibility of gathering harmonic noise measurements in the wind tunnel environment with non-zero mean flow. 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 rotor harmonic noise in the wind tunnel environment with non-zero mean flow. Improved system design will be refined based upon the data gathered in Phase I. The complete system will be operationally tested and evaluated by the contractor in a noise data-gathering wind tunnel test (to be determined) with participation from Army personnel. Conventional microphones will be used in the test to verify results obtain from the laser-based system. The contractor will support and conduct such testing and be an integral part of the evaluation. Classified proposals are not accepted under the DoD SBIR Program. In the event DoD Components identify topics that will involve classified work in Phase II, companies that submit Phase II proposals for such efforts must have or be able to obtain the proper facility and personnel clearances in order to perform Phase II work.

PHASE III: Further development of the above acoustic measurement system to become a “turnkey” 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 wind tunnel-based data acquisition equipment. Detail 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. A final evaluation and demonstration of the resulting system will be performed by the contractor in a wind tunnel test to be determined by the Army.

The resulting measurement technology and hardware is applicable to both military and commercial aircraft and rotorcraft. Key military applications include: (1) extension of this laser-based remote sensing capability to airborne platforms to enable real time aural situation awareness; where the need to accurately know the forward noise directivity will help assess and minimize the likelihood of acoustic detection and increase the survivability of military helicopters, (2) enabling accurate direct measurement-based self-noise tracking (not relying on predictions) to develop cabin displays/piloting cues for pilot training to achieve real-time low noise flight operations, (3) enhancing the precision of mission planning/route optimization tools for assessing the risk of acoustic detection during mission execution. This improved noise measurement capability unit will also provide the missing acoustic data (at locations in the wind tunnel that are unable to accommodate tower struts) needed to validate and improve rotor/propeller noise models. The data and their associated/validated mathematical models will be useful for accurate designs of quiet flight paths for both military and civilian community operations.

REFERENCES:
1. Sim, B., JanakiRam, R. and Lau, B., “Reduced In-Plane, Low Frequency Noise of an Active Flap Rotor,” Journal of the American Helicopter Society, Vol. 59, No. 2, April 2014, pp. 022002-1 to 22002-17.

2. Valière, J., Herzog, P., Valeau, V. and Tournois, G., “Acoustic Velocity Measurements in the Air by Means of Laser Doppler Velocimetry: Dynamic and Frequency Range Limitations and Signal Processing Improvements,” Journal of Sound and Vibration, Vol. 229, No. 3, pp. 607-626, 2000.

3. Le Duff, A., S. Poggi, G. Plantier, and J. C. Valière, "Real-time acoustic velocity measurement in the air by means of laser doppler velocimetry," In Instrumentation and Measurement Technology Conference, 2001. IMTC 2001. Proceedings of the 18th IEEE, Vol. 1, pp. 234-238, 2001.

4. Valière, J., (2014) LDV for Acoustics, in Acoustic Particle Velocity Measurements Using Lasers, John Wiley & Sons, Ltd, Chichester, UK.

5. Butman, J., Lombardi, G., Lyons, T., "Acoustic Surveillance, Targeting and Reconnaissance System (ASTARS)", final report (For Official Use Only), sponsored by DARPA/STO, Contract No. N66001-06-C-2040 issued by SPAWAR Systems Center San Diego, Dec 31, 2010.

KEYWORDS: laser Doppler velocimetry, wind tunnel, rotors, propellers, noise, acoustics, sound measurement, data acquisition

A15-002 TITLE: <u>Development of Additive Manufacturing for Aerospace Gear Applications</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate an additive manufacturing process for advanced aerospace gears meeting or exceeding the mechanical properties of SAE AMS 6308.

DESCRIPTION: The lead time for manufacturing gears for testing in Science and Technology (S&T) prototype demonstrators can be several months and requires costly special tooling. Additive manufacturing is a manufacturing technique that can be used to reduce the lead time and cost for prototype hardware. Additive Manufacturing (AM) refers to a process by which digital 3D design data is used to build up a component in layers by depositing material.

The goal for this topic is to develop a new or improved AM process for aerospace gear applications. Potential AM processes that could be improved upon includes (but is not limited to) Laser Engineered Net Shaping (LENS) and Electron Beam Melting (EBM). The AM process must be developed to overcome existing challenges that limit the use of AM for gear manufacturing. Some of the common challenges/limitations are:

a. Residual stresses can be high in AM parts, which limit the loading of parts. Stress mitigation and optimization strategies must be developed as part of the effort.

b. Density of the material throughout AM parts can be inconsistent. Density can be influenced by un-melted entrapped powders. Overcoming this challenge needs to be addressed as part of the effort.

c. The rapid cooling rates associated with AM processes can affect the microstructure of the base material resulting in variations in desired strength, ductility, toughness, and modulus. The new AM processes must mitigate the effects to material properties.

Final components manufactured using the developed process must meet or exceed the mechanical properties of SAE AMS 6308 (Pyrowear 53). Pyrowear 53 may be considered as an Aerospace Grade 3 material, as defined in AGMA 926-C99. Any additional processing steps (such as hardening or surface finishing) must be defined, and should be minimized if possible. Specific metrics for the final manufactured gears are:

1) Minimum surface contact stress allowable = 250ksi
2) Minimum bending stress allowable = 40ksi
3) Minimum core hardness = 34 HRC
4) Minimum case hardness = 60 HRC
5) Minimum core yield strength = 140ksi
6) Minimum core ultimate tensile strength = 170ksi
7) Maximum surface finish = 16Ra

PHASE I: Demonstrate the feasibility of the new or improved AM process for use in additive manufacturing. Efforts should show that the formed parts can meet the properties equivalent to SAE AMS 6308 steel by utilizing simple geometric shape test specimens that have been produced using additive manufacturing.

PHASE II: Contractors are encouraged to collaborate with an Army rotorcraft OEM during Phase II. The contractor shall further optimize the AM process based on the Phase I results. This optimization shall include developing methods to reduce additional gear manufacturing processes (such as carburization, peening, surface finishing) by altering the AM process. Coupon level testing shall be performed to demonstrate mechanical properties such as yield and ultimate tensile strength. Several sets of 4 inch diameter spur gears (representative of aerospace quality gears) shall be manufactured using the developed process. Testing and analysis of these final gears shall be performed to demonstrate that each of the topic metrics has been met. Additionally, the microstructure of the final gears shall be analyzed and compared to Pyrowear 53.

PHASE III: Transition the new process via aerospace Original Equipment Manufacturers (OEM) and/or qualified suppliers for Army rotorcraft. Demonstrate the AM process for actual aircraft components.

REFERENCES:

1. SAE International Aerospace Material Specification (AMS) 6308, available as Carpenter’s Pyrowear 53 and Latrobe’s Lesco 53.

2. Additive Manufacturing - Definition is taken from the International Committee F42 for Additive Manufacturing Technologies (ASTM).

3. “Measurement Science Roadmap for Metal-Based Additive Manufacturing,” NIST, May 2013.

4. “Recommended Practices for Carburized Aerospace Gearing”, from American Gear Manufacturers Association, Alexandria, VA, AGMA Information Sheet No. AGMA 926-C99, 1999.

5. “Rating the Pitting Resistance and Bending Strength of Generated Straight Bevel, Zerol Bevel and Spiral Bevel Gear Teeth”, from ANSI/AGMA 2003-C10.

6. “Metallic Material Properties Development and Standardization”, MMPDS-08, April 2013.

7. “Standard Test Methods and Definitions for Mechanical Testing of Steel Products”, ASTM A 370-09, Jan 2009.

8. “Standard Test Methods for Tension Testing of Metallic Materials”, ASTM E8, May 2004.

9. “Standard Test Method for Plane-Strain Fracture Toughness of Metallic Materials”, ASTM E399, April 1991.

10. “Standard Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials”, ASTM E466, June 2002.

11. “Standard Test Method for Measurement of Fatigue Crack Growth Rates”, ASTM E647, April 2001.

KEYWORDS: Gears, additive manufacturing, rotorcraft, drive system, transmission, Pyrowear

A15-003 TITLE: Durable, Non-Stick Coatings for Metallic and CMC Hot Section Components of Gas Turbine Engines

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and validate durable, non-stick coatings for metallic and CMC hot section components of turbine engines.

DESCRIPTION: Gas turbine metallic combustor liner walls, along with gas generator turbine blades, vanes and shrouds are typically coated with an intermediate bond coat and a porous, ceramic-based thermal barrier coating (TBC) system to enable the base metal to withstand high temperature operation. Similarly, with the development of advanced ceramic matrix composite (CMC) materials to replace metallic versions of these components, environmental barrier coatings (EBCs) are used in place of the TBCs for protection against temperature/moisture-induced degradation. Gas turbine engines that ingest sand are subject to the accumulation of partially melted sand & dust deposits on the TBC/EBC surfaces. The sand builds up onto the flowpath components leading to significant blockage of the main turbine flow which can cause flow mismatches between engine components and result in large performance (power) losses. The build-up/glazing can also cause plugging of cooling flows which can lead to premature oxidation of the hot section components. The build-up of the sand constituents along with the high temperatures provides the potential for Calcia-Magnesia-Alumina-Silicate (CMAS) deposits from the sand to wick into the TBC/EBC. In the case of electron beam – physical vapor deposited (EB-PVD) yttria-stabilized zirconia TBCs, the coating structure is columnar, which allows the CMAS material to wick between the columns. Upon cooling and subsequent hot-cold cycles, the CMAS-filled TBC/EBC is unable to handle the thermal expansion mismatch between the infiltrated CMAS material and the coating. These stresses are then relieved by TBC/EBC spallation. Therefore, the developed high temperature, nonstick coatings must be able to protect conventional TBC coatings from CMAS and EBC coatings from moisture induced degradation or must be able to be applied to CMAS resistant TBC/ moisture resistant EBC coatings with good adhesion. The objective of this topic is to develop and validate durable, non-stick coatings for metallic and CMC hot section components of turbine engines that alleviate the issue of sand & dust build-up on component surfaces and either effectively replace the TBC/EBC coating or work effectively with the TBC/EBC coatings as a top coating to the TBC/EBCs.

The program metrics include the following: 1) the new coating must be shown to be durable with good adhesion and 2) the new coating must be shown to prevent significant build-up (no more than 1 mil) of deposited sand onto representative high pressure turbine components in a simulated engine environment with surface temperatures of greater than 2200 degrees F, and 3) the coating must be able to withstand surface temperatures greater than 2200 degrees F. Test sand to be used for validation testing is AFRL02 sand for hot furnace laboratory testing and

AFRL03 for engine sand testing. These test sands are available from Powder Technology, Inc. The small business is encouraged to work with and establish a clear transition path with a turbine engine manufacturer. Government hot ingestion rigs to perform validation testing are available at the Army Research Labs (ARL) or at the Air Force Research Labs (AFRL). Laboratory contact information is available upon request from the topic author. Validation testing shall be performed at these or other acceptable Government facilities unless the offeror can prove that their facilities are able to provide better validation capability in a cost effective manner.

PHASE I: Assess the feasibility of promising high temperature, non-stick coatings for application to HPT components. Coating should be evaluated on representative TBC coated metallic and/or EBC coated CMC specimens through dynamic hot furnace testing with representative test sand being flowed onto the specimen surface at greater than 2200 degrees F surface temperatures.

PHASE II: Apply non-stick coating technology to high pressure turbine component(s) for optimization in hot furnace thermal cyclic testing at greater than 2200 degrees F surface temperatures with representative test sand being flowed onto the specimen surface and/or evaluation in a full-scale cyclic engine endurance test (with sand ingestion of the appropriate constituents to promote CMAS) at greater than 2200 degrees F surface temperatures to demonstrate that the coating does not spall and prevents sand build-up onto HPT components.

PHASE III: The optimized coating technology shall be applied to HPT component(s) for full engine test validation to TRL 6 in an advanced high temperature engine, such as the Improved Turbine Engine Program (a planned acquisition program to replace the current engines in the Army UH-60 and AH-64 helicopters with an advanced high performance, high temperature engine). Validation will include engine sand test (of the appropriate constituents to promote CMAS) demonstration with appropriate cyclic content.

DUAL USE APPLICATIONS: The resulting technology will enable significantly enhanced time-on-wing/durability of hot section components of future advanced engines with high turbine inlet temperatures operating in sandy environments. Both military and commercial aircraft applications are likely to encounter such an environment and thereby will derive benefit from this technology.

REFERENCES:
[1] Krämer, S., Yang, J., Johnson, C., and Levi, C. Thermochemical Interaction of Thermal Barrier Coatings With Molten Cao-Mgo-Al2o3-Sio2 (CMAS) Deposits. (http://www.materials.ucsb.edu/MURI/papers/Kraemer-JAcerS1205.pdf)

[2] Drexler, J.M., et al. Air-Plasma-Sprayed Thermal Barrier Coatings that are Resistant to High-Temperature Attack by Glassy Deposits. Acta Materialia. 58. pp. 6835-6844. 2010.

[3] Li, L. Hitchman, N., and Knapp, J. Failure of Thermal Barrier Coatings Subjected to CMAS Attack. Journal of Thermal Spray Technology. 19 (1-2). pp. 148-155. 2010.

[4] Kramer, S., et al. Mechanisms of Cracking and Delamination within Thick Thermal Barrier Systems in Aero-Engines Subject to Calcium-Magnesium-Alumino-Silicate (CMAS) Penetration. Materials Science and Engineering A. 490. pp. 26-35. 2008.

[5] Kendra M. Grant, Stephan Krämer, Jan P.A. Löfvander, Carlos G. Levi, CMAS Degradation of Environmental Barrier Coatings. (http://www.materials.ucsb.edu/MURI/papers/Grantetal_CMASonEBC.pdf)

KEYWORDS: gas turbine engine, non-stick coating, thermal barrier coating, environmental barrier coating, calcia-magnesia-alumina-silicate

A15-004 TITLE: W-band Beamforming Network

TECHNOLOGY AREAS: Electronics

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

foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop a prototype active sensor array utilizing silicon-based beamforming and power amplification at W-band using commercially available components and fabrication techniques.

DESCRIPTION: W-band brings distinct advantages over lower frequency sensors. The higher frequency allows smaller aperture sizes when traded against sensor beamwidth. Very small beamwidths allow sensors to render images of structures that would otherwise be hidden due to low resolution in aperture-limited applications. These type sensors have typically been very expensive, large, heavy and cumbersome. Recent advancements in silicon-based components allow for higher frequency components to be designed and fabricated on these substrates. Silicon processes are quite mature, and the ability to fabricate components on processes that support large wafer sizes creates a unique situation where electronic costs drop quickly. Silicon-based beamforming therefore represents a new era of low-cost, affordable phased array networks for a variety of military sensor systems and platforms. By moving beamforming architectures from traditional III-V-based semiconductor devices to low-cost, silicon-based devices, an opportunity is created to lower cost across all sensor systems by as much as two orders of magnitude. Such cost reductions in high performance phased array systems profoundly addresses affordability requirements across all warfighter/military sensor-based applications.

This topic will seek to develop an all-weather capable sensor at W-band. Silicon Germanium (SiGe) technologies have been matured by the telecommunications industry and can be adapted for use as a beamformer for military applications. Silicon complementary metal oxide semiconductor (CMOS) brings an additional savings over SiGe devices. These technologies present an optimum solution due to their extremely small process sizes (90 to 120nm processes) and highly integrated chipsets for use at the high frequencies that this topic will require. For affordability, the use of mature, industry-ready processes is a necessity throughout this effort, with the hierarchy of chosen components being: commercially available (off-the-shelf (COTS)), followed by the use of commercial processes and fabrication techniques when COTS are not available. Finally, specialized components requiring specific design work, fabrication and tooling (such as the development of a specific SiGe beamforming chip set) should utilize commercial industry known processes.

PHASE I: Design an active imaging W-band sensor utilizing silicon-based beamforming and power amplification technology to address the following requirements associated with this topic: at least a 90 degree field of view in the forward direction with a synthetically formed beam scanning at 30 frames per second to distances up to 100 m using an aperture smaller than 25 cm2. The associated number of elements (minimum of 8) in the array, spatial resolution and effective antenna gain, transmit power requirements, beamforming methodology, and associated control must be specified for the proposed system assuming a single heterodyne receiver. This is not a radar, so range measurement is not required. The design must be informed by quantitative trade investigations of aperture size, weight, frequency, power requirements and number of apertures (possible interferometric solution), thermal management, and direct current (DC) power requirements. Given that technologies based on SiGe or Si CMOS chipsets are required, solutions that promise lightweight, low power consumption, low cost performance will be favored. The integrated array may consist of stacked linear sub-arrays, each with elements spaced roughly lambda/2 apart to maximize beamsteering. The deliverable for Phase I will be a detailed, component-level design of a prototype sensor array based on this thorough trade analysis.

PHASE II: Construct, characterize, and deliver the prototype phased array sensor designed in Phase I. This array should be capable of beam-steering in 2 dimensions with the specified range, resolution, and field of view. Tests of the prototype must verify beamsteering capability, power density, thermal management, and gain profiles. The final array size should consist of at least 8 elements in a scalable architecture that could be expanded to a 2^n element array.

PHASE III: Develop a fully integrated, platform-specific, system-engineered, W-band imaging sensor based on the methodology and prototype developed here. From this sensor, many spin-off applications can be envisioned, including imaging through obscurants to assist in degraded visual environments, all weather area surveillance, fire and rescue in challenging environments, omni-directional, high bandwidth wireless datalinks, and a RADAR variant that could be used for collision avoidance in semi- or fully-autonomous ground and air vehicles.

REFERENCES:
1. DARPA BAA 11-46

2. DARPA BAA 11-50

3. H. Li, H.-M. Rein, T. Suttorp, and J. Böck, "Fully Integrated SiGe VCOs with Powerful Output Buffer for 77-GHz Automotive Radar Systems and Applications around 100 GHz," IEEE Journal of Solid-State Circuits, vol. 39, pp. 1650-1658, 2004.

4. G. E. Moore, "Cramming more components onto integrated circuits", Electronics, vol. 38, no. 8, pp. 114-117, 1965

5. E. O. Johnson, "Physical limitations on frequency and power parameters of transistors", RCA Rev., vol. 26, pp. 163, 1965

6. A. Hajimiri, "Distributed integrated circuits: An alternative approach to high-frequency design", IEEE Commun. Mag., vol. 40, no. 2, pp. 168-173, 2002

7. J.-S. Rieh, et al., "SiGe HBTs for millimeter-wave applications with simultaneously optimized fT and fmax of 300 GHz", IEEE Radio Frequency Integrated Circuits Symp. Dig. Papers, pp. 395-398, 2004

8. R. C. Hansen, Significant Phased Array Papers, 1973:Artech House

9. R. S. Elliott, Antenna Theory and Design, 1981:Prentice-Hall

10. M. Golio, The RF and Microwave Handbook, Session 6.9, 2000:CRC

KEYWORDS: W-band, RADAR, phased array, beamforming, silicon germanium, CMOS, datalinks

A15-005 TITLE: Development of Fidelity Metrics for Image-based Missile Simulation Environments

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: Develop a method and supporting tools for assessing and estimating the target and background simulation scene fidelity requirements of smart munitions using multidimensional measures of fidelity using Modeling and Simulation (M&S) to obtain system performance assessments.

DESCRIPTION: Advanced, autonomous seeker systems are comprised of imaging sensors coupled with signal-processing algorithms and the on-board processing power to perform engagement, tracking, and terminal guidance operations against a target or threat. Exhaustive testing of these systems is typically accomplished using a simulation environment. The various types of simulations used for Army purposes are as follows:

1) All digital – digital models of the sensor and seeker are exercised in a closed loop process using simulated scenes hosted on CPU or GPU processors.

2) Signal injection – a digitally-generated target and background scene, including sensor effects, is injected directly into the missile’s seeker processing hardware, bypassing the sensor and allowing testing on a stationary test-stand.

3) Hardware-in-the-loop – a scene projector projects a dynamic, digitally generated target and background scene into the seeker’s sensor hardware while the missile hardware is mounted on an azimuth and elevation slewable test stand.

With the continuous advancement of scene generation capabilities, target and terrain modeling tools, and available computing power, the fidelity of simulated scenes is rapidly improving. In each of these simulation types, the fidelity, spatial resolution, and accuracy of the simulated target and background signature is necessarily a function of the type and sophistication of the seeker subsystem. For example, the simulation fidelity requirements for a seeker using a spiral-scanning, single-detector sensor and pulse-detection target tracking process are significantly less than a high-resolution, imaging sensor feeding an advanced, feature-based tracking algorithm.

In addition, the generation of estimated radiance-maps using physics-based process for large-area scenes containing targets and terrain backgrounds is both labor and computationally expensive with run times often measured in weeks. Therefore, it is of great importance to match the fidelity of the simulated scene and the corresponding background and target detailed features needed for proper seeker subsystem development and testing without over-specifying fidelity and its associated costs.

Consequently, the development of a systematic approach for quantifying required levels of simulation fidelity, along with the needed supporting metrics, is required. The task will consider the spectral, spatial, temporal, scene dynamic dimensions, etc., to determine the required level of fidelity needed for appropriately simulating the scene commensurate with the seeker's capabilities. Potentially, several of these dimensions could be rolled up into a single scalar value. Additionally, measures in each of the dimensions would be available for assuring fidelity requirements.

The goal of this research topic is to develop meaningful metrics and an analysis process that can be used by the simulation community to determine overall scene generation requirements and specific rendered image fidelity suitable for a particular missile seeker or sensor system performance assessments. The metrics will necessarily be tied to the specific sensor system or seekers under development and test. Essentially, the tools and methods developed will serve as a quantitative and object method for assessing the suitability of various scene generation techniques for use in simulation-based seeker development and system-performance evaluation.

PHASE I: Identify and develop an initial methodology and metrics for assessing simulation fidelity requirements dependent on the seeker's sensor and signal processing capabilities. Army and DoD systems with different simulation requirements will be identified.

PHASE II: Develop and demonstrate a mature set of metrics and processes developed during Phase I efforts and run a user test case for a seeker system to confirm. Plan a detail verification and validation test which will compare results using both measured and simulated target and back scenes.

PHASE III: Create and publish a guide to assessing simulation fidelity with respect to seeker hardware specifications for use in the missile-borne seeker community.

REFERENCES:
[1] ATRWG. Image Metrics, ATRWG 90-003 edition, June 1990.

[2] J. Beard, L. Clark, and V. Velton. Characterization of atr performance in relation to image measurements. In ATRWG Working Paper, Wright-Patterson AFB, OH 45433, December 1984. AFWAL/AARF.

[3] J.J. Carlson, J.B. Jordan, and G.M. Flachs. Task specific complexity metrics for electronic vision. In SPIE, Image Processing, Analysis, Measurement and Quality, volume 901,pages 35-43, 1988.

[4] A.S. Glassner. Principles of Digital Image Synthesis, volume 1. Morgan Kaufmann Publishers, Inc., 1995.

[5] A.S. Glassner. Principles of Digital Image Synthesis, volume 2. Morgan Kaufmann Publishers, Inc., 1995.

[6] R.A. Peters II. Image Complexity Measurement for Predicting Target Detectability. PhD thesis, University of Arizona, October 1990.

[7] R.A. Peters II and R.N. Strickland. An image complexity metric for automatic target recognizers. In ATR Systems Technology Conference. Naval Systems Warfare Center, October 1990.

[8] J.S. Weszka, C. Dyer, and A. Rosenfeld. A comparative study of texture measures for terrain classification. IEEE Trans. on System, Man, and Cybernetics, SMC-6:269–285, 1976.

KEYWORDS: scene generation, fidelity metrics, validation, scene models, terrain models, target models

A15-006 TITLE: Estimating Emissive Signatures of Non-horizontal Terrain Morphologies for Simulation

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: Attain higher fidelity terrain radiance models for seeker system development and testing by the addition of terrain features like ditches, gulches, washes, and road shoulders having medium length scale vertical surfaces (near horizontal surface normals) that are typically lost in high resolution topographic descriptions of backgrounds.

DESCRIPTION: There are a number of technical challenges in building high fidelity background scenes that are suitable for developing and testing missile seeker systems as well as any 3-D virtual environment such as military training systems, and visualization of threats, real-world locations, and weather conditions on military planning, training, and preparations. Physics-based models are used to determine the radiance fluctuations from the background at the input aperture of the sensor in the Very-Near (VNIR), Short-Wave (SWIR), Mid-Wave (MWIR), and Long-Wave (LWIR) infrared bands. Heat transfer models are used to estimate the physical temperatures of the terrain and features that comprise the background scene.

Medium length scale terrain features like ditches and washes are important observable features in all bands. The steeply sloped sides of these features are illuminated, or solar-loaded, differentially from horizontal terrain adding to the overall texture of the scene clutter. For example, their signature is strongly affected by solar heat at low solar angles when compared to the adjacent near horizontal surfaces. This differential terrain heating can give rise to vehicle-sized clutter features depending on the flight path through the terrain, the viewing geometry, and in combination with other features.

In available highly-resolved terrain topography data sets, these features are not likely to be resolved or are substantially underestimated. Consequently, efforts are required to develop methods and tools to add these features to the terrain topography in some automated manner. Information that could be used to create these features may be a-prioi knowledge of the existence of such features, information from the available topographic data, soil type, and site surveys. To achieve such an integrated, natural and man-made feature-set for a given terrain, tools need to be developed that automatically incorporate these features with all the corresponding natural variations for a given instance of the background.

Standard heat transfer approaches for terrain temperature calculations typically use a one dimensional (1D) approximation for the soils and roads. In the transition areas between the horizontal and vertical features at the small to medium length scales of interest, the 1D approximation is no longer valid for these non-horizontal structures. Consequently, efforts must be made to automatically detect these transition regions and employ a more suitable heat-transfer approximation at these locations. This solution will have boundary conditions that smoothly transition to the bordering areas where the one dimensional approximation is valid.

This technology will also improve training systems representation of IR terrain signatures (ditches, ravines, and mountainous areas). Current clutter classification software such as ERDAS Imagine could be improved upon to better utilize satellite or surveillance imagery data values and positions to see features that would not normally be visible and to locate geo-positions of features that would otherwise not be represented. It will also reduce artifacts in rendering of steep terrain based on rectilinear gridded input classification and topographic data and potential for application in the entertainment sector (films and video games). The results will transition to and influence commercial applications involving land, aerial, and flight training simulations, tools to development terrain models used in these simulations, and defense and commercial scene generation technology.

PHASE I: Develop heuristic methods and procedures to identify the locations of these non-horizontal terrain elements such as washes, gulches, and ditches, and create the needed geometrical structure for representing them that integrates with the existing scene topography and cultural features. Derive quality metrics to compare real imagery to that of simulated imagery for areas with vertical surfaces that need these required improvements in signature modeling. Identify and select government and/or industry toolsets that provide visualization processes, synthetic environments, and scene rendering technologies to augment the fidelity and quality of the terrain scenes.

PHASE II: Develop the corresponding heat transfer solutions and build an application that can be used to automatically incorporate and solve for the surface temperatures of these vertical sided features. Demonstrate with government and/or industry toolsets defined in Phase I. Compare fidelity and scene content of the signatures to that of measured data.

PHASE III: Integrate the application into existing scene generation software applications used by the Tri-Service community. Conduct a thorough demonstration of processes to obtain these missing scene features and complete source code augmentation and release of improved capabilities into industry or Government scene visualization toolset(s).

REFERENCES:
[1] L.K. Balick, J.R. Hummel, J.A. Smith, and D.S. Kimes. One-dimensional temperature modeling and techniques review and recommendations. SWOE SWOE 90-1, CRREL, 1990.

[2] L.K. Balick, L.E. Link, and R.K. Scoggins. Thermal modeling of terrain surface elements. Technical EL-81-2, WES, 1981.

[3] M. Barnesly. Fractals Everywhere. Academic Press, New York, 1988.

[4] O. Farouki. Thermal properties of soils. Technical Report 81-1, CRREL, December 1981.

[5] W.I. Futterman, E.L. Schweitzer, and Newt J.E. Estimation of scene correlation lengths. In Characterization, Propagation, and Simulation of Sources and Backgrounds, number 1486, pages 127–140. SPIE, 1990.

[6] F.P. Incropera and D.P. DeWitt. Introduction to Heat Transfer. Wiley, New York, 2nd edition, 1990.

KEYWORDS: terrain models, clutter classification, surface temperatures, DEM resolution, topographic attributes, heat transfer, infrared, terrain signatures

A15-007 TITLE: <u>Cellular Architecture Optimization for Tailored Frequency Response in Missile Components and Structures</u>

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: Develop design and analysis tools to optimize the cellular architecture of missile structures and components to reduce weight and tailor frequency response.

DESCRIPTION: Guidance and navigation components within missile systems are vulnerable to performance degradation caused by vibrations generated in adjacent components. Conventional methods to alleviate this degradation include installing passive vibration-damping materials that add parasitic weight to systems. Advances in manufacturing processes provide the opportunity to build components and structures that were previously impractical. Design and analysis tools are needed to develop cellular structures that exploit state-of-the-art manufacturing capabilities and tailor the frequency response of missile components and associated structures while minimizing the weight. Development of tools that are numerically efficient is needed; the tools should require minimal computer processing time and integrate with existing commercially available FEA and CAD tools. Topology optimization tools that can tailor the global shape as well as cellular composition of the structure are desired.

PHASE I: Demonstrate a cellular optimization procedure via analysis and validate by experiment at the coupon level or with an analog component. The demonstration should be done on the scale of an object that occupies a volume less than a six inch cube. An example of a demonstration application is an accelerometer mounting bracket that needs to avoid a natural frequency of 625 Hz. This bracket is constrained by a volume of 4 inches x 3 inches x 3 inches and mounts to a structure with a quantity of six 1/8 inch diameter fasteners. Also formulate a plan for integration of the analysis tools into a commercial finite analysis code.

PHASE II: Integrate the cellular optimization tool in a commercial analysis package and demonstrate on a minimum of three relevant applications. An example of a relevant application is a mounting bracket for a vibration sensitive navigation component mounted adjacent to other noise generating hardware. Demonstration should include component and system level structural and dynamic analysis, fabrication utilizing advanced manufacturing techniques, metrology to verify dimensional accuracy, and structural and dynamic testing. Three different applications are required to demonstrate repeatability of the entire design and fabrication process and a seamless transition of digital data throughout.

PHASE III DUAL USE APPLICATIONS: Demonstrate the cellular optimization on a relevant Army application, and provide complete engineering and test documentation for development of manufacturing prototypes. A relevant application could include weight reduction from a navigation component in an existing and/or future system application. Programs that would benefit from this innovation include but are not limited to: Javelin, TOW, and Advanced Survey Emplacement System. Package tools into a software set for use for systems outside of missile components community.

REFERENCES:

1. Evans A, Hutchinson J, Fleck N, Ashby M, Wadley H. The topological design of multifunctional cellular metals. Progress in Materials Science. 2001;46:309-27.

2. Nguyen J, Park S-i, Rosen D. Heuristic optimization method for cellular structure design of light weight components. International Journal of Precision Engineering and Manufacturing. 2013;14:1071-8.

3. Chu C, Graf G, Rosen DW. Design for additive manufacturing of cellular structures. Computer-Aided Design and Applications. 2008;5:686-96.

4. Burblies A, Busse M. Computer based porosity design by multiphase topology optimization. AIP Conference Proceedings 2008. p. 285-90.

KEYWORDS: cellular structures, tailored frequency response, topology optimization

A15-008 TITLE: <u>Low Thermal Conductivity Fiber for Solid Rocket Nozzle Insulation</u>

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: Develop through a domestically sustainable process a low thermal conductivity fiber for composite rocket nozzle insulation, and demonstrate equivalent or superior performance to traditional viscose rayon-based carbon fibers.

DESCRIPTION: Traditional carbon phenolic rocket nozzle insulation materials have long relied on the use of viscose processed rayon-based carbon fiber to provide reinforcement to the structure through good interfacial bond strength while maintaining low thermal conductivity. To date, rayon-based carbon fiber remains the industry standard for ablative nozzle applications due to the reliability and success of its thermostructural performance. Several factors, including more stringent environmental regulations, the replacement of commercial grade rayon by other materials, and the relatively small volume demand for carbonizable rayon from the defense and aerospace industries, have led to the obsolescence of domestically-supplied, continuous filament, aerospace (carbonizable) and textile grade rayon. Many programs have sought to address this gap and have demonstrated the potential of candidate carbon fiber replacements from commercially available polyacrylonitrile (PAN), pitch, phenolic and rayon precursors; however, in each case additional effort is required to hone in the fiber properties and demonstrate consistent performance at the composite level.

Instead of attempting to post-process commercially available precursor fibers into a suitable replacement, the goal of this topic is to develop a new precursor fiber and post-process (carbonization schedule) that yields a fiber with equivalent or better thermal and structural properties than those of legacy rayon-based carbon fibers. An innovative processing solution that offers low cost, sustainability within the U.S., and relative scalability for production is necessary. Key metrics for this effort will include fiber thermal conductivity equivalent to or below that of the traditional rayon-based carbon fibers, ablation/erosion characteristics and thermomechanical behavior equivalent to or better than the traditional rayon-based carbon fibers, and the use of a low cost, domestically sustainable process. Ease of fiber handling and fiber strength suitable for weaving is essential, as is the ease of handling the woven fabric for incorporation into the matrix. A fiber surface that yields good interfacial bonding with the matrix is critical for success at the laminate level. In addition, due to the storage life requirements for Army missile systems, consideration should also be given to the maintenance of material properties upon aging. For the purpose of this effort, the matrix material will be limited to a phenolic resin.

PHASE I: Develop and demonstrate a process for creating a continuous filament fiber with the necessary thermostructural properties. Produce at least one (1) gram of representative fiber to characterize its thermomechanical properties (e.g., heat capacity, thermal conductivity, strength, modulus, thermal expansion, etc.). Demonstrate a fiber thermal conductivity equivalent to or below that of a typical NARC rayon-based carbon fiber, = 4 W/m•K [5,6].

PHASE II: Refine and scale up the fabrication process to produce sufficient quantities of material for composite level and subscale rocket motor testing. Verify thermomechanical properties at fiber level. Produce at least 100 lbs of phenolic-matrix prepreg, and characterize the thermomechanical properties at laminate level using a traditional and/or improved phenolic resin matrix for comparison with state-of-the-art carbon phenolic composites utilizing legacy rayon-based carbon fiber. Demonstrate thermostructural performance through subscale solid rocket motor testing using high performance aluminized or reduced smoke propellants with flame temperatures > 5000 °F. Pressures for subscale rocket motor testing should be 1000-2500 psi with burn times > 0.8 seconds such that equilibrium erosion performance can be established. Provide evidence of process viability for large scale production while focusing on low cost (i.e., lower cost than traditional viscose processed rayon based carbon fibers such as NARC or Enka), process efficiency from both time and resource perspectives, and minimizing environmental impacts while maintaining the necessary material performance. The traditional viscose process for producing rayon precursor fibers requires large amounts of water and energy usage as well as caustic materials that pollute the waste water. Environmental regulations, in addition to the resource-intensive process, contributed to increased cost burden of manufacturing viscose rayon and the subsequent shutdown of viscose plants in the U.S. The new precursor fiber process developed under this effort should be environmentally friendly in that it does not contribute to resource depletion or pollution or incur significant cost for the disposal of waste materials.

PHASE III: Demonstrate the new fiber’s thermostructural capability in a relevant environment. A Phase III application for integration into Army missile systems would include replacement of obsolete or foreign-supplied materials used in rocket nozzle insulation in systems such as GMLRS, PAC-3 MSE, or Technology Efforts for Air Defense or Long Range Precision Fires. Programs that would benefit from this innovation are not limited to Army systems, but extend throughout the Department of Defense and to the National Aeronautics and Space Administration. In addition to solid rocket motor nozzles, this technology could address obsolescence issues and potentially provide performance enhancements to other heatshield and ablative applications such as re-entry vehicles. Commercial applications for a low thermal conductivity carbon fiber may also exist in the private sector of the aerospace industry.

REFERENCES:

1. Edward Mills, “The Problems with Rayon,” JANNAF Rocket Nozzle Technology Subcommittee Rayon Replacement Workshop, Huntsville, AL, November 15-16, 2001.

2. Alan Frankel, “Carbon Fiber Production for Ablative Applications,” JANNAF Rocket Nozzle Technology Subcommittee Rayon Replacement Workshop, Huntsville, AL, November 15-16, 2001.

3. R.D. Torczyner, S.S. Tan, K.A. Barczi, “Alternate/Replacement Heatshield Materials,” Interim Report for Period December 1995 through November 1996.

4. R.M. Poteat, W.E. Lundblad, J.R. Koenig, “Solid Propulsion Integrity Program Exploratory Testing: PAN-Based Ablative Material Evaluations,” Final Report December 1994.

5. R.C. Rossi, W.C. Wong, “Availability of Aerospace Rayon for SRM Nozzle Insulators,” AIAA.

6. Experimental and Applied Mechanics, Volume 6: “Proceedings of the 2011 Annual Conference on Experimental and Applied Mechanics,” page 219, Tom Proulx, 2011.

CITATIONS FROM AIAA

7. 2007 Update: Sustainable Carbonized Rayon for SRM Nozzles, Steven Peake, Russell Ellis, and Bernard Broquere, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit. July

8. Update: Sustainable Carbonized Rayon for Solid Rocket Motor Nozzles, Steven Peake, Russell Ellis, and Bernard Broquere, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit. July

9. A Review of Ablation Modeling for Thermal Protection Systems, Joseph Koo, Wai Ho, and Ofodike Ezekoye, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit. July

10. Sustainable C2 Rayon-Based Carbon Cloth for the Ariane 5 SRM Nozzle, Michel Berdoyes, Bernard Broquere, Sylvie Loison, and Martine Dauchier, 41st AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit. July

11. A Sustainable and Secure Source of Carbonized Rayon for Solid Rocket Motor Nozzles, John Tauriello, Sean Doyle, and Russell Ellis 41st, AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit. July

12. A Replacement for Obsolete Graphite Phenolic, Gary Williams and James Murray, 44th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit. July

13. 2007 Update: Sustainable Carbonized Rayon for SRM Nozzles, Steven Peake, Russell Ellis, and Bernard Broquere, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit. July

14. NARC Rayon Replacement Program for the RSRM Nozzle, Phase IV Qualification and Implementation, Status M. Haddock, Gary Wendel, and Roger Cook, 41st AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit. July

15. NARC rayon replacement program for the Space Shuttle Reusable Solid Rocket Motor Nozzle - Screening Summary, R. Cook, M. Fairbourn, and G. Wendel, 36th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit. July

KEYWORDS: Thermostructural composites, ablation, erosion, rocket nozzle, insulation, carbon fiber, rayon replacement, carbon cloth phenolic

A15-009 TITLE: Plenoptic Non-Intrusive Measurement for High Speed Ground Test Environments

TECHNOLOGY AREAS: Weapons

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

OBJECTIVE: To develop non-intrusive measurement techniques for the quantification of flowfield properties during high speed ground tests using plenoptic imaging techniques.

DESCRIPTION: Considerable research has gone into the development of non-intrusive laser diagnostic techniques for the characterization of high speed flowfields such as laser doppler velocimetry, coherent anti-stokes Raman spectroscopy, stimulated Raman spectroscopy, and laser induced florescence. Such techniques to date suffer from the inability to make high quality measurements within the short duration (less than 50 millisecond) of shock tunnel and expansion tunnel runs severly limiting the use of these laser diagnostic techniques for hypersonic ground test facilities where instantaneous measurements become a necessity. Furthermore, these laser diagnostic techniques require optical access into the ground test facility from multiple directions – a requirement which is not always a possibility. Additional requirements, such as flowfield seeding, become vastly more difficult in hypersonic faciities.

The requirement for flowfield diagnostic measurements in high speed ground test facilities has become considerably more urgent of late with the current investment in hypersonic air-vehicles, both powered and unpowered [1]. Without such non-intrusive techniques, all measurements are largely restricted to model surface measurements – pressure transducers and heat flux gauges – to deduce the characteristics of these complex flows.

Recent advances in the development of the plenoptic or light-field camera, however, offer new approaches to the non-intrusive measurement of flowfield properties which could potentially overcome the limitations of the existing laser based techniques.

A plenoptic camera is a unique 3-D imaging technique that uses a conventional imaging sensor with a microlens array to capture not only the intensity variation in a scene, but also the angle information of the incoming ray. Post processing of the intensity and position information from the sensor array allows for the reconstruction of a 3-D image. This is analogous to holographic recording where the intensity distribution and the light field angle information is recorded in the emulsion by two laser pulses. Post processing of the holographic recording requires developing the plates and then performing analog reconstruction to a 3-D image using a reconstruction laser. A plenoptic imager is completely digital and has the advantage that only a single field-of-view is required unlike other stereo imaging techniques. In blow down facilities the test event last for a very small fraction of a second, with the plenoptic camera the entire 3-D light field is captured in a single exposure. Multiple exposures can be recorded to access velocity information due to measured changes in the 3-D florescence pattern that might encoded in the test gas with appropriate laser illumination system.

The key to the plenoptic based technology for flowfield measurement in ground test facilities lies in the single view, instantaneous three-dimensional field maps of the flowfield produced by the camera. The technology, however, need not be restricted to hypersonic flow facilities but the same advantages for both low speed and transonic flowfield ground test wind tunnels.

What are needed then, are innovative applications of the plenoptic technology to measure flowfield properties such as velocity, density, species and temperature.

PHASE I: Innovative technical approaches will be formulated in Phase I leading to the development of plenoptic flowfield measurement techniques as a marketable product. Success will be based on the variety of properties to be measured, the quality of those measurements, and the range of flowfield conditions to be covered. As field measurements, the spatial and temporal resolution will be important.

To demonstrate and validate these approaches, plans will be formulated in Phase I for completion, in Phase II, of ground based tests in a Government ground wind tunnel test facility. The goal of these tests will be validation of the proposed plenoptic measurement techniques using either known flowfield conditions or using simultaneous measurements with another validated non-intrusive diagnostic technique. These Phase II demonstration will require a minimum of 100 x 100 microlenses with at least 10 x 10 sensor pixels per microlens for verification of the flowfield measurement technique to provide at least 98 percent agreement with the validation data.

The ultimate goal, if proven successful, will be a turn-key plenoptic technology based, flowfield measurement instrument system as a commercial product which may be readily adaptable to a variety of ground based wind tunnel systems.

PHASE II: The proposed Phase I plan for ground based tests in a Government test facility will be executed to validate the use of plenoptic or light-field camera based flowfield measurement techniques. Execution will entail plenoptic measurements and comparisons with either the known flowfield conditions or simultatneous measurements using some other validated non-intrusive technique. Deliverables will include the wind tunnel test data and measurement comparisons.

The Phase-II plenoptic camera must exhibit at least 100 x 100 microlenses with at least 10 x 10 sensor pixels per microlens for verification of the flowfield measurement technique. At least 98 percent agreement with validation data will be required to advance any of the proposed plenoptic technological approaches.

The end state of the Phase-II effort then will be a verified plenoptic technology demonstration of flowfield property measurements which will serve as a basis for maturation to a commercial product.

PHASE III DUAL USE APPLICATIONS: If successful, the end result of this Phase I/Phase II research effort will be both a validated approach for non-intrusive measurement of flowfield properties during high speed ground tests using plenoptic imaging techniques to form the bases for development of a flowfield measurement instrument system as a commercial product. Full development of the commercial product will likely exceed the time and financial limits of the SBIR Phase-II effort requiring completion in a Phase-III endevor. Furthermore, the commercial measurement system should push for a factor of ten improvement in resolution meaning 1000 x 1000 microlenses with at least 100 x 100 sensor pixels per microlens.

For military applications, this technology is directly applicable to all missile systems and other flight vehicles to include UAVs and helicopters.

For commercial applications, this technology is directly applicable to ground based testing of all commercial flight vehicles to include airplanes and missiles.

REFERENCES:
1. “Fast Forward,” Aviation Week and Space Technology, 8 July 2013, pp. 24-25.

2 . http://en.wikipedia.org/wiki/Light-field_camera.

3. http://en.wikipedia.org/wiki/Light_field.

4. Ren Ng, “Digital Light Field Photography,” Ph.D. Dissertation, Stanford University, 2006.

5. Thurow, B. and Lynch, K., “Development of a High-Speed Three Dimensional Flow Visualization Technique,” AIAA Journal, Vol. 47, pp. 2857-2865, 2009.

6. Levoy, M., “Light Fields and Computational Imaging,” IEEE Computer, pp 46-55, 2006.

KEYWORDS: Plenoptic camera, Light-field camera, Ground based testing, Flowfield, Measurements

A15-010 TITLE: Manned/Unmanned Multi-platform Target Effects Teaming and Collaborative Engagement

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design and prototype an open architecture standards based system-of-systems concept for small-unit manned/unmanned effects teaming.

DESCRIPTION: The Future Force will possess a wide range of organic and highly deployable manned/unmanned systems that can acquire targets and deliver scalable effects out to operational distances.

The capability developed under this topic will allow the Future Force small combat unit to harness and optimize the utilization of a heterogeneous mix of organic manned and unmanned sensor and effects assets including small unmanned air and ground based sensor/effects assets as well as soldier borne assets to find, fix, and deliver required effects on targets in a full spectrum operational environment to include operations in urban and complex terrain.

The key to success is the ability of the dismounted soldier/leader to control, coordinate multiple unmanned sensor/effects resources while minimizing soldier/leader workload. This requires employment of embedded intelligent agents/ "assistants," on SUAV/SUGV platforms/controllers, that are capable of mixed initiative, task-level, and behavior-based control; dynamic planning and re-planning; coordination, collaboration and teaming to reduce operator work load and quickly and accurately execute target search, acquisition, geo-location, hand-off and collaborative engagement of threat targets. Hardware/software solution approaches should be modular, have well defined interfaces, conform to open architecture standards and be configurable and tailorable to meet specific platform/sensor capabilities, performance constraints and mission/task requirements. Architecture and algorithm approaches should address the integration of lower level distributed/decentralized state estimation and cooperative platform guidance and control laws and associated performance issues related to network connectivity/latency as well as higher level task control/planning/re-planning, operator interactions and automated event driven behaviors associated with typical small unit target surveillance, acquisition, tracking, engagement and network effects teaming mission threads.

PHASE I: Investigate innovative distributed intelligent control algorithms, architectures, protocols, prototyping/analysis tools and real time processing architectures with potential to meet the topic requirement. Conduct analysis to determine the best overall software/hardware component design approach and system-of-system integration approach for follow-on Phase II proof-of-concept demonstration. Demonstrate via simulation and/or analysis, feasibility and anticipated performance capability of proposed approach.

PHASE II: Develop and demonstrate a proof-of-concept prototype implementation of the manned/unmanned effects teaming and collaborative target engagement technology proposed in Phase I in a realistic small unit scenario. Conduct testing to demonstrate feasibility and performance of the developed proof-of-concept prototype in a networked, multi-platform hardware/software in-the-loop demonstration. Platforms may be a combination of vendor supplied and government supplied platforms and/or simulated platforms.

PHASE III: The algorithms, software and prototypes developed under this effort will have dual use applications in all domestic security operations where a highly automated, multi-tiered approach to security and incident response is required. Multi-tiered Homeland Security operations such as the Border Patrol, airport security, and FEMA could use this capability in automating their response to security incidents or natural disasters. This capability can also be used by private security companies which provide large scale industrial security at power plants, chemical plants, etc.

REFERENCES:
1. TRADOC PAM 525-66, Military Operations Force Operating Capabilities.

2. D. Cruz, J. McClintock, B. Perteet, et al. "Decentralized Cooperative Control: A multivehicle platform for research in networked embedded systems", IEEE Control Systems Magazine, vol. 27, no. 3, June 2007.

3. C. McMillen and M. Veloso, "Distributed, play-based role assignment for robot teams in dynamic environments," Distributed Autonomous Robotic Systems, Springer Japan, 2006,

4. M. Quigley, S. Griffiths, A. Eldridge, et al. Target Acquisition, Localization and Surveillance Using a Fixed Wing Mini UAV and Gimbaled Camera. IEEE ICRA, 2005.

5. Grocholsky, B., Swaminathan, R., Keller, J., Kumar, V. Pappas, G., "Information Driven Coordinated Air-Ground Proactive Sensing," In proc. IEEE conf. on Robotics and Automation, ICRA April 2005 p. 2211-2216

6. R. Olfati-Saber, A. Fax, and R. Murray, Consensus and cooperation in networked multi-agent systems, Proceedings of the IEEE 95 (2003), 215–233.

7. W. Ren and R.W. Beard, Consensus seeking in multi-agent systems using dynamically changing interaction topologies, IEEE Transactions on Automatic Control 50 (2005), 655–661.

8. Ahmadzadeh, Keller, An optimization-based approach to time critical cooperative surveillance and coverage with unmanned aerial vehicles of Rio de Janeiro: International Symposium on Experimental Robotics. 2006

9. W. Burgard, M. Moors, C. Stachniss, and F. Schneider, Coordinated Multi-Robot Exploration IEEE Transactions on Robotics (2005) 86-10

10. J. O'Kane, B. Tovar, P. Cheng, S. LaValle, Algorithms for Planning under Uncertainty in Prediction and Sensing (2005) Chapter 18 in Autonomous Mobile Robots: Sensing, Control, Decision-making and Applications.

KEYWORDS: Effects, Teaming, Collaborative engagement, Manned/unmanned teaming, Intelligent controls, time critical targeting, sensor to shooter, Intelligent agents, Robot teams, open architecture

A15-012 TITLE: Counter-UAS Technologies for Swarming UASs

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop and demonstrate a low-cost and lightweight countermeasure system that can be used to detect, disrupt, disable, and neutralize enemy unmanned aerial systems (UASs) platforms in swarming scenario.

DESCRIPTION: The role of unmanned aerial systems (UASs) in the battlefield continues to grow for both US forces and our enemies. These platforms serve a variety of roles, including support of communications, surveillance, and even attack capabilities. Their relatively low cost and access to previously-unavailable vantage points has led to their increasingly-pivotal role in ensuring battlefield dominance. To ensure our military's continued technical and tactical superiority on the battlefield, it is imperative that technologies are developed and deployed to enable the detection and neutralization of enemy UASs. These technologies should include capabilities to 1) identify the UASs themselves to include swarm of UASs and 2) initiate countermeasures that are effective in defeat swarming UASs. These countermeasures may include either a) disrupt these platforms' autonomous flight-control and navigation capabilities or b) cueing a weapons system like the Remotely-Operated Weapon Station (RWS) or other medium or large-caliber weapon. The objective of these capabilities is to enable the detection and capture and/or destruction of all enemy UASs on the battlefield.

PHASE I: The objective of this phase will be to develop concepts to support the detection and disruption of swarming UASs. This Phase should include a review of concepts suitable for installation on a variety of platforms, including fixed-site, vehicular, and airborne (e.g., on Army UASs) as well as interface requirements for cueing C-UAS weapons. Upon completion of Phase I, the contractor shall provide one or more baseline designs, as well as a review of the relevant performance and interface requirements necessary to support swarming UAS countermeasures.

PHASE II: The objective of Phase II will be to demonstrate a lightweight, low-cost swarming UAS countermeasure system suitable to one or more of the platforms described above. This Phase will include testing of the sensor system at a Government facility, including both laboratory and over-the-air testing, as well as demonstration of interoperability with RWS and/or other counter-UAS weapons. Based on the results, a final design will be identified and a prototype will be delivered.

PHASE III: Based on Phase II results, a prototype UAS countermeasure system will be optimized for commercialization and transition to military platforms. The prototype will be adapted to provide unclassified UAS protection capabilities for public/civil service agencies (e.g., critical infrastructure, public safety, etc.) and commercial entities requiring facilities and personnel protection and protection from industrial espionage (e.g., power and communications companies, the media and entertainment industries, auto industry, etc.). Transition opportunities identified during Phase I and Phase II will be used to tailor and deliver specific configurations of the system. The Army wants to cover the spectrum of military operations, from the brigade level and above out to the tactical edge. One application in the military area will use this system against drones by signal jamming the Command and control link or blocking, and the radar detection and conventional counterattack used against any other aircraft. Another application of such systems to be deployed by the army will be to use system capabilities in terms of using detection of the datalink to geolocate the threat UAV ground station and support its engagement using heavy weapons fire. After this Phase III is completed the most likely path for transition of this SBIR from research to operational capability will be to transition the final product/technologies into Program of records (PORs) across multiple PMs such as PM EW, PM RADAR, PM AMMO and other agencies.

REFERENCES:

1. Swarming and the Future of Warfare
http://www.rand.org/content/dam/rand/pubs/rgs_dissertations/2005/RAND_RGSD189.pdf

2. Faculty Explore Defensive 'Swarming' Strategies to Counter UAVs
http://www.nps.edu/About/News/Faculty-Explore-Defensive-Swarming-Strategies-to-Counter-UAVs.html

3. Flight Demonstrations of Unmanned Aerial Vehicle Swarming Concepts
http://www.jhuapl.edu/techdigest/TD/td2701/Bamberger.pdf

KEYWORDS: Unmanned Aerial System (UAS), Swarming, Threat Detection

A15-014 TITLE: <u>Nanoparticle Capacitors for Multi-Point Initiation</u>

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Ammunition

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

OBJECTIVE: The objective of this effort is to develop a small, low cost, high voltage nanoparticle capacitor for electronic fuzing applications. Once a proof-of-concept capacitor is demonstrated, a cost model should be established, as well as a transition plan to bring the devices into production. Emphasis during all phases of this project should be on developing a device with minimized cost and size.

DESCRIPTION: A typical multi-point electronics design utilizes several high voltage capacitors. These capacitors are significant contributors to the cost and size of the multi-point system, making them non-starters for many ARDEC applications. Current state of the art capacitors that are used in these applications cost $50-$100 per capacitor and are approximately 440mm^3 for a 0.1uF 1500V device. The government is seeking innovative, cost effective solutions for developing small, low cost high voltage capacitors for pulse discharge applications utilizing novel dielectric materials. For example, Sandia National Labs has developed nanoparticle based materials such as barium titanate (BaTIO3) and lead zirconium titanate (PLZT) that could result in devices with very high energy densities, small sizes, and high voltage standoff capability. However, the government is open to any dielectric material solutions that can meet device requirements. A few specifications of the capacitors needed are 0.1-0.4μF, 1500V rating, and 100mm^3. The existing capacitor technology that comes close to meeting these requirements is very expensive. Any solution proposed should demonstrate the ability to be significantly less expensive than current devices, with $5 as a reasonable cost objective. The device packaging should be a standard surface mount package, with low inductance, that can easily be populated on a pick-and-place production line. It is desirable for the offerer to have expertise in device manufacturing to eventually be able to mature this technology to the point where it is producible in high quantities.

PHASE I: During Phase I, a feasibility study shall be conducted to demonstrate how the nanoparticle materials will be utilized for the development of a small, low cost, capacitor. This study should identify the equipment and resources needed to process the materials and build a device, as well as initial device designs and unit cost estimates. Deliverables include a final report.

PHASE II: Execution of the prototyping plan from phase 1 shall begin. Phase II will end with a proof-of-concept prototype that demonstrates the performance and producibility of the device. The requirements for the capacitors needed are 0.1-0.4μF, 1500V rating, 100mm^3. Deliverables include a prototype and final report.

PHASE III: Military applications for these devices include fuzing, electronic safe and arm devices, and ignition safety devices. Potential commercial applications include oil field exploration, mining, and LCD displays.

REFERENCES:
1. T.C. Monson, D.L. Huber, C.B. DiAntonio, T.E. Stevens, M. Winter; Room Temperature Aqueous Synthesis of PLZT Nanoparticle Precursors; January 14, 2013.

2. C.B. DiAntonio, T.C. Monson, T.C. Chavez; Synthesis and Electrical Analysis of Nano-crystalline Barium Titanate and PLZT Nanoparticle-composites for use in High-Energy Density Applications; 2013 MRS Spring Meeting; April 2013, San Francisco, CA.

3. C.B. DiAntonio, T.C. Monson, P. Yang, M. Winter, T.C. Chavez; Synthesis and Characterization of Nanoparticle/Nanocrystalline Barium Titanate and PLZT for Functional Nanoparticle-Polymer Composites; Electronic Materials and Applications 2013; January 2013, Orlando, FL.

4. C.B. DiAntonio, T.C. Monson, T.P. Chavez, P. Yang, M.R. Winter; Dielectric and Ferroelectric Analysis of Nanoparticle/Nanocrystalline Barium Titanate and PLZT; Materials Science & Technology 2011; Columbus, OH, October 16-20, 2011.

5. Enhanced dielectric properties of BaTiO3/poly(vinylidene fluoride) nanocomposites for energy storage applications, Yu, Ke and Wang, Hong and Zhou, Yongcun and Bai, Yuanyuan and Niu, Yujuan, Journal of Applied Physics, 113, 034105 (2013), DOI:http://dx.doi.org/10.1063/1.4776740.

KEYWORDS: fuze, fuzing, capacitor, capacitors, nanoparticle, dielectric manufacturing, electronics, component manufacture, munition, initiation, armament, safe arm

A15-016 TITLE: True Double-clad Fully Crystalline Laser Fiber Development for DEW Applications

TECHNOLOGY AREAS: Weapons

OBJECTIVE: High energy lasers with nearly diffraction-limited beam quality (HEL) are required for directed energy weapons (DEW). One promising class of lasers to achieve this is fiber lasers. The purpose of this program is to develop double-clad fully crystalline coilable fibers to enable HEL power scaling to DEW-sufficient power level from a single fiber aperture. Technology must have high potential for manufacturability, mass production, low cost, and thermal management adequate for DEW applications.

DESCRIPTION: Conventional glass-based fiber lasers have shown great potential for military laser designs. They have higher reliability because they have much fewer discrete components and interfaces than bulk solid-state lasers, and because their beam quality is formed by the natural fiber modality rather than free-space external cavity (which bulk lasers usually use). For this reason, fiber lasers are very promising for building lasers required for DEW development and related applications. Unfortunately, to-date, the DEW-sufficient power level (~100 kW) from conventional glass-based fiber lasers can only be achieved by coherent or incoherent power combining from multiple laser apertures. This added complexity significantly undermines system reliability, tremendously increases system cost, and leads to an unacceptable for small Army platforms system Space, Weight, and Power (SWAP). Thus, finding a solution to fiber laser scaling to the DEW-sufficient power level from a single fiber aperture is of critical importance.

Recent success with crystalline yttrium aluminum garnet (YAG) rod-like fibers (air-clad crystalline cores), which are used as thin (< 1 mm) and relatively short (50-60 mm) laser rods in a free-space external cavity [1-3], does point to some application niche [3]. But this is merely a bulk solid-state laser with somewhat improved thermal management, and (i) it cannot be cladding-pumped and (ii) its beam quality is not formed by the fiber modality – so the beam quality and laser efficiency are mutually exclusive. Thus, this approach has very limited power scalability if high beam quality is required, and is not acceptable for DEW applications.

Serious advantages of the Cr4+, Nd3+ or Yb3+-doped YAG crystalline-core double-clad fibers with glass cladding versus all-glass fibers have been demonstrated recently [4-6]. This approach allows for both cladding pumping and mode selection in the crystalline core fiber. It also is fiber length-scalable [6]. And yet crystalline core/glass cladding fiber architecture will not scale to DEW-class powers due to high thermal resistance of the relatively thick glass cladding. Significant difference in thermal expansion coefficients of the core and cladding in this case is also detrimental: fiber rupture is expected at DEW-class pump powers.

Fully crystalline YAG-based doped core/undoped clad small-core fibers hold great promise for power scaling, as they have an order of magnitude higher thermal conductivity as well as 10 times higher absorption and emission cross sections of common dopants versus glass fibers with the same dopant [7]. A significant value added of the YAG-core fibers is the low YAG's Brillouin gain coefficient (9x10-15 - 5x10-12 m/W [7], based on data from different sources), which is 10 - 104 lower than that of silica glass (5x10-11 m/W). Estimates [7, 8] indicate that fully crystalline double-clad fiber lasers can be scaled to ~30-70 kW of power with nearly diffraction-limited beam quality even in the most demanding single longitudinal mode spectral laser regime. Despite numerous publications with the above (or similar) estimates, true double-clad fully crystalline coilable fibers have never been reported, and technology development for their fabrication is of great importance.

Fiber designs sought in this solicitation are true double-clad fully crystalline, coilable (to ~100 cm diameter), fibers with Yb3+ or Er3+-doped single-mode core. The most feasible solution would be a fiber with an ultra-low (< 0.003 cm-1) loss doped YAG core cladded by an ultra-low loss single-crystalline or poly-crystalline cladding. Technology must be developed with the high potential for manufacturability, mass production, low cost, efficiency, ease of use, and with thermal management potential adequate for DEW applications.

PHASE I: The focus at this technical feasibility stage is expected to be on the proof of concept design and demonstration of reasonably sized true double-clad fully crystalline crystalline core/crystalline cladding, coilable (to ~100 cm diameter), fibers with Yb3+ or Er3+-doped single-mode core. Double-clad fibers have to be fabricated based on YAG material, single-crystalline or poly-crystalline, to form a low-loss doped core/low-loss cladding configuration. Fabrication should rely on a process which is length-scalable (to over 1.5 meters of length) to produce laser components for DEW-class laser during a follow-on Phase II project. Phase I deliverables are to include single-mode (SM) coilable doped core/undoped cladding fibers, with the length not less than ~100 mm, suitable for demonstrating true double-clad fully crystalline laser performance benefits versus all-glass or crystalline core/glass cladding structures for resonant pumping and allow for baseline thermal management and further power scaling estimates. Estimated core diameter is around 50 microns in this first phase. Coating of the fully-crystalline fiber by a low-index polymer or SiO2 outer cladding has to be evaluated at this stage. The overall emphasis should be placed on fiber quality and cladding technology required to achieve high laser efficiency. Deliverable for this phase should be 2-3 fully crystalline fibers per specs listed above with laser grade polished end faces. Best-effort devices shall be provided to the Army Research Laboratory for comprehensive testing and scalability evaluation.

PHASE II: This phase will be devoted to optimization of the device proposed in Phase I and to demonstration of reproducibility of the entire technological process. Full optical characterization of the device (propagation loss, absorption, index measurements of the core and cladding) will be carried out. Power handling experiments must be conducted as well as gain/lasing experiments. Advanced fully crystalline coilable structures useful for initial high-power (at least 1 kW) laser demonstrations, with the length of over ~1.5 m, shall be produced by a process that is scalable to designs for multi-ten kilowatt operation. The coilable diameter for the structures should be ~100 cm or less. The outer cladding (coating) per the Phase I findings, should be optimized. Close cooperation with the Army Research Laboratory's laser testing facility in the course of Phase II for establishing critical manufacturing, design and lasing parameters is essential for a successful transition to ruggedized fully crystalline coilable laser fibers. The scaled-up fully crystalline fibers (LMA-sized core with NA not to exceed 0.1 is expected in Phase-II) will be further characterized for optical, mechanical and thermal properties in order to provide a proper baseline for laser weapon development. The deliverables, no less than three devices coilable to a diameter ~100 cm or less, with specifications listed above shall be delivered for testing at the Army Research Laboratory.

PHASE III: Development of double-clad fully crystalline coilable fibers enabling HEL power scaling to DEW-sufficient power level from a single fiber aperture will result in higher HEL overall efficiency, reduction in weight/size, and significant cost reduction. It will also provide much higher DEW design flexibility and improved ruggedness. Both military and commercial applications (like laser welding, cutting) are in equal need of efficient high power lasers that demand reliability at lowest possible cost. The military has a strong interest in incorporating advanced eye-safe HEL's based on the resonant, low-quantum-defect, diode-pumped operation of crystalline Er3+-doped gain media into directed energy weapon systems. Department of Defense organizations with interest in such lasers include the Army Space and Missile Defense Command, Missile Defense Agency and the High Energy Lasers Joint Technology Office. Current specific tasks would include laser-based remote mine clearing and counter-RAM (rockets, artillery, mortars) applications. Another important area of application is the use of the developed laser technology for pumping tunable mid-IR OPOs for infrared countermeasures and atmosphere pollutant monitoring. Further commercial applications that would benefit from this technology's high beam quality and power include longer-working-distance laser welding and cutting, such as in the automotive industry, and higher power densities for endoscopic surgery.

REFERENCES:
1. I. Martial, S. Bigotta, M. Eichhorn, et al., "Er:YAG fiber-shaped laser crystals (single crystal fibers) grown by micro-pulling down: Characterization and laser operation," Opt. Materials 32 (9), 1251-1255 (2010).

2. I. Martial, F. Balembois, J.Didierjean, et al., "Nd:YAG single-crystal fiber as high peak power amplifier of pulses below one nanosecond," Opt. Express 19 (12), 11667-11679 (2011).

3. X. Delen, Y. Zaouter, I. Martial, et al., "Yb:YAG single crystal fiber power amplifier for femtosecond sources," Opt. Lett. 38 (2), 109-111 (2013).

4. C. Y. Lo, P. L. Huang, T. S. Chou, L. M. Lee, T. Y. Chang, S. L. Huang, L. Lin, H. Y. Lin, and F. C. Ho, “Efficient Nd:Y3Al5O12 crystal fiber laser,” Jpn. J. Appl. Phys. 41, L1228, 2002.

5. K. Y. Huang, K. Y. Hsu, D. Y. Jheng, W. J. Zhuo, P. Y. Chen, P. S. Yeh, and S. L. Huang, “Low-loss propagation in Cr4+:YAG double-clad crystal fiber fabricated by sapphire tube assisted CDLHPG technique,” Opt. Express 16, 12264, 2008.

6. C. Lai, C. Ke, S. Liu, D. Jheng, D. Wang, M. Chen, Y. Li, P. Yeh, S.-L. Huang, "Efficient and low-threshold Cr4+:YAG double-clad crystal fiber laser," Opt. Lett. 36 (6), 784-786 (2011)

7. J. W. Dawson, M. J. Messerly, J. E. Heebner, P. H. Pax, A. K. Sridharan, A. L. Bullington, R. J. Beach, C. W. Siders, C. P. J. Barty, and M. Dubinskii, “Power scaling analysis of fiber lasers and amplifiers based on non-silica materials,” Proc. SPIE 7686, 768611-1 - 768611-12 (2010).

8. T. A. Parthasarathy, R. S. Hay, G. Fair, and F. K. Hopkins, “Predicted performance limits of yttrium aluminum garnet fiber lasers,” Optical Engineering 49 (9), 094302-1 - 094302-8 (2010).

KEYWORDS: Fiber laser, double-clad fiber, rare-earth doped, crystalline core, crystalline cladding, single-crystalline, poly-crystalline

A15-017 TITLE: Integrated High Temperature Sensors for Advanced Propulsion Materials

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: The objective of this program is to develop, mature and integrate high temperature sensor technology for advanced propulsion materials (e.g. ceramic matrix composites) via reliability and durability testing. The evaluated superior performing high temperature engine sensing technology will be applicable to new generation and existing military fixed wing aircraft and rotorcraft gas turbine engines.

DESCRIPTION: Currently no reliable direct measurement method of structural temperature, strain or in-situ damage assessment is available for engine hot section components like turbine rotor or stator vane. Temperature and strain is computed based on inlet temperature measurement and gas path analysis. Accurate and reliable direct measurement of structural component temperature and strain would lead to optimized turbine rotor blade and vane designs. Early damage detection and reliable prognosis of hot section components would minimize catastrophic events like blade off events. Direct measurement of structural substrate temperature would also accurately characterize the performance of the thermal barrier coating and the bond layer. Thermal Barrier coating damage assessment can also prevent or minimize the fracture leading to the rotor blade structural substrate material failure. In essence, it would lead to better gas turbine engine survivability of extreme environment, better life prediction and increased engine vulnerability reduction while accomplishing missions of longer endurance and faster flight with higher payload.

Ceramic matrix composites (CMCs) have the capability to operate at temperatures to 2400 degree F and more. Future generations of turbine engine materials protected by environmental and thermal barrier coatings offer the potential to withstand higher operating temperatures. To increase specific fuel consumption and reduce NOx emissions, CMC and metal alloys components are being developed for the hot sections of turbine engines. These engine components include combustors, turbine shrouds, vanes and blades. A key enabling technology to support advanced gas turbine engine component development is the ability to measure temperature and strain at temperatures at 2400F and higher. Advanced turbine materials and reliable sensor technology to monitor them is a significant leap for engine vulnerability reduction. Thin film and fiber optic sensors have been developed with high temperature capability. They have been applied to metallic components mostly with limited or no trials on CMC substrates. However recent engine tests show that the sensors require more technology maturation to survive the high temperature and reliability demonstration for future integration into military engine platforms. New high temperature piezoelectric materials like lanthanides, tantalates and barium titanate has demonstrated piezo properties that can be exploited to develop thin film ultrasonic or surface acoustic wave sensors for early detection of turbine blade cracking and material degradation. To assess their suitability for new CMC high temperature gas turbine components, further evaluation is needed. The choice of the structural substrate material for mounting of the sensors and testing under very harsh environment is very important to avoid creep-related issues affecting the tests. Different sensor mounting and integration techniques would be explored, such as etching, diffusion bonding and flush mounting the sensors onto the structural substrate. Alternatively, molecularly bonding the sensor element on a structural ceramic layer like alumina and depositing directly onto the structure. The sensor and sensor attachments would be continuously monitored for delamination, wrinkles, cracking, or peeling off of layers under exposure to extreme environments. The connectivity in the hot zone of the sensor to the data acquisition system would also need to be monitored closely. High-temperature environment testing needs to be conducted to advance high temperature sensing technology maturation.

This topic seeks to develop and mature the high temperature sensor technology for advanced turbine engine materials like ceramic matrix composites through reliability and durability testing and integration of the high temperature sensors to hot section engine components.

PHASE I: This phase is primarily intended for identifying the sensor technology (including sensing material, data acquisition hardware and software), sensor structural substrate material, sensor mounting, and integration methods. The following tests for assessing the sensor durability, survivability, stability, and drift are to be conducted for sensing technologies evaluation: 1) Isothermal static test; 2) Biaxial tensile torsion test; 3) Thermomechanical Fatigue test; and 4) Blister test. The high temperature sensing technology method attached to a CMC turbine blade material coupon, subjected to relevant thermomechanical fatigue loads, needs to survive 2400 deg F for 250 hot/250 cold hours (Total 500 hours). The accuracy of sensor data needs to be within +/- 2% error for temperature measurement accuracy.

PHASE II: This phase is primarily focused on further development of the high temperature sensing method, miniaturization, hardware packaging and integration strategies. Further tests need to be carried out to mature the sensor technology. The high temperature sensing technology method attached to a CMC turbine blade material coupon, subjected to relevant thermomechanical fatigue loads, needs to survive 2700 deg F for 3000 hot/3000 cold hours(Total 6000 hours). Relevant engine environment tests for sensor survivability and durability would include successful Atmospheric Burner Rig Test and Vibration Tests. The accuracy of sensor data needs to be within +/- 1% error. Wireless data transmission from sensor should be developed in this phase.

PHASE III: This phase is to transition the developed sensor technology to the OEM Engine Manufacturers. The developed sensor technology should be demonstrated on a military air vehicle (rotorcraft or aircraft) engine at relevant environment which may include engine test cell and/or flight test. The developed high temperature sensor technology needs to be a device that can be used during in-flight, onboard at aircraft and/or during line maintenance and/or at the overhaul and repair maintenance depots.

REFERENCES:

1. Ghoshal, A., Kim, H. S., and Le, Dy D., "Technological Assessment of High Temperature Sensing Systems under Extreme Environment," Sensor Review, Vol. 32, Issue 1, pp. 66-71, 2012.

2. Wrbanek, J. D., Fralick, G. C., Farmer, S. C., Sayir, A., Blaha, C. A. and Gonzalez, J. M., (2004) "Development of Thin Film Ceramic Thermocouples for High Temperature Environments," 40th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, AIAA 2004-3549, Jul 11-14.

3. Gregory, O. J., Luo, Q. and Crisman, E. E., (2002). "High temperature stability of indium tin oxide thin films," Thin Solid Films, Vol. 406, Issues 1-2, pp 286-293, March.

4. Sayir, A, Farmer, S.C., Dynys, F., (2006) "High temperature piezoelectric La2Ti2O7," Ceramic transactions 2006, Vol. 179, pp 57-68.

KEYWORDS: High Temperature Sensors, Gas Turbine Engines, Advanced Propulsion Materials, Ceramic Matrix Composites, Sensor Integration, Propulsion Material State Awareness, Wireless Transmission

A15-018 TITLE: Radioisotope Power Source for Long-Lived Sensors and Communications

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: Contractor shall develop a radioisotope power source system suitable for long-lived unattended sensors or network communications nodes, capable of providing a fixed voltage (between 1.5 and 3.3 volts) at 100 microWatt power level for >20 years over military useful temperature ranges.

DESCRIPTION: Contractor shall develop a long-lived radioisotope power source to meet the following requirements:

(1) Any radioisotope-based (including nuclear isomers) power sources that meet all the requirements are acceptable solutions. However, neither thermal energy conversion nor energy harvesting will be considered;
(2) the power source output voltage shall be a fixed voltage between 1.5 volts and 3.3 volts;
(3) the power source shall have a 20 year lifetime or greater for operation and storage;
(3) the power source's temperature range shall cover the full military temperature range of -55 C to +125 C desired;
(4) the power source shall provide 100 microWatts average trickle charge power with a capability to provide 50mW burst modes for radio transmission;
(5) the power source shall be environmentally friendly, with minimal disposal issues. Plans for obtaining a NRC license and for life-cycle management typical of radiation in military materiel are required;
(6) a power source that can be certified flight worthy;
(7) the power source shall be no larger than 2 by 4 by 4 inches;
(8) the power source shall weigh no more than 1 lb;
(9) novel radioisotope and energy conversion configurations are of interest, if they provide advantages in meeting other requirements; and
(10) hybrid energy storage systems and power sources may also be of interest.

PHASE I: Contractor shall provide a feasibility study to develop a radioisotope power source meeting the requirements in the description section. Contractor may develop models, prototypes, and/or simulations to meet the requirements. Contractor shall provide a final phase I report. For a nuclear power source system, contractor shall include preliminary plans for obtaining a NRC license and for life-cycle management.

PHASE II: Contractor shall develop a radioisotope power source to meet the requirements described in the description section. Contractor shall develop test method(s) to verify the power source meets the requirements described in the description section. Contractor shall provide the government with a report describing the test method(s) and all test results.

Contractor shall have an independence source, with government concurrence, test and evaluate prototype power source.

Contractor shall provide a copy of the test and evaluation report to the Government. Contractor shall deliver 2 prototype power sources to the government point of contact for test and evaluation.

Contractor shall provide midterm and final reports. For a nuclear power source, contractor shall include in the final report a plan for obtaining a NRC license and a life-cycle management plan.

PHASE III: Batteries are problematic in long-lived unattended sensor and communication node applications. Current batteries do not have more than 5 to 10 years of shelf life over the military temperature range. A radioisotope battery, with a > 20 year operating/shelf life would eliminate replacing batteries every 5 years.

Low power consumer electronics, industrial control, oil and gas monitoring systems, and harsh environment monitoring systems would all benefit from long life battery technology. Medical electronics (pacemakers, and insulin pumps) would also benefit from improved battery technology.

REFERENCES:
[1] K.E.Bower, ed., "Polymers, Phosphors, and Voltaics for Radioisotope Microbatteries," CRC Press, 2002

[2] D. Linden and T. Reddy: "Handbook of Batteries," McGraw-Hill Companies, 2001, ISBN: 0071359788.

[3] Zaijun Cheng ; Zhiwen Zhao ; Haisheng San ; Xuyuan Chen, "Demonstration of a GaN betavoltaic microbattery," Proceedings of the 2011 6th IEEE International Conference on Nano/Micro Engineered and Molecular Systems February 20-23, 2011, Kaohsiung, Taiwan

[4] M. V. S. Chandrashekhar, Christopher I. Thomas, Hui Li, M. G. Spencer, and Amit Lal, "Demonstration of a 4H SiC betavoltaic cell," Applied Physics Letters 88, 033506, 2006

KEYWORDS: Radioisotope battery; beta battery; long-lived power source; low-power, unattended Sensors; communication nodes; power source; hybrid power source

A15-019 TITLE: Very High Dynamic Range RF Two Tone Measurement Instrument and Sensor

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: Develop an RF measurement instrument capable of measuring intermodulation product signal powers with high broadband dynamic range in the presence of two test signals very close in frequency in the RF (Radio Frequency) range (between 400 MHz and 6 GHz).

DESCRIPTION: There are many application areas where small RF signals must be measured in the presence of large signals. These include characterization of materials and detection of buried objects using non-linear response to multi-tone probe signals; of satellite navigation receivers (and other receivers) operating near high power cellular telephone systems, in a jamming environment, or in the presence of adjacent band interference from high power digital transmitters; of distortion performance of analog circuit components; and of non-linear radars that detect the presence of electronic systems by detecting harmonics and intermodulation products in the reflected RF signal. In the design of these systems, components and the overall system must be tested to determine compliance with manufacturing specifications and with FCC and other governmental standards. The increasing sensitivity of modern radar, radio, and sensor systems has led to greater concern with ultralow distortion products and a concurrent effort to control these through tighter specifications and standards, requiring improved testing methods for compliance. At the same time there is a growing recognition that electro-thermal effects, vibration, passive intermodulation (PIM), and time-frequency effects can make significant contributions to system noise. The research into these effects, and ultimately their control in systems design, require the same measurement of very small RF signals in the presence of very large signals. This topic addresses an instrument with a capability at least 2 orders of magnitude better than commercially available instruments at small tone separations and with much greater bandwidth.

This topic addresses mission command and tactical intelligence, which is one of the Army Top Challenges. It will enable communications systems to be conceived, designed, and tested for compliance, with unprecedented tight control of the frequencies generated in a communication channel, allowing maximum utilization of frequency spectrum. It will enable the identification and remediation of physical sources of interference between electronic systems, for example the major problems of co-site interference between closely mounted electronics systems on helicopters and tactical vehicles. It will enable the assessment of vulnerability of electronic systems to electronic warfare attack or to unintended interference. It will enable the laboratory exploration of the physical causes of 1/f noise and other effects which have previously been lumped into the largely poorly understood category of "noise floor."

Measurement systems based on filters are not able to address the high dynamic range with small tone separation due to the finite roll-off of the filter characteristics. This is particularly true of phase errors in the filter response. In addition, they require the physical change out of filter elements to achieve measurements throughout the test signal range. Other more promising approaches, including feedforward systems, have been reported in laboratory experiments. The references demonstrate some feasible approaches to this topic.

The goal of this topic is a flexible, commercially available, and automated RF measurement instrument for two tone tests with very high dynamic range in the presence of moderate power test signals which can be very close in frequency. The below references describe possible technical approaches which have shown significant improvements over more common approaches.

PHASE I: Demonstrate the concept by designing a flexible, automated, and compact instrument architecture to meet the specifications for the RF instrument capable of measuring intermodulation product (2f1-f2, 2f2-f1, where f1 and f2 are the frequencies of the 2 test signals) signal powers and phases in the presence of two 43 dBm test signals with a dynamic range of at least 120 dB. The separation between the two test signals must be continuously tunable between 10 Hz and 100 MHz without changing major components, around a center frequency that can be anywhere in the full range from 400 MHz to 6 GHz. The effort in phase I should focus on demonstration of a proof-of-principle for the proposed approach in which the techniques for measurement of two RF tones with very high dynamic range are clearly identified. Phase I should include predictive calculations and modeling to demonstrate the capability of the design to meet the performance metrics above. In phase I the risk factors for the design implementation should be identified and risk mitigation measures developed. Alternative architectures should be analyzed in determining a design approach.

PHASE II: Develop and demonstrate a compact, packageable prototype measurement instrument capable of meeting the specifications listed in Phase I. Where possible, utilize commercial off-the-shelf components to reduce cost. Conduct a detailed cost analysis and provide a manufacturing plan for productization. Demonstrate the prototype instrument at a designated government laboratory. Conduct bench level experiments to resolve problems with specific components. Identify technical opportunities to reduce the frequency separation of the two test signals from 10 Hz to 1 Hz. Demonstrate the prototype instrument under realistic conditions, i.e. measurements made in a laboratory with realistic electronic signatures. Packaging issues should be identified and mitigation procedures developed. Develop a detailed market analysis and business plan addressing opportunities for sales to such institutions as military development laboratories, industrial design laboratories and activities, government testing laboratories, and government spectrum management activities and laboratories.

PHASE III: Develop a compact, rugged packaged automated product meeting the technical specifications of Phase I and II for commercial sales. Implement and demonstrate the approach identified in phase II to reduce the frequency separation of the test signals to 1 Hz. Scale the manufacturing process for quantities determined by market demand. This system is expected to find a market in military and commercial electronic system laboratories and government laboratories enforcing compliance with electromagnetic compatibility and WCDMA standards, particularly in the cell phone industry. This instrument is expected to provide an unparalleled capability for the design of military and commercial radio and radar systems, for testing of these systems, and for the analysis of system vulnerabilities. Additional system ruggedization is expected during this period. The contractor is expected to continue to follow and execute the business plan developed in phase II and to pursue contacts with potential identified customers and to establish (if appropriate) third party collaborative arrangements with other private sector businesses. It is expected that the same underlying technology could provide unique signature analysis capabilities for military systems in the field, however that is not the subject of this SBIR topic.

Specific military applications: Operational real time electronic vulnerability analysis of hostile communications and radar systems (PM Electronic Warfare), Laboratory electronic vulnerability analysis of friendly communications and radar systems under development (PM EW and/or PEO-STRI EW Science and Technology), Spectrum certification of military electronic systems (PEO-STRI PM ITTS Instrument Management Office and/or OSD Test Resource Management Center T&E/S&T Spectrum Efficient Technologies), Networked electronic support threat sensors (PM ITTS Threat System Management Office), UXO Detection by Enhanced Harmonic Radar (CERDEC I2WD).

Likely military program transition path: Evaluated at Army Research Laboratory – Sensors and Electron Devices Directorate (ARL-SEDD) and Communications and Electronics Research, Development, and Engineering Center (CERDEC) Intelligence and Information Warfare Directorate (I2WD), followed by adoption by a program management office such as PM Electronic Warfare.

REFERENCES:
1. Wetherington, J.M. and Steer, M.B., “Robust Analog Canceller for High-Dynamic-Range Radio Frequency Measurement”, IEEE Trans. Microw. Theory Tech. 60, 1709-1719 (2012).

2. Wilkerson, J.R., Gard, K.G., and Steer, M.B., “Automated Broadband High-Dynamic Range Nonlinear Distortion Measurement System”, IEEE Trans. Microw. Theory Tech. 58, 1273-1282 (2010).

3. Andersen, O., Wisell, D., and Keskitalo, N., “Measurement of ACLR with High Dynamic Range”, IEEE MTT-S Int. Microw. Symp. Dig., Jun 15-20 (2008), pp. 273-277.

4. Roussel, A., Nicholls, C., and Wight, “Frequency agile RF feedforward noise cancellation system”, Proc. IEEE Radio and Wireless Symp., Jan 22-24 (2008), pp. 109-112.

5. Steer, M.B., Wilkerson J.R., Kriplani, N.M., and Wetherington, J.M., “Why it is so Hard to Find Small Signals in the Presence of Large Signals”, in 2012 Workshop on Integrated Nonlinear Microwave and Millimetre-Wave Circuits (INMMIC), 3-4 Sept (2012), available as an IEEE publication.

KEYWORDS: RF test instrumentation, high dynamic range, manufacturing test, nonlinear distortion measurement, adjacent channel leakage, co-site interference

A15-020 TITLE: Wireless Networking Using Multiple Antenna Interference Alignment

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Research and refine network interference alignment algorithms and develop a software suite to allow multiple wireless transmit receive pairs to communicate at the same time, leading to improved network throughput and delay performance.

DESCRIPTION: One of the innovations upon which the Army's future war fighting capabilities will be built is the Tactical Mobile Ad hoc Communications Network (TMACN). TMACN technology is important because it will provide the backbone for exchange and sharing of information from sensors, manned and unmanned vehicles and systems, and dismounted soldiers. Communications using multiple antennas, such as multi-input multi-output (MIMO) in ad hoc networks is an emerging field and will likely soon be utilized in TMACN in order to improve link performance, energy consumption, and throughput. However, conventional MIMO does not allow for more than one transmitter to be active at any given time.

Interference alignment [1] is potentially a game-changing technique that makes use of coordination between the transmitters to improve the overall throughput of a wireless network [2]. It extends MIMO, by allowing multiple transmitter-receiver pairs to be active at the same time, by aligning their signal spatially, so that it minimizes or eliminates the interference at receivers "listening" to other active transmitters. Interference alignment in multiple antenna interference channels has been shown to multiply the total throughput relative to previous techniques in certain network configurations [3].

Initial research on interference alignment has been limited to mathematical models or prototypes with many idealistic assumptions [4]. Further research is necessary to make an interference alignment network feasible. Specific challenges that need to be addressed include coordination to set up the transmission (including estimation of channel state), low-complexity design and implementation of specific waveform algorithms, sharing of channel state, scheduling, and coordinated medium access. A network capable of using interference alignment should also be able to adapt between interference alignment and conventional MIMO techniques based upon the network status.

In order to make interference alignment work, there must be more coordination between radios in the network. In large networks, algorithms are necessary to partition the network into clusters to make the aligning signals feasible. Within the cluster, algorithms need to determine which transmitter receiver pairs will be active, and then radio channel states need to be determined for the alignment algorithms. Signal processing for transmit waveform and receiver steering need to be used, to implement the interference alignment algorithms. Higher level control is necessary for scheduling and determining how many transmit-receiver pairs should be active (including degenerate case of single transmitter receiver pair, corresponding to conventional MIMO).

The ultimate goal of this project is to produce efficient suite of physical layer, medium access, and networking algorithms implemented in software that can be demonstrated on a small network of multi-antenna radios.

PHASE I: Delineate trade-offs between various algorithms and software architectures for interference alignment used in ad hoc networks. Results should include theoretical analysis required to design and implement a prototype network, such as interference alignment physical layer algorithms, clustering, and trade-offs between alignment and conventional multi-antenna algorithms. Simulate design to show performance gain over traditional MIMO, taking into account additional overhead. Initial high level design of the software suite should be completed.

PHASE II: Refine analysis from Phase I and produce a prototype design to demonstrate an interference alignment network. Implement design in a software suite that can be run on a network of multiple antenna radio platforms of the offeror's choice. Prototype the design and demonstrate the performance of the interference alignment network (goal of 20% throughput improvement over using traditional MIMO algorithms in a 20 nodes network).

The algorithm and software emphasis is on the control of the interference alignment algorithms, but will also need to include modulation and multi-antenna signal processing. Software must utilize modular design, so that different modulation and communications standards can be accommodated by changing software modules.

PHASE III: Refine the design, algorithms, and software suite for DoD and commercial applications. Develop application program interface (API) for software. Potential DoD receivers applications include tactical vehicular and dismounted radio. Commercial applications include Wi-Fi networks, cellular networks, and emerging multi-hop wireless communications networks to include first responder networks. The benefit to the customer will be improved network data throughput. It is envisioned that the software would be licensed, but other avenues, such as licensing patented algorithms or hardware-software system solution may also be pursued.

REFERENCES:
1. O. El Ayach, S. W. Peters, and R. W. Heath, Jr., "The Practical Challenges of Interference Alignment", IEEE Wireless Communications Magazine, vol. 20, no. 1, pp. 35--42, 2013.

2. V. R. Cadambe and S. A. Jafar, “Interference alignment and degrees of freedom of the K-user interference channel,” IEEE Trans. Information Theory, vol. 54, no. 8, pp. 3425–3441, 2008.

3. S. W. Peters and R. W. Heath, Jr., "Cooperative Algorithms for MIMO Interference Channels", IEEE Trans. on Vehicular Technology, vol. 60, no. 1, pp. 206-218, 2011.

4. R. Tresch, G. Alfano, and M. Guillaud, “Interference Alignment in Clustered Ad Hoc Networks: High Reliability Regime and Per-Cluster Aloha,” IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), pp. 3348-3351, 2011.

KEYWORDS: Multiple-Input Multiple-Output (MIMO), Space-time processing, Interference Alignment, Tactical Communications, Wireless Networking

A15-021 TITLE: Health Conscious Structures for Zero-Maintenance Rotorcraft Platforms

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop structural state awareness technology with real-time monitoring of components to enable zero-maintenance aircraft structure. Key attributes of Health Conscious Structures are the ability to detect precursors to damage and predict remaining useful life of the aircraft structure.

DESCRIPTION: Metallic and composite aircraft structures are susceptible to damage during their service life. Fatigue failure in metallic aircraft structures is dominated by crack initiation followed by propagation to failure. Fatigue in composite aircraft structures triggers a progressive accumulation of damage that may begin as matrix cracking followed by delamination followed by fiber pull-out leading to fiber failure. Both types of failure, in the respective materials, have been shown to lead to loss of structural integrity and ultimately catastrophic failure if not detected early.

To meet the goal of developing future zero-maintenance Army aviation vehicles, early detection of damage will not be adequate. Current non-destructive inspection (NDI) techniques intended to detect flaw initiation are routinely carried out to evaluate the integrity of the structure. Routine scheduled NDI inspections are costly, laborious, and require aircraft downtime. Also, these techniques depend highly on an operator, and may at times be highly impractical as they require extensive disassembly and subsequent reassembly of the structure. Because structural health monitoring (SHM) techniques have many advantages over conventional NDI techniques, SHM is gaining acceptance as the technology to use for monitoring critical structures for aircraft/rotorcraft/spacecraft. Current SHM systems have demonstrated the ability to detect, locate, and determine the size/severity of damage in structures. However, in order to ensure zero-maintenance operation, over the life of a structural component, a paradigm shift from traditional NDI and current SHM detection of damage state toward determination of the material state by achieving awareness of precursors to damage must be achieved. Precursors are not necessarily objects to be measured, such as cracks of a certain length. Instead, the precursors of interest are characteristics of the material state, and show up as physical trends during the service life of a material. For example, as certain steels are exposed to cyclic fatigue loading, over time the electrical resistance changes. The change in electrical resistance shows a measurable trend during the fatigue life, and can therefore be used to predict the remaining useful life of the material. Similar precursors are sought for other materials, with particular interest in structural materials, both metal and composites.

There is a need to develop Health Conscious Structures that are capable of capturing and quantifying precursors to damage, prior to damage initiation, to improve structural integrity awareness. In the case of metals, well known precursors have been demonstrated in the presence of fatigue loading such as increases in dislocation density, changes in electrical resistivity, and changes in temperature. These precursors to damage have been captured and quantified accurately in laboratory settings. However, corresponding lightweight portable sensing technologies appropriate for aircraft platforms with similar accuracy are lacking. For composites, the likelihood of combining sensors with the material by various fabrication methods without compromising structural integrity, durability, repairability, and manufacturability must be addressed. Also, in order to capture the accumulation of damage as it progresses to failure in composites, physical fields beyond traditional interrogation via high frequency waves must be investigated, including electrical, thermal, and chemical sensing. Thus, the proposed innovation must contain multi-physics sensors integrated throughout the structure so that during the service life the structure will self-report in real-time to assess the health state of the structure prior to damage initiation to enable a zero-maintenance approach, eliminating the need for routine inspections. In order to achieve the goal of self-reporting, the sensor data should be integrated into a modeling framework that allows the precursor measurement to be used to make a remaining useful life prediction. This will require the collection of data and the updating of model predictions in real time to enable decision making to support a zero-maintenance methodology.

This Health Conscious Structures technology consists of (i) material state awareness based on detection of precursors to damage, (ii) advanced multi-physics sensor diagnostics through impedance, ultrasonic signal, acoustic emission, thermal, chemical, electrical and other measurements, and (iii) integration of precursor measurement into a modeling framework that allows a remaining useful life prediction.

PHASE I: Select one structural material, either metallic or composite, and investigate/report on the following: damage precursors exhibited in the material response, methods to measure the precursors, methods to quantify the damage precursors over the fatigue life, with particular attention to the 80% or so of life before structural integrity would be compromised. Establish a modeling framework to incorporate precursor measurements into remaining useful life predictions. For the selected material establish the feasibility of capturing at least two distinct types of precursors with multi-physics sensors that incorporate lightweight, fully integrated strategies. The sensing technology should be able to capture a precursor to indicate 50% of remaining useful life. The modeling framework must be capable of incorporating sensor data to make the life prediction in real-time.

PHASE II: Select a component for constant amplitude fatigue testing to demonstrate a prototype Health Conscious Structure. In a lab, demonstrate the ability to capture the two precursor types identified in the Phase I. Verify that the durability and structural integrity of the structural component has not been compromised by the sensing technique. Insert the detected precursor evidence into the developed modeling framework. Integrate the modeling framework to automatically update using sensor data, such that in the case of both precursors, the measurements can lead to remaining useful life predictions. The goal of the demonstration effort is to predict 50% remaining useful life with greater than 50% confidence and 85% reliability using multi-physics sensor networks and models, where a successful prototype predicts the remaining useful life to the exact number of cycles based upon the prediction at 50% of life.

PHASE III: Zero-maintenance is a goal for the next generation of Army aircraft, such as Future Vertical Lift (FVL). In Phase III, the objective shall be to work with interested major aircraft manufacturers and program managers to further mature Health Conscious Structures technology for transition to the next generation of military and commercial aircraft. Additionally, efforts should be made to extend the potential applicability in other Army applications such as ground vehicles and UAVs, and commercial industries, such as automotive, civil infrastructure, space, and energy.

REFERENCES:
1. Hall, Asha J., I. V. Brennan, E. Raymond, Anindya Ghoshal, Kuang C. Liu, Michael Coatney, Robert Haynes, Natasha Bradley, Volker Weiss, and Jerome Tzeng. Damage Precursor Investigation of Fiber-Reinforced Composite Materials Under Fatigue Loads. No. ARL-TR-6622. ARMY RESEARCH LAB ABERDEEN PROVING GROUND MD VEHICLE TECHNOLOGY DIRECTORATE, 2013.

2. Ghoshal, Anindya, James Ayers, Mark Gurvich, Michael Urban, and Nathaniel Bordick. "Experimental Investigations in Embedded Sensing for Structural Health Monitoring of Composite Components in Aerospace Vehicles." In ASME 2012 Conference on Smart Materials, Adaptive Structures and Intelligent Systems, pp. 845-854. American Society of Mechanical Engineers, 2012.

3. Shiao, Michael, YT J. Wu, Anindya Ghoshal, James Ayers, and Dy Le. "Probabilistic structural risk assessment for fatigue management using structural health monitoring." In SPIE Smart Structures and Materials+ Nondestructive Evaluation and Health Monitoring, pp. 834724-834724. International Society for Optics and Photonics, 2012.

4. Le, Dy, V. Weiss, J. C. Riddick, B. Miller, N. Bordick, "Fatigue-Free Platforms: Vision for Future Army Rotorcraft," in the proceedings of the American Helicopter Society 70th Annual Forum, Montreal, Canada, May 20-22, 2014.

KEYWORDS: Structural Health Monitoring, zero-maintenance, sustainment, multifunctional structure, self-reporting material

A15-022 TITLE: Front-end Application Specific Integrated Circuit for Navigation-Grade MEMS Gyroscope

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: Develop an application specific integrated circuit front-end for a microelectromechanical systems (MEMS) gyroscope capable of providing navigational grade signal fidelity to an inertial measurement unit. Zero-rate signal performance will adhere to navigational grade criteria including but not limited to angle random walk (ARW), bias drift, scale factor stability, full scale linear range, and bandwidth. Active collaboration with U.S. Army Research Laboratory is highly desirable.

DESCRIPTION:
Background -
Global position system (GPS) denied environments are an exponentially growing concern for position, navigation, and timing (PNT). As battlefield awareness increases so does the dependency on GPS. Existing inertial measurement units (IMU) suffer from size, weight, power, and cost (SWaP-C) restrictions which in turn make the dismounted soldier rely solely on GPS. DARPA and other PNT programs have been focusing on microelectromechanical (MEMS) sensor solutions; however, little focus has been towards front-end MEMS interfacing electronics. Current state-of-the-art high aspect ratio MEMS gyroscopes with piezoelectric and capacitive transducers are not yet complementary metal-oxide-semiconductor (CMOS) compatible. In order to facilitate SWaP-C improvements for PNT, navigation grade specifications have to apply to both the sensor and interfacing ASICs. Moreover, as MEMS solutions offer lower noise and higher dynamic ranges so should the interfacing ASIC.

Research -
Research methods and approaches to develop a front-end MEMS coriolis vibratory gyroscope (CVG) ASIC with both state-of-the-art system noise floor and dynamic range, and piezoelectric and capacitive drive and sense transducers. Single- or multi-die solution in both a packaged and unpackaged form is desirable. The ASIC zero-rate output must adhere to the navigation grade specifications [1-2]. This includes but is not limited to angle random walk (ARW) less than 0.001 deg/ hr^(1/2), bias stability less than 0.001 deg/hr, scale factor variation over temperature less than 1 ppm, bandwidth greater than 100Hz, full scale linear range greater than 400 deg/s, and startup time less than 10ms.

Electrically the developed CVG ASIC should have: minimum detectable capacitive change of 10zF/Hz^(1/2), incorporate automatic mode matching between sense and drive with less than 1ppm accuracy, be able to drive both piezoelectric and electrostatic elements with a dynamic range greater than 100dB and 10VDC maximum bias at 30mA maximum supply current, be able to tune drive and sense frequency by piezoelectric and electrostatic elements with dynamic range greater than 100dB, drive and sense frequencies ranging from 1-30kHz, and incorporate both open and close loop quadrature cancellation. Further advancements in ASIC design would be to be configurable having the ability to switch from CVG mode to a whole-angle free vibration mode. ASIC chip size should adhere to a size constraint of 10x10mm or smaller. All CVG ASIC specifications should be temperature compensated over the range -40C to 85C.

PHASE I: Phase I expectations is to deliver electronic design concepts and schematics for a navigational grade front-end application specific integrated circuit (ASIC) for a hybrid electrostatic/piezoelectric microelectromechanical (MEMS) gyroscope. Single- or multi-die solution will be acceptable.

Initial design should address the following criteria: minimum detectable capacitive change of 10zF/Hz^(1/2), incorporate automatic mode matching between sense and drive with less than 1ppm accuracy, and be able to drive both piezoelectric and electrostatic elements with a dynamic range greater than 100dB at 10VDC maximum bias with 30mA maximum supply current at frequencies ranging from 1-30kHz.

PHASE II: Provide United State Army Research Laboratory with front-end application specific integrated circuit to interface with hybrid, piezoelectric and capacitive, MEMS gyroscope meeting the navigational grade specifications along with the other requirements listed in topic's description.

PHASE III: The MEMS application specific integrated circuit (ASIC) market is currently over a $3.4 billion industry [3]. As trends in wearable sensor and handheld electronics increase so will front-end ASIC interfaces. ASIC advancements will enable higher resolution MEMS sensor solutions. Commercial applications include but are not limited to navigation grade inertial measurement unit (IMU) for handheld electronics, wearable sensor interfaces, and drilling and mining system navigation. Navigation grade IMUs in handheld environments will revolutionize the consumer smartphone industry. Smartphones will have the ability to be constantly aware of your position whether you're outside, inside, underwater, in an urban-canyon, or any other GPS-denied environment.

REFERENCES:
[1] http://beforeitsnews.com/science-and-technology/2013/07/2013-status-of-the-mems-industry-the-asic-mems-market-is-expected-to-reach-3-3b-2622372.html

[2] Sharma, Ajit, Mohammad Faisal Zaman, and Farrokh Ayazi. "4 CMOS Systems and Interfaces for Sub-Deg/Hr." MEMS: Fundamental Technology and Applications (2013): 69.

[3] Norouzpour-Shirazi, Arashk. "Interface Circuits and Systems for Inertial Sensors." (2013).

[4] Sharma, Ajit. CMOS systems and circuits for sub-degree per hour MEMS gyroscopes. ProQuest, 2007.

KEYWORDS: ASIC, front end interface, MEMS, micro position navigation timing, gyroscope, piezoelectric, capacitive

A15-023 TITLE: High Performance, Flexible, Silicon-Based Photovoltaic Devices

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The main objective of this program is to develop novel concepts for fabricating flexible, light weight silicon photovoltaic (PV) sheets with high power throughput comparable to that of state of the art rigid silicon panels. The technology should demonstrate man-portable PV sheets with low cost, high efficiency, high power per unit mass, and operation over wide angles of incidence.

DESCRIPTION: The Army's dependence on fossil fuel is deemed as a strategic risk, and key mitigation measures which include renewable energy solutions have been explored. One solution of particular interest is the use of photovoltaic technologies that can reduce the number of batteries carried by the dismounted Soldier and hence associated weight during an unsupplied 72 hours mission. Two major disadvantages to utilizing solar cells is 1) they operate best during peak sunlight, and 2) the solar cells with superior performance (III-V-based technologies) in terms of power per unit area and power per unit mass are too expensive for most Army applications. Therefore, to make solar power a competitive solution, low-weight, flexible, high performance and cost-effective technologies that can sustain long mission times are required. This program is designed to marry the cost effectiveness of silicon with advancements in quantum size effects and optical nanostructures to maximize the performance of silicon based technologies for all-day operation while maintaining low cost and weight per unit area. It is expected that the necessary innovations required will include (but are not limited to) the use of quantum size effects in silicon based nanopillars and quantum dots to increase the absorption strength per unit thickness and novel optical coupling/trapping/waveguiding schemes to maximize photon interaction lengths in thin silicon films.

PHASE I: Develop and evaluate the feasibility of methods for increasing the efficiency of silicon-based solar cells at wide angles of incidence for all-day operation while reducing the weight and increasing flexibility. The results should show a clear pathway for the development of flexible silicon-based PV sheets with low cost (<$5/W), high power per unit mass (>0.05W/g), high peak efficiency (>22%), and enhanced operability over a wide range of incidence angles (>40°) for all-day operation.

PHASE II: Demonstrate flexible silicon-based PV sheets with high power per unit mass (>0.05W/g), high peak efficiency (>22%), and enhanced operability over a wide range of incidence angles (>40°) for all-day operation. A cost model should be presented that shows this technology, when scaled up to production levels, would yield a cost per Watt of less than $5.

PHASE III: Scale the technology demonstrated in Phase II up to a level that produces flexible silicon PV modules with the required performance at a cost of less than $5/W

REFERENCES:
1. Y. Zhai, L. Matthew, R. Rao, D. Xu, and S. K. Banerjee, "High-performance flexible thin-film transistors exfoliated from bulk wafer," Nano Lett. 12, pp. 5609–5615, 2012.doi:10.1021/nl302735f

2. V. Gupta, J. L. Cruz-Campa, M. Okandan, G. N.Nielson, "Microsystems-Enabled Photovoltaics: A Path to the Widespread Harnessing of Solar Energy", Future Photovoltaics 1, 2010 28-36

3. Fraunhofer, "24 percent efficienct n-type silicon solar cell", Press Release - Freiburg November 27, 2013

KEYWORDS: silicon, nanophotonics, light weight, flexible, power

A15-024 TITLE: High Operating Temperature Long Wave HgCdTe Focal Plane Arrays

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: Develop approaches to increase the minority carrier lifetime to near theoretical limits in long wave infrared (LWIR: 8-12 microns) HgCdTe via identification and reduction of the concentration of high capture coefficient traps and increase the performance and temperature of operation of high operating temperature (HOT) long wave P-I-N HgCdTe detectors.

DESCRIPTION: The US Army is pursuing mercury cadmium telluride (HgCdTe)-based photovoltaic technology for high-performance, thermal imaging systems. Next-generation systems are envisioned to entail large-format (>1M pixels), infrared focal plane arrays (IRFPA). For cost effectiveness, approaches which can result in increasing the temperature of operation of these IRFPAs are critical. A higher operating temperature would result in several advantages to an infrared imaging system, mainly a reduction in power and weight requirements, thus lowering mission costs and allowing infrared systems to be deployed on various new platforms. This work would have significant impact on several mission areas including Missile Defense Agency, Army and other platforms. This technology will increase IR detection range, spatial resolution of imagery, reducing the carry-on weight of an individual warfighter, etc. besides having a significant impact on the size, weight and power (SWaP) of the overall IR imaging system. While there has been much progress in the increase of operating temperature of detectors based on the non-equilibrium operation concept [1-4], the temperature of operation is still below the theoretical limits of this material. The current state of the art 10 micron cutoff detectors have dark currents roughly 3E-6 Amps/cm^2. It may be possible to grow/anneal such that the concentration of the Shockley-Read centers with high carrier capture coefficients is reduced. This would improve the minority carrier lifetime as well as reduce the dark current. At present, LW HgCdTe suffer SRH recombination lifetimes when n-type doping is less than 1.0x10^15/cm^3. If minority carrier lifetimes are increased, the temperature of operation could be raised. Other approaches that reduce dark currents will also be considered. This solicitation seeks innovative solutions to increase the temperature of operation of the current state of the art of the HOT detector technology in HgCdTe based IRFPAs.

PHASE I: Demonstrate the feasibility of the proposed innovation for increasing the temperature of operation of LWIR HgCdTe detectors (cutoff greater than 10 microns) to 90K that keeps the dark current at or below 3E-6 Amps/cm^2. The innovation method must be scalable to 120K with the same dark current.

PHASE II: Demonstrate 10 micron cutoff HOT LWIR HgCdTe detectors at 120K with dark current at or below 3E-6 Amps/cm^2. The detector size must be 400 square microns or smaller and the process must be appropriate for large area (at least 1000 x 1000) LWIR HgCdTe focal plane arrays.

PHASE III: Successful completion of Phase II, followed by validation of the innovative approach to increase the temperature of operation of the LWIR HgCdTe based IRFPAs will lead to commercialization of the approach to fabricate high performance large density LWIR HgCdTe FPAs for many DOD applications, in fact, this process could be used for most, if not all, future IR focal plane arrays. Specific applications include affordable sensor arrays for threat detection and imaging. It is expected that the small business would team with or license a patent to a larger defense contractor to mass produce focal plane arrays. Commercial applications include smog detectors, temperature arrays for weather satellites, and sensors for the examination of real time manufacturing yield, as well as various applications in astronomy.

REFERENCES:
1. C. T. Elliott and T. Ashley, Electronics Letters 21, 451 (1985)

2. C. D. Maxey et al, Proc. SPIE 3122, 453 (1997); M. Bevan, Appl. Phys. Lett. 67, 3650 (1995)

3. R. S. Hall, N. T. Gordon, D. C. Herbert, A.M. White, C. D. Maxey, C. L. Jones, M. Ahmed, N. E. Metcalfe, A. Scholes, and R. A. Catchpole, 2000 US II-VI Workshop Abstracts, 179

4. C. D. Maxey, Chapter 6 on ‘Metalorganic Vapor Phase Epitaxy (MOVPE) Growth in the book Mercury Cadmium Telluride , growth, properties and applications, editors Capper and Garland, Published by Wiley, 2011, page 113

KEYWORDS: HgCdTe, focal plane arrays, HOT, mercury interstitials

A15-025 TITLE: Compact Vehicle Transmission Concept with Large Reduction Ratio

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop an innovative compact and lightweight transmission capable of large reduction ratios for propulsion systems in military vehicles. Design concepts to achieve reduction ratios on the order of minimally 10:1, and preferably 50:1 or greater to enable advanced drivetrain arrangements for future vehicles, significantly reducing footprint. The primary application of interest is rotorcraft, although concepts with potential extending to ground/marine drivetrains will be considered.

DESCRIPTION: In military rotorcraft propulsion systems, increases in power-density are driven in large part by reductions in drive system weight. These transmissions generally utilize spiral bevel, helical, and/or planetary gears in order to transmit and change the axis of rotation of mechanical power from engines to the mast output. The Army is interested in new and innovative concepts to transmit mechanical power that reduce the transmission foot print and the resulting drive system weight. Planned future programs such as Future Vertical Lift (FVL) aim to increase the speed and range of vertical lift vehicles, which will likely require the ability to vary the output speed of the transmission by 50 percent. This will likely result in a weight increase of the total drive system.

Past efforts to improve the power density of rotorcraft include items like the implementation of face gear technology in the Apache AH-64E helicopter, which was put into production as the first helicopter drive system to utilize this technology to increase power density by over 20% [1]. Other past examples of efforts to obtain compact high-reduction ratio include traction, toroidal, planocentric and nutating drives [2,3]. While these concepts may have been shown to have specific limitations in the past, recent technology advancements (e.g. new lubricant additive technology, increased viscosity lubricants, new materials, etc.) may have increased concept feasibility. An example of using past efforts to implement new solutions to transmission technology include the combination of face gear technology and the nutating drive to form the pericyclic transmission [4].

Highly innovative game-changing configurations will be favorably considered and are not restricted to those using gears to transmit torque. All concepts will be required to demonstrate reliability, durability, and performance characteristics that make them competitive with currently utilized technologies. Such performance characteristics include a minimum efficiency of 95% and the ability to be backdriven, allowing for autorotation in emergency situations. Proposed concepts with multi-ratio capability should provide the same output direction at all available ratios. Concepts that are single ratio should include a discussion of their compatibility with multi-ratio arrangements. Those showing a potential to reduce cabin noise will also be favorably considered.

PHASE I: Explore the allowable design limits for rotorcraft transmission applications that the proposed concept would need to satisfy. Investigate issues relevant to integration with typical aviation drive systems and establish operational conditions and evaluation metrics to which the concept would be subjected.

Establish feasibility of at least one compact, large-reduction ratio transmission configuration applicable to rotary wing vehicles. Conduct appropriate and relevant kinematic, static, dynamic and other analyses. Concepts should achieve weight savings over current technology (as outlined in Figure 7 of [5]) with a minimum efficiency of 95%. Proposals for Phase I efforts should clearly explain how the proposed effort can provide a robust and improved power transmission concept, including identification of component risk and associated mitigation during the technology development.

PHASE II: Refine the technology developed in Phase I and validate its feasibility through some combination of subscale component experimentation and simulation. Verify Phase I assumptions and required performance to design and execute an appropriate evaluation methodology. Examine the vehicle operational envelope to identify critical flight conditions under which the proposed technology will be most challenged.

Perform complete design and construct a 3-dimensional simulation or prototype that verifies the kinematics of the design. Simulate operation at various torque levels that realistically mimic the characteristics of transmissions in rotorcraft applications. Identify any shortcomings of the concept and determine risk mitigation plan in moving forward with the candidate technology.

PHASE III: Applications for the technology primarily include powerplant and drive systems for aerospace vehicles. Both commercial and military rotorcraft are clear benefactors of this technology, as are other aviation propulsion systems such as turboprops and geared fans. Some proposed technologies may also be relevant to wind turbine gearboxes and other industrial power generation equipment.

REFERENCES:
[1] G. F. Heath, R. R. Filler, and J. Tan, “Development of Face Gear Technology for Industrial and Aerospace Power Transmission,” The Boeing Company, Mesa, AZ, Contract Report NASA/CR-2002-211320; ARL-CR-0485;, May 2002.[2] S. H. Loewenthal and D. P. Townsend, “Design Analysis for a Nutating Plate Drive,” NASA Lewis Research Center, Cleveland, OH, Technical Memorandum NASA TM-X68117, Oct. 1972.

[3] S. H. Loewenthal and E. V. Zaretsky, “Design of Traction Drives,” NASA Lewis Research Center, Cleveland, OH, Reference Publication NASA RP-1154, 1985.

[4] Z. Saribay, E. C. Smith, R. C. Bill, S. Rao, and K.-W. Wang, “Design Analysis of Pericyclic Variable-Speed Transmission System for a 600HP Class Unmanned Rotorcraft,” presented at the AHS International Specialists’ Meeting on Unmanned Rotorcraft Systems, Phoenix, AZ, 2009.

[5] M. T. Tong, S. M. Jones, W. J. Haller, and R. F. Handschuh, “Engine Conceptual Design Studies for a Hybrid Wing Body Aircraft,” NASA Glenn Research Center, Cleveland, OH, Technical Memorandum NASA/TM-2009-215680; ARL-TR-4719; GT2009-59568, Nov. 2009.

KEYWORDS: Gears, transmissions, drivetrain, rotorcraft, propulsion, helicopters

A15-026 TITLE: Real-Time Camera-Independent Image Processing System For Long-Range Tactical Imaging Applications

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop and demonstrate an innovative camera-independent real-time image/video processing module and system that will have advanced characteristics of low-power, low-latency, high-performance, and Input/Output standard agnostic to mitigate atmospheric turbulence effect during long-range tactical imaging process.

DESCRIPTION: Real-time, high-resolution, long-range imaging is critical in military applications such as remote reconnaissance, surveillance, situational understanding, and target identification. The Future Force requires the capability to enable battlefield visualization, understanding, coordination, and synchronized action by sharing, displaying and integrating essential information. However the compounded effects of natural atmospheric turbulence over long distances always introduce variations in image quality, causing the overall image or video to appear blurred and distorted. Several techniques and algorithms have been developed to mitigate the effect of atmospheric turbulence. Presently many of these techniques are the post-imaging process, complex, platform specific, and also in-efficient. The algorithms that have been created to mitigate the effects of atmospheric turbulence may work in laboratory experiments, but are too computationally intense to be implemented for real-time processing on modern desktop PCs. The need exists for a more comprehensive algorithm package to be capable of effectively mitigating atmospheric turbulence as well as be computationally inexpensive to be practical for real world scenarios. The development of integrated circuit (IC), field-programmable gate array (FPGA), and GPU technologies has enabled a new horizon for faster and efficient electronic processing systems. The aforementioned algorithm can be accelerated on hardware to exceed the capacity of modern day PCs. This topic seeks to leverage the latest electronic technologies and demonstrate capable algorithms and corresponding imaging platform independent hardware for the mitigation of atmospheric turbulence effects occurred during long-range tactical imaging. Offerors should develop an innovative compact, lightweight, low-power, and camera-independent real-time (>30 fps) image/video processing system (visible to IR) that effectively mitigates atmospheric turbulence during long-range imaging for operation over tactical distances (0.5 km – 10 km).

PHASE I: Effort should be directed toward the development of initial design of the proposed real-time camera-independent image processing system concept. Detailed algorithms for image processing should be evaluated, using a combination of real data, high fidelity simulation and field experiments, for effectiveness in turbulence mitigation efficiency under various atmospheric turbulence 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 for real-time image/video processing during Phase II.

PHASE II: Effort should be focused on prototype development by implementing image processing algorithm in hardware on a camera independent platform. The function of this prototype system in turbulence mitigation effects in tactical scenarios should be demonstrated. Based on this atmospheric evaluation of the image quality, the system should be optimized through algorithm refinement and hardware improvement. A working system with identifiable improvements in image quality should be available by the end of Phase II.

PHASE III: The prototype should be further refined toward military applications including Visible/Infrared tactical imaging, reconnaissance and surveillance systems, battlefield identifications, target recognition and tracking from air and ground mobile platforms. Civilian applications will include long-range high-resolution imaging and security video surveillance. The offeror should work with Army scientists and engineers, along with industry partners, to identify and implement technology transition to military and civilian applications.

REFERENCES:
1. Maignan, W. and D. Koeplinger, “Hardware Acceleration of Lucky-Region Fusion (LRF) Algorithm for Image Acquisition and Processing,” In Proc. of SPIE vol. 8720. (2013).

2. Aubailly, M., and M. A. Vorontsov, “Imaging with an array of adaptive subapertures,” Optics Letters, Vol. 33, No.1, pp.10-12, 2008.

3. Vorontsov, M., and G. Carhart, “Anisoplanatic imaging through turbulent media: image recovery by local information fusion from a set of short-exposure images,” JOSA A Vol. 18, No 6, 1312-1324, (2001).

KEYWORDS: Real-time atmospheric imaging, turbulence mitigation, camera-independent image processing, adaptive optics

A15-027 TITLE: Aerodynamic Interference Module Development for Rotorcraft Design

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: The objective of this research is to develop a flow solver and software module to accurately predict the rotorcraft aerodynamic interactions with low computational cost in order to render a practical design tool for rotorcraft development. The solver should be able to link to computational fluid dynamics (CFD) and computational structural dynamics (CSD) codes for a complete rotorcraft analysis that fully addresses the interaction of the rotors/wing/fans/fuselage/empennage.

DESCRIPTION: Rotorcraft represent very sophisticated dynamic systems that encounter highly complicated unsteady aerodynamics and aerodynamic interactions. Rotorcraft design requires evaluation of the design over hundreds or even thousands of trim points through multiple design iterations. A reliable rotorcraft design tool must accurately address the modeling of various complex rotorcraft structures, the 3-D unsteady aerodynamics, and their strong interactions and at the same time must have a relatively low computational cost.

Remarkable progress has been made in developing a CFD-based rotorcraft aerodynamics analysis tool in recent years, especially in rotor loads calculation through coupled CSD/CFD methods. Most of the efforts have thus far been focused on the rotor performance, airloads and structural loads. A desired and necessary next step is the development of a comprehensive CSD/CFD solution for the complete rotorcraft aerodynamics that fully addresses the interaction of the rotors/wing/fans/fuselage/empennage.

Modern CFD tools provide very accurate solutions, but most are still too computationally expensive to support rotorcraft design and engineering analysis. A difficult aspect of CFD solvers for aerodynamic interaction is the inherent artificial vorticity dissipation from the numerical discretization scheme which results in the inaccurate or poor predictions of aerodynamic interaction problems. Resolving the artificial vorticity dissipation problem requires the use of either a high order scheme or a high grid density, which often results in prohibitively high computational requirements and, therefore, limits its use for practical design applications. Therefore, there is a need to develop a flow solver which combines a near surface CFD solver and a wake solver to resolve the full rotorcraft aerodynamics for the entire flow region in a robust and efficient manner.

Recent studies on the rotor airloads predictions using a CFD solver for near surface and a viscous vortex particle method for rotor wake demonstrated that the same accuracy can be achieved compared to the full CFD analysis but with only 10% of the full CFD computational time.

The ultimate goal of this research is to develop a flow solver and interface software to accurately predict the rotorcraft aerodynamic interactions with low computational cost in order to render a practical design tool for rotorcraft development. The proposed solution should meet the following requirements:

1) The flow solver should, either by itself or by linking with other software, predict the full aircraft aerodynamics including interactions between aerodynamic components (e.g. rotor blades, fixed wings) and non-aerodynamic bodies (e.g. the fuselage).

2) The flow solver should be able to run in parallel and demonstrate significantly lower computation time compared to a RANS CFD solver.

3) The flow solver should be compatible with existing CFD solvers for the near body and rotorcraft comprehensive analysis (CSD) programs for structural loads and trim.

4) A software module should be developed with user-friendly interface in order to be integrated with existing CFD and rotorcraft comprehensive analysis tools.

PHASE I: In Phase I, proposer should identify a technology that will meet the above requirements. Proposer should also demonstrate the accuracy and the computational efficiency of the selected technology and devise a plan for integrating it with existing CFD and CSD tools. The feasibility study can be performed with a typical fuselage interference on rotors or on aerodynamic surfaces. In Phase I, manually coupling inputs and outputs with CFD, CSD, or comprehensive analysis codes is acceptable.

PHASE II: In Phase II, the solution methodology identified in Phase I needs to be developed and evaluated further with a relevant aircraft and flight conditions. The evaluation should focus on demonstrating the technology's ability to calculate the full vehicle aerodynamics and interactions. In addition, the user interface should be prototyped which is user-friendly and compatible with existing CFD solvers and rotorcraft comprehensive analysis programs.

PHASE III: In Phase III, solver and interface software prototyped in Phase II should be transitioned into a commercial product that can be used to be coupled with existing and widely used rotorcraft comprehensive analysis programs (RCAS, CAMRAD, DYMORE) and CFD solver for rotorcraft performance, airloads, and structural loads analysis. A closer relationship with federal laboratories and industry customers and should be established in order to enhance the software capabilities to support rotorcraft design efforts. Funds from other government agencies and industry should be sought for further developing the technology.

REFERENCES:
1. Strawn, R. C. and Djomehri, M. J., “Computational Modeling of Hovering Rotor and Wake Aerodynamics,” Journal of Aircraft, Vol. 39, No. 5, September-October, 2002.

2. Potsdam, M. and Yeo, H. and Johnson, W., “Rotor Airloads Prediction Using Loose Aerodynamic/ Structural Coupling,” AHS 60th Annual Forum, Baltimore, MD, June 2004.

3. Bhagwat, M. J.; Ormiston, R. A.; Saberi, H..A and Xin, H., “Application of Computational Fluid Dynamics/ Computational Structural Dynamics Coupling for Analysis of Rotorcraft Airloads and Blade Loads in Maneuvering Flight,” Journal of the AHS, Vol. 57, No. 3, July 2012.

4. He, Chengjian and Zhao, Jinggen, “Modeling RotorWake Dynamics with Viscous Vortex Particle Method,” AIAA Journal, Vol. 47, No. 4, April 2009.

5. Phuriwat Anusonti-Inthra and Matthew Floros "Coupled CFD and Particle Vortex Transport Method: Wing Performance and Wake Validations," AIAA 38th Fluid Dynamics Conference, AIAA-2008-4177, Seattle, WA, 2008

KEYWORDS: Rotorcraft design, Aerodynamic interference, CFD, CSD, flow solver

A15-028 TITLE: Development of Broadband Nanostructured Antireflection Coatings for Improved Infrared Focal Plane Arrays (IRFPA) Performance

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a robust broadband Nanostructure based antireflection coatings for improved Infrared Focal Plane Arrays (IRFPA). Infrared focal plane arrays are needed for a variety of Army Applications, which include soldiers’ day-night sights, vehicle mounted and robotic day-night capability for various Army missions including covert operations. This antireflection technology will allow the EO/IRFPA and the sensor undetectable with any laser based systems for various operations.

DESCRIPTION: There is a significant effort in developing nanostructured based EO/IR focal plane arrays that cover Ultraviolet (UV), Visible-Near infrared (VIS-NIR), Shortwave (SWIR), Mid-wave infrared (MWIR) and Long wave Infrared (LWIR) focal plane arrays for a variety of Army Sensors and imaging systems. These include threat warning systems, day-night imaging systems, Rifle sights and vehicle mounted systems. Nanostructured based coating technology for the IRFPA’s will allow much higher performance and make the systems harder to detect with various detection systems including laser based systems.

Nanostructured based anti-reflection technology that minimizes the reflection of the incident radiation preferably to less than 2 percent are needed for these applications. Current technology does not meet these performance requirements. This technology is at TRL 1 level. The goal of the SBIR program is to bring the technology to TRL 3 level.

PHASE I: Design, develop and demonstrate innovative approaches for high quality growth of antireflection coatings on a variety of substrates for IRFPA applications. The nanostructured designed and grown layers will be characterized in detail. Characterization shall include quantitative characterization of optical characteristics versus wavelengths, and performance characteristics as a function of incident angle of light, versus wavelengths. The nanostructured coated samples shall be characterized for performance (to include radiation absorption efficiency and durability). Identical samples shall also be provided for testing and evaluation. The Phase I designs will be prototyped and further evaluated and improved in Phase II. Phase I reporting shall include the nanostructured design's scientific and technical merit and feasibility, while also addressing the overall business case viability. Business considerations typically include plan for production scale up, projected costs per unit area as produced, and all within the context of one or more projected EO/IR sensors and imaging systems markets.

PHASE II: Using the technology approach developed in Phase I, further effort to demonstrate high quality nanostructured antireflection technology with improved properties as compared to Phase I. Quantitative characterization testing and evaluation to include at minimum detailed optical and electrical characteristics, reliability and durability capabilities, for a variety of expected environments. All of the EO/IR sensor technologies will benefit from the development of advanced antireflection (AR) coatings that minimize reflection losses to less than 2 percentage over a wide range of wavelengths and incident angels. The goal is to bring the technology to TRL 3 level.

PHASE III: Various military and civilian applications of this technology are envisioned. Commercialization could be through direct sales and/or via sub-systems, component supply to larger integrated system suppliers. These high performance nanostructured IRFPA/ Imaging systems for day-night capability can be integrated for homeland security or other innovative and duel use applications.

REFERENCES:
1) A.K. Sood, P. Haldar, E. F. Schubert, N.K. Dhar and P.S. Wijewarnasuriya " Development of Nanostructured AR Coatings for EO/IR Sensor Applications" Proceedings of SPIE, Volume 8868, 8868P-1 (2013)

2) J. Q. Xi, M.F. Schubert, J.K. Kim, E.F. Schubert, M. Chen, S.-Y. Lin, W. Liu, and J.A. Smart "Optical Thin-Film materials with low refractive index for broadband elimination of Fresnel reflection," Nature Photonics, Vol. 1, 2007, pp. 176-179.

3) A. K. Sood, N. K. Dhar, D. L. Polla, and P. S. Wijewarnasuriya, "Multispectral EO/IR sensor model for evaluating UV, Visible, SWIR, MWIR and LWIR system performance" Proceedings of SPIE, Vol. 7300, 73000H, 2009

KEYWORDS: antireflection coating (AR), nanostructured, Infrared (IR) focal plane arrays, Ultraviolet [UV), Visible-Near infrared (VIS-NIR), Shortwave (SWIR), Mid-wave infrared (MWIR) and Long wave Infrared

A15-029 TITLE: Human Skin Simulant for Ballistic Testing

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a material solution with matching kinematic and penetration responses as human skin. The proposed solution will allow for the consistent assessment of skin penetration resistance to training rounds, non-penetrating "less lethal" kinetic munitions, and low energy ricochet fragments.

DESCRIPTION: Specific less-than-lethal and close combat training rounds carry a requirement ensuring the projectile will not penetrate human skin. This requirement is poorly defined and needs to be understood in the context of its application to personnel safety. Penetration resistance of a uniform is not an adequate solution to address the injury requirement. Ballistic gelatin simulates thigh muscle tissue and can be useful in understanding wound cavity formation following ballistic penetration. The gelatin assumes the energy lost due to skin penetration is negligible compared to the energy dissipation captured by the ballistic gelatin interaction and cannot be used to assess skin penetration accurately or effectively. A test material effectively capturing the ballistic response of human skin to penetration kinematics is currently unavailable. Testing labs require a solution to accurately address human skin penetration resistance in a consistent and controlled manner.

PHASE I: Conduct a literature review (government, academic, and commercial) to capture existing data sets to include boundary conditions, loading rates, and ballistic projectile geometry.

Propose a material solution that enables the simulation of the penetration response of skin, over an existing muscle tissue simulant (like ballistic gelatin). Provide the following parameters regarding material characterization: frequency sweep response (0.001-1000Hz), load-displacement data (to failure), fatigue load-displacement response data. Propose a material model (hyperelastic, viscoelastic, etc.), with defined coefficients based off submitted data package. Compare proposed material solution to existing penetration models of human skin in the literature.

Submit a report summarizing all findings that includes a bibliography of relevant literature referenced, a description of the proposed material solution, and the aforementioned material response data sets.

PHASE II: Define the methodology for manufacturing the proposed material solution en mass. Define a calibration procedure and calibration limits and conditions. Specify conditions and factors that would erode consistency. Define supply, storage life, abilities and limitations. Create a "user's manual" that includes, as a minimum, everything mentioned previously plus everything needed to conduct a successful munition test to assess the penetration response of human skin.

PHASE III: In addition to the US Army, civilian police forces in major cities nationwide employ less-than-lethal munitions for the tactical control of riots and other situations. A commercially available ballistic skin simulant would likewise be of interest to foreign governments for the development of less-than-lethal munitions for their armies and civil police forces. Less-than-lethal and training munitions developers would use this product for their in-house testing and/or it would be included as a specification in the testing documents of third party testers. The manufacturers of recreational marking projectiles, such as paintballs, would also find a use for a commercially available ballistic skin simulant.

REFERENCES:
1. Bir, C.A., et al, "Skin Penetration Surrogate for the Evaluation of Less Lethal Kinetic Energy Munitions", Forensic Science International, Volume 220, Issue 1, pp 126-129, 10 July 2012.

2. Bir, C.A., et al, "Skin Penetration Assessment of Less Lethal Kinetic Energy Munitions", Journal of Forensic Sciences (2005), Volume 50, no. 6, pp 1426.

3. Duck, F.A., 1990, "Physical properties of tissues: a comprehensive reference book", Academic Press, Harcourt Brace Jovanovich Publishers, London.

4. Jussila, J., "Ballistic Skin Simulant", Forensic Science International, Volume 150, Issue 1, pp 63-71, 28 May 2005.

5. Roberts, J.C., et al, "Computational and experimental models of the human torso for non-penetrating ballistic impact" Journal of Biomechanics (2007) 40:125-136.

6. Saraf, H., et al, "Mechanical Properties of soft human tissues under dynamic loading", Journal of Biomechanics (2007) 40(9):1960-1967.

7. Saraf, H., et al, "Measurement of the Dynamic Bulk and Shear Response of Soft Human Tissues" Experimental Mechanics (2007) 47:439-449.

8. Wang, H.C., 1995, "Development of a side impact finite element human thoracic model" Ph.D. Thesis, Wayne State University, Detroit, MI.

KEYWORDS: Human skin simulant, ballistic testing, non-lethal munition, less-than-lethal munition, ballistic gelatin, close combat training ammunition, deformation rate, tissue penetration mechanics, ballistic wound replication, binding rate

A15-030 TITLE: Parachute Shape and Airflow Measurement During an Airdrop

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: To design and build a system that can simultaneously collect measurements of a parachute's shape and the airflow near a parachute during flight of an airdrop system.

DESCRIPTION: This research is designed to develop a capability for U.S. Army Yuma Proving Ground (YPG) to collect parachute shape measurements [primary capability] and airflow near a parachute system [secondary capability]. During Developmental Test (DT) there is limited data to assess parachute performance as related to the shape of the parachute system. The shape of a parachute changes during the deployment of the canopy, during control inputs by the paratrooper/guidance system, and due to environmental effects. With improved data on the shape YPG will be able to improve characterization of control inputs to changes in parachute performance, understand parachute interaction with environmental conductions such an aircraft wake, and to evaluate the impact of parachute interactions.

Currently, data collection methods to characterize flight performance are limited to the system level and are difficult to separate by subsystem which would improve the understanding of total system and controller design. To characterize system performance during a DT it is required to collect data on canopy control inputs from an Autonomous Guidance Unit (AGU) log file or paratrooper control input instrumentation. Typically, control input data is collected from AGU or paratrooper pull measurements, but the relationships between pull length, control surface deflection, and canopy response are not linear. Also, during paratrooper airborne operations and muilti-bundle airdrops the interactions of multiple paratrooper/canopy interactions is difficult to quantify, which has limited the ability of developmental testers to assess hazards to the paratroopers and airdrop load due to canopy starvation and interactions.

Additionally, this research and capability will support basic research in Modeling and Simulation (M&S) to support the design and testing of parachute system, which continues to be a significant technical challenge. The computational modeling of the fluid-structure interaction (FSI) between the relative airflow and the permeable flexible material of parachute systems has not been validated with operationally representative airdrops. Use of wind tunnels and other methods of collecting airflow and shape measurements are limited by blockage and scaling affects.

To solve these problems a comprehensive capability is required to measure the physical shape [primary capability] and airflow [secondary capability] around a parachute(s), suspension lines, and slider. The system would be used on a large variety of parachute systems including 100 ft2 ram-air, 2,000 ft2 ram-air, 25 ft round, 100 ft round, multi-parachute systems and interactions with adjacent airdrop loads. Ideally the system could perform the shape and airflow data collection concurrently, but limitations in technology may limit data collection to either shape or airflow.

The shape measurement portion of the system should provide data to support building a three dimensional rendering and a Computer Aided Design file of the shape at the rate of 10hz after the parachute has deployed and stabilized. The accuracy of the shape data must be 2 cm for the fabric portion of the canopy and to an accuracy of 4cm for all other components above the parachute attachment point. This data must be reference to either a payload or global coordinate system so that the data can be correlated in time with other data sets.

The airflow measurement portion of the system should provide a three dimensional field inside and outside from the top of the payload up over the parachute system (e.g., a cube with edges approximately two times the maximum parachute diameter and centered about the canopy), it would provide the velocity of the airflow (accuracy of 0.05 m/s in x,y,z). The spacing of the airflow measurements should be scalable to the size of the parachute system and of sufficient detail to understand the characteristics of the airflow. The data should be correlated directly to the space measurements in location and reference frame.

The airdrop environment for the system to operate will be from a maximum aircraft exit altitude of 25,000 ft MSL to a minimum 0 ft MSL. Any equipment place on the load or parachute should be able to withstand the parachute opening, flight, and ground impact. Additionally, any equipment place on the aircraft, airdrop load, or parachute should not present a safety hazard to personnel on the aircraft or the ground and should be able to be certified for use on U.S. Air Force cargo aircraft. Also, the implementation of the system should not impact the system performance that is under measurement.

Work has been completed by the U.S. Natick Solider Research Development and Engineering Center (NSRDEC) to develop capabilities for wind tunnel testing, controlled indoor drops, and limited airdrops. The intention of this research would be to mature current technologies or develop other technologies that would provide an instrumentation set that could be used on an operational airdrop test. This instrumentation would support NSRDEC and the U.S. Army Yuma Proving Ground (YPG) in very distinct ways. For NSRDEC this instrumentation would support research by providing truth source data in verification and validation (V&V) of Computational Fluid Dynamics (CFD) and FSI models and simulations. These results would, in turn, be used in the design and development of airdrop systems.

PHASE I: Perform a feasibility study in support of the development of a system that can simultaneously collect measurements of a parachute's shape and the airflow around a parachute during flight of an airdrop system. Conduct an assessment of innovative technologies which may be utilized to build, integrate, and test a system to meet the challenges listed above. Perform a trade-off analysis to determine the best approach for a system and develop a preliminary design.

PHASE II: Develop a prototype system to simultaneously collect measurements of a parachute's shape and the airflow around a parachute during flight of an operational airdrop system. Demonstrate the system technology is a real world airdrop and characterize its performance.

PHASE III: The system developed under this topic could be developed into a standard set of instrumentation to support airdrop and aviation testing, such as missile separation testing. This system could be adapted and marketed to aircraft manufactures and integration companies to collect airflow measurements around aircraft and measure aircraft shape in-flight for assessment of aeroelastic effects such as flutter. Additionally, these capabilities would support any work where FSI is a critical issue, such as tents, kites, aerostats, gliders, and clothing.

REFERENCES:
1. Jenkins, Thomas P., Desabrais, Kenneth J., "Three-Component Velocity Field Measurements Near a Parachute During a Drop Test," Proceedings of the 48th AIAA Aerospace Sciences Meeting Including the New Horizons Forum and Aerospace Exposition, 4-7 January 2010, Orlando, Florida, AIAA paper 2010-1030

2. Jones, Thomas W., Downey, James M., Lunsford, Charles B., Desabrais, Kenneth J., Noetscher, Gregory., "Experimental Methods Using Photogrammetric Techniques for Parachute Canopy Shape Measurements," Proceedings of the 19th AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 21-24 May 2007, Williamsburg, VA, AIAA paper 2007-2550

3. Desabrais, Kenneth J., Lee, Calvin K., Buckley, Jack, Jones, Thomas W., "Experimental Parachute Validation Research Program and Status Report on Indoor Drop Tests," Proceedings of the 19th AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 21-24 May 2007, Williamsburg, VA, AIAA paper 2007-2500

4. MIL-STD 810G Environmental Engineering Considerations and Laboratory Tests, dated 31 Oct 2008

KEYWORDS: Airdrop, parachute, measurement, airflow, computational fluid dynamics (CFD), fluid-structure interaction (FSI), Joint Precision Airdrop System (JPADS), paratrooper, aerodynamic decelerator, instrumentation, modeling and simulation (M&S), verification and validation (V&V)

A15-031 TITLE: Open Air Virtual Partial Alcove Anechoic Chamber

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop a concept, methodology and prototype system that can act as an outdoor virtual partial alcove anechoic chamber to attenuate transmitted Electronic Warfare (EW) signals within a 15 degree sector, both horizontal and vertical. The thrust of this objective is to negate or minimize interference caused by future EW testing to the US aviation and commercial wireless industries.

DESCRIPTION: DOD conducts limited open air testing on ground based EW systems within the continental US to validate the systems effectiveness by operation under realistic conditions. The signal frequencies attacked often fall within US frequencies bands allocated to Aviation (FAA) and commercial enterprise (FCC). The frequencies subject to EW attack testing are driven by our adversaries' use of the radio spectrum throughout the world. Open air EW testing is often conducted in remote test locations to negate or minimize the potential interference to the aviation and commercial enterprises utilizing their assigned frequencies. The rapid expansion of the commercial wireless industry's spectrum demands, coupled with the widening distribution of wireless geographical communications cells have increased the potential for current EW testing methods to cause interference to these entities.

Many of the ground based EW test locations have a heavy investment in site and instrumentation infrastructure. Shuttering or repositioning these facilities is prohibitively expensive. For the foreseeable future, the life span of existing facilities could be extended by attenuating the transmitted EW signals in the directions of the most vulnerable aviation and commercial receiver sites. The proposed system would need to function much like a partial alcove anechoic chamber, but without the typical size limitations posed by metal walls and standard anechoic material. The proposed system would need to create the attenuation zone at a much further distance from the EW transmitters to allow the EW test's target receivers to be positioned within the virtual alcove and thus subject to the full effects of the EW system being tested. For the purpose of this project, the ground based EW test site will be assumed to be one kilometer in diameter with transmitter(s) positioned near the center, targets and sensors distributed throughout the test site. Test sites are assumed to be multi- kilometers distance or further from the nearest commercial victim receiver sites and also located within or behind signal blocking terrain in most directions. The proposed system is intended as a gap-filler where other interference mitigation factors such as site location, transmitter directional antennas, power/distance scaling are unable to provide a total solution.

The system developed under this effort must meet the following performance goals:
1. Produce an attenuation zone that:
a. Provides a minimum of 60 dB attenuation in all current & proposed FAA and US cellular frequency bands.
b. Allows un-attenuated target receiver operation within 500 meters of the EW transmitter.
c. Covers a sector 15 degrees in width by 15 degree in elevation starting at ground level relative to the center of the test site.
d. Achieves the desired attenuation with no more than 1000 meters of zone depth.
e. Does not create signal reflection or backscatter that would interfere with the ground based EW transmitter or its target receivers. Tolerance less than 1% reflected power.
f. Provide continuous time of presence with not more than 10 nanosecond lapses per second.
2. Can be stationary but re-locatable with an 8 hour work shift.
3. Does not create environmental, chemical, ionization or material safety hazards.
4. Does not raise the spectral noise floor greater than 10 db within 500meters of the attenuation zone.
5. Ruggedness: Temperatures from -40 to +140°F plus water and dust proof
6. Wind: operational effectiveness 0-8 knots, resist structural damage 0-30 knots

Other desired goals that the system developed under this effort could optionally incorporate are:
1. Unit system cost does not exceed $100,000 cost and $250/hour to operate (less operator labor) per unit.
2. Power: Self-contained or user provided generator w/12 VDC or 120 VAC output.

PHASE I: Perform a feasibility study to identify concepts, methods, and technologies that could create a system which meets the specifications above. Evaluate innovative technologies which may be used to build, integrate the system and leverage existing technologies. Perform trade-off analysis to determine the best approach for producing the system, and develop a preliminary design for the system.

PHASE II: Develop a prototype that demonstrates that a system that creates the effects of an outdoor virtual partial alcove anechoic chamber system is feasible. Demonstrate the system technology and characterize its performance.

PHASE III: The radio spectrum is becoming increasing crowded and the trend will only escalate as new wireless devices and services proliferate. Even with the upper frequency boundaries are pushed higher each year, there will still be a shortage of bandwidth to meet growing needs. Sharing and reuse of the existing spectrum will become even more critical. Any reasonable concept, methodology or system that aids this should find a marketable use. This project’s system could be marketed to the wireless industry as a means to reduce co-site interference at and between commercial transmitter and repeater sites thus allowing greater frequency reutilization. Additionally, the virtual partial alcove anechoic chamber could also allow test centers to conduct limited outdoor EMI testing within the attenuation zones achieved frequency spectrum on equipment too large to fit in existing facilities.

REFERENCES:

1. MIL STD 461E, Requirements for the Control of Electromagnetic Interference Characteristics of subsystems and Equipment, August 1999

2. MIL STD 464, Electromagnetic Environmental Effects requirements for Systems, March 1997

3. Manz, Barry, “The Spectrum Management Challenge”, The Journal of Electronic Defense, Volume 36, Number 38, pp 28-35, August 2013

4. Manual of Regulations and Procedures for Federal Radio Frequency Management (Redbook), 2013, National Telecommunications & Information Administration (NTIA), www.ntia.doc.gov

KEYWORDS: Electronic Warfare, partial alcove, Anechoic chamber, Radio frequency interference, interference mitigation, electromagnetic interference, NTIA Redbook

A15-032 TITLE: Mission Command of Autonomous Systems

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this topic is to identify and demonstrate innovative technologies to enable Commanders and Staff to naturally interact and communicate their intent to unmanned robotic entities, thereby improving two-way collaboration between the Commander and autonomous systems to reduce the time to conduct mission planning, and complexity of the decision making process.

DESCRIPTION: Today's Commanders and Staff are over inundated with information from multiple manned and unmanned sources to satisfy their mission goals. It is extremely challenging for Commanders to communicate mission intent to their staff let alone expressing this intent to robotic entities. Currently, autonomous entities are operated remotely using joysticks/keyboards. These methods of operation are inefficient, labor intensive, and require lead time to complete mission critical tasks. To permit a more natural, efficient means of interaction, context-based modes of communication with autonomous systems such as, but not limited to, continuous speech, hand gestures, eye contact, and body language are needed. This is conceptually identical to the interactions between the Commanders and their human staff members before, during, and after mission execution. However, today’s speech recognition, gesture, and eye tracking technologies do not allow Commanders to naturally and fluently interact with unmanned systems. The contractor shall develop an innovative method for Commanders to interact with autonomous systems through a natural, human-like manner. In the future, A Commanders-centric approach to this collaboration with autonomous systems is required to allow only the Commander to control and task any unmanned asset to satisfy mission intent. As a companion to the Commander, the autonomous system shall receive input from the Commander via an innovative multimodal Human Computer Interaction (HCI) approach that better conveys the commander’s intent in a natural way. The Commander would provide information to the autonomous system in a human-like manner, utilizing multiple forms of communication typical of high level interpersonal interactions. For example, the autonomous system may receive a task from the Commander to navigate to a particular area of interest and provide a reconnaissance operation to assist the Commander’s ability to conduct mission planning. The resulting technology should combine disparate modes of communication into a single software interface for eventual integration with Mission Command systems.

PHASE I: Contractor shall perform a feasibility analysis of alternative modes of interacting with autonomous systems during a simulated mission Command task, as described in this “Mission Command of Autonomous Systems” SBIR topic. These modes should be akin to the way humans collaborate with one another. Contractor shall document the strengths and weaknesses of various approaches during the mission command planning process. Contractor shall provide a final technical report documenting analysis and approaches.

PHASE II: The contractor shall produce a prototype system that demonstrates a natural means of HCI using a commercial robot, wearable computer and head mounted display. Contractor shall demonstrate enhanced interaction with actual autonomous entities in a live, U.S. Army fielded environment with soldiers during a CERDEC hosted C4ISR Ground Activity field test event. During the experiment, contractor shall show how an autonomous system is able to understand and conduct a mission command task. CERDEC will assist contractors in gaining access to C4ISR operational experiment fields. Developed Commander-centric software shall be integrated on the Commander to allow Commanders to remotely interact and collaborate with autonomous systems, whether they're dismounted, mounted, or in a Command Post.

PHASE III: The contractor will test prototype system in a relevant, operational environment with soldiers to receive operational feedback as to system's ability to naturally interact with the Commanders' tasks. CERDEC will assist contractors in gaining access to C4ISR operational experiment fields. Naturally interacting with prototype autonomous systems have applicability to the commercial market, as well. Law enforcement could use a robotic companion to protect fellow police officers and the general public. The medical field, for example, could also use the technology to assist children with mental disorders.

REFERENCES:
1. Vladimir I. Pavlovic, Rajeev Sharma, Thomas S. Huang, Visual Interpretation of Hand Gestures for Human-Computer Interaction; A Review, IEEE Transactions on Pattern Analysis and Machine Intelligence, 1997.

2. J.C.R. Licklider. Man-Computer Symbiosis. In IRE Transactions on Human Factors in Electronics, pages 4-11, 1960.

3. Multimodal Architecture and Interfaces; W3C Recommendation 25 October 2012.

KEYWORDS: Human Computer Interaction, multimodal, unmanned systems, autonomous systems, hand gestures, eye tracking

A15-033 TITLE: Technologies to Enable Screen Size Independent Software

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Perform research into generalized techniques that will enable software business logic to execute independent of screen size, in order to allow the Commander to maintain situational awareness as he or she transitions between the command post, mounted, and dismounted tactical environments.

DESCRIPTION: As personal digital devices become ubiquitous in the Army, development organizations wishing to deploy capabilities in multiple echelons are faced with the problem of how to develop software that can execute on both small screen and large screen devices. The trivial solution of zooming or scaling (i.e. Just displaying large screen interfaces on smaller screens and using localized magnification that follows focus) is not useful for small screens and is awkward to use on those devices. Changing the layout of the interface based on screen size is also problematic in that workflows also change based on what can be displayed on any given screen. Android "fragments" (see: http://developer.android.com/guide/components/fragments.html) appear useful for a small range of screen sizes, but it is unclear if this approach usefully scales. The research would be to examine this problem in depth and to propose and demonstrate an approach to user interface (UI) design that allows software to execute over a range of screen sizes, but does not significantly impact the cost of development or user training.

PHASE I: The goal of Phase I is to investigate potential technologies that will ultimately lead to a methodology that innovatively solves how the described problem will be addressed. The contractor will begin by:
1) Performing a feasibility study to identify technologies as described above that will relate to the effectiveness of executing software business logic regardless of screen size. This study will help to ascertain which elements should be included in a prototype conceptual framework.
2) Develop an initial design that describes how the technologies would be implemented as the commander utilizes this technology across the different tactical environments.
3) Investigate software architecture or any other related issues associated with the inclusion of the technologies in the dynamic tactical environment.

PHASE II: The goal of Phase II is to see that the contractor begins work on the software prototype. The contractor will:
1) Describe a detailed design that illustrates the technologies working to provide intuitive user interface (UI) capabilities that allow effective execution of software business logic independent of screen size.
2) Collect data during the early stages of Phase II in the midst of prototype development and evaluation.
3) Demonstrate the application of the technologies across all three computing environments in a relevant operational scenario.

Deliverables will include:
- A written document describing the technologies
- A functional prototype
- A written report that details the results from (3) above

PHASE III: The goal of Phase III is to provide a technology that can be utilized and provide software business logic independent of screen size—enabling usability across different tactical environments. Not only could this technology be used in command and control systems, but many other military applications (fire support systems such as AFATDS, intel systems such as TIGR, or supply and logistics management, etc). This technology could also be utilized in commercial industry such as air traffic control or financial analysis. In general, this technology could be applied to any system that requires the user to execute the same task, but operate on different devices (desktop, tablet, mobile) to allow flexibility and adaptability.

The research into these technologies that enable screen-independent software, if deemed successful, would be granted the opportunity to integrate into an existing command and control system that will allow for enhanced and more intuitive interaction, and the commander's increased agility out in the field.

Software source code and related user documentation will be delivered at the end of Phase III.

REFERENCES:
1.) Army Doctrine Reference Publication (ADRP) 6-0, Mission Command.

2.) M. Endsley, "Design and evaluation for Situational Awareness Enhancement," Proc. Human Factors Soc. 32 Annual Meeting, 1988, pp. 97-101.

3.) R. Maltz, "Shared Situational Understanding: Fundamental Principles and Iconoclastic Observations," Military Review, Sept-Oct 2010, pp. 53-57.

KEYWORDS: android, tactical, computing, environment, mission command, command and control, adaptability

A15-034 TITLE: Managing Digital Communications via Virtual Staff

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Demonstrate a capability that will reason over multiple sources of communications available in a tactical environment and provide a commander both organizational and operational recommendations to meet mission objectives.

DESCRIPTION: One of the growing challenges in the modern mission command environment is information overload and the cognitive burden that it inflicts on the tactical commander and his staff, especially, at the lower echelons where staff elements are minimal. The modern commander continuously finds themselves bombarded by various information flows that range from email and chat to PowerPoint and images that can range from being critical information to completely irrelevant based on the situation. The relevance of available information and information flows will vary as a function of workflow, location and time. The goal of this topic is to provide a capability that can effectively manage tactical information and then support reasoning over those information flows in a context-aware manner, taking into account workflow, location and time, as a minimum, to enhance mission effectiveness in near-real time. Developing a capability that supports this requirement will need to enable functionality from basic information management capabilities such as the ingest of unstructured, semi-structured and fully relational data from multiple sources, to innovative user interface techniques that highlight the ability of the development to provide a tactical commander useful insights and recommendations in a rapidly evolving and complex situation. Although it has not been expressly stated, the primary deliverable from this effort will be a virtual staff functionality to assist a tactical commander by providing a capability that will perform data harvesting from their existing information flows, identify the commander's on-going and future workflows and their data and information requirements, reason over the existing information flows as they apply to workflows, location and time, as a minimum, and then based on mission criticality make recommendations to the commander/user that will enhance mission outcome. One major challenge in the typical scenario that will drive this effort is the uncertainty or stochastic nature of the data or information that will be available to a tactical level commander. Ideally, these recommendations can come in a variety of forms that range from highlighting missing information to provide critical information needed to make a decision to providing suggested courses of action. Trust or more specifically, the commander's ability to trust the recommendations will also be an important factor for the success of the capability.

PHASE I: The contractor shall develop an architectural approach that will enable the creation of a virtual staff element that can be employed at tactical echelons of Company and below to provide a commander both organizational and operational recommendations to meet mission objectives. The architectural approach should consider mechanisms to address trust surrounding recommendations that the capability provides. The contractor shall provide a final technical report documenting their architectural approach to providing an analysis of the approaches ability to provide the desired virtual staff functionality.

PHASE II: The contractor shall produce and demonstrate a prototype system that provides all of the functionality described in Phase I. The virtual staff capability shall reduce information overload by providing mission-aware recommendations that supports the commander's evolving workflow. The contractor shall develop a scenario that shall be used to demonstrate the capability in a US Army Field test environment with soldiers. The contractor shall provide a final technical report that documents all phase two results to include demonstrated test results from field tests with soldiers.

PHASE III: Phase III of the Managing Digital Communications via Virtual Staff SBIR will provide the military user with a comprehensive virtual staff element that will reduce information overload and aid in mission accomplishment by providing a context-aware capability that can reason across multiple source of communications available to the commander based on mission workflows, location and time. A military example of this could support the complex task described in the NY Times article listed in the reference section, entitled, "In the New Military, Data Overload can be Deadly", In this article they author describes a scenario where the drone operators in Nevada monitoring a situation on the ground in Afghanistan incorrectly identified a massing group as a hostile convoy because reports from soldiers on the ground that identified large number of children in the group was overlooked. Ideally, the virtual staff component would identify all critical information that could be used in supporting the decision to target the massing group and highlight concepts like observation of children or the elderly that typically don't comprise a hostile force. This capability could also be useful in supporting the complex decision support scenarios for homeland defense and humanitarian assistance and disaster recovery situations. The virtual staff capability could transition into future plans for the Tactical Computing Environment as a component of the Commander's Tool kit concept that is being developed in conjunction with The Mission Command Battle Lab, Ft. Leavenworth, KS and the Army Research Laboratory, Human Research and Engineering Directorate (HRED).

In terms of commercial transition of virtual staff technology, this could support complex decision support scenarios such as humanitarian assistance and disaster recovery scenarios in both CONUS and OCONUS scenarios like those that would have been needed to support operations during Hurricane Katrina or the Earthquake in Haiti. One potential area would be a communications manager virtual staff element that could take all data and information sources (voice, email, text, social network such as Ushahidi, …) coming into the operations center and identify key activities, events, locations and organizations involved in on-going operations to minimize the disconnects during a particular operation. A virtual staff capability could be useful in other cognitively difficult for a single individual such as optimized fleet management systems for large trucking companies where one is trying to optimize products delivery over time, space, weather, accidents and road closures while also minimizing the miles the truck has to travel without a paying load and potentially if an effective workflow model could be developed an analyst support tool for managing the dynamic information flows that a stock analyst would use to make complex decisions.

REFERENCES:

1. Shanker, T., and Richtel, M., “In New Military, Data Overload Can Be Deadly”, NY Times, 16 January 2001, downloaded on 25 June 2014 from website:
http://www.nytimes.com/2011/01/17/technology/17brain.html?pagewanted=all&_r=0

2. TRADOC Pamphlet (PAM) 525-3-3, The United States Army Functional Concept for Mission Command, 13 October 2010.

3. Field Manual (FM) 3-57, Civil Affairs Operations, October 2011, Headquarters, Department of the Army.

4. McCauley, Dan, "The Facets of Mission Command," Small Wars Journal, 21 June 2012, downloaded on 11 Sept 2014 from website: http://smallwarsjournal.com/jrnl/art/the-facets-of-mission-command.

KEYWORDS: Decision Support Capability, Artificial intelligence, Human-Centered Design, Trust Research, Workflow and Task Analysis

A15-035 TITLE: Laser-based Wireless Power Transfer

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop an advanced and safe wireless power transmission system capable of beaming power over several kilometers, to a moving platform from ground, fixed or mobile, or from a moving platform to ground, by employing laser technology at wavelengths from the near to the mid-infrared.

DESCRIPTION: Remotely powered devices and sensors have limited operating times and require periodical refueling or replacement of their portable power sources. This is currently done by deploying personnel carrying the replacement power sources or fuel. Such operations expose the warfighter to enemy ambushes or allow the enemy to observe warfighter movements that can lead to the location of the emplaced powered devices and sensors. This risk can be substantially reduced with a laser based system that uses a beam operating in the infrared region (which is difficult to detect without specialized equipment) and at wavelengths greater than 1.5 um (eye safe) to beam energy to devices and sensors.

Laser-based wireless power transmission systems have better energy transfer efficiencies over large distances than do their microwave counterparts. Laser-based systems are continually improving in electricity to photon transmitting efficiency or “wall-plug efficiency”, which makes them well suited for power transfer applications. Wireless power transmission using lasers has been successfully demonstrated. However, a significant improvement is required to advance the existing state of the art for practical applications. The systems required should exceed 12% efficiency of power conversion from DC source to DC load at a minimum distance of 1,000 - 1,500 meters. For proof of concept a system should be capable of delivering 150W to a load and it should be scalable to at least 600-1000W, in order to be used in the unmanned vehicle (UAV) scenario for Phase II. The energy density on the receiving transducer is suggested to be between 1400W – 3000W/m^2.

In applications where power is delivered from a moving or a flying platform, the source is expected to track the load by using both a dynamically controlled steering mechanism and beam steering. The power delivering system must establish contact with the load and upon contact begin and maintain contact during power transfer. The system will disengage power transfer in the event the contact is broken. The application, possibly a helicopter of mass of approximately 2 kg, is expected to perform in mild winds-not to exceed 2.5 miles per hour-and a good visibility.

In summary the system must be optimized for safety, size, weight, power transfer capacity, efficiency and to minimize detectability due to IR emission.

PHASE I: The purpose of this phase is to conduct a five month study, with experimentation, to lead to the selection of a potential system which can efficiently transmit power over several kilometers. This phase should provide a foundation for prototypes to be developed in Phase II. During this effort the offeror will demonstrate the proposed innovation in a proposed approach. The offeror will prove the fundamentals of the approach by providing comprehensive results in the form of experimental data, simulations and applied research. The system will demonstrate high wall-plug efficiency of the laser source, the ability to steer the beam to maintain contact on a moving target/load, and to incorporate the most efficient energy conversion devices to transform photonic energy into electrical energy.

Potential areas of both military and commercial applications must be identified. A detailed approach to commercialization of the product should be provided.

PHASE II: During this phase a system prototype(s) will be built to demonstrate overall system performance. Wall-plug efficiency for emitting system should exceed 45%, energy and photonic converter to DC load efficiency should be between 20-28% and beam steering rate should range from 0.001rad/sec to 0.01rad/sec.

The system will be built and shipped for testing to the government facilities, in order to be tested by government personnel in two phases. One would demonstrate power efficient power transfer to a stationary load and the other to a hovering/moving load. The system should meet and exceed specification mentioned in description above.

PHASE III: Based on Phase II results, select the best possible designs for the military and/or commercial markets. This phase focuses on developing a product for mass production and intended for military field implementation and for commercial markets.

The potential military and commercial applications to be addressed are where low levels of power need to be transferred over large distances and the presence of electrical conductors could be hazardous, costly or inconvenient.

REFERENCES:
1. Leopold Summerer, Oisin Purcell, “Concepts for wireless energy transmission via laser”, Space Agency (ESA)-Advanced Concepts Team, 2009, http://www.esa.int/gsp/ACT/doc/POW/ACT-RPR-NRG-2009-SPS-ICSOS-concepts-for-laser-WPT.pdf

2. Richard M. Dickinson, Jerry Grey, “Lasers for Wireless Power Transmission”, 1999, http://trs-new.jpl.nasa.gov/dspace/bitstream/2014/16855/1/99-0263.pdf

3. Richard Mason, “Feasibility of Laser Power Transmission to a High-Altitude Unmanned Aerial Vehicle” RAND Corporation, 2011. http://www.rand.org/content/dam/rand/pubs/technical_reports/2011/RAND_TR898.pdf

KEYWORDS: laser, photonics, wireless energy transmission, high efficiency laser, high efficiency infrared energy converters, Shockley-Queisser limit, thermal photo voltaic, pyroelectric, high efficiency thermoelectrics, rectenna

A15-036 TITLE: Cyber Ontology Development

TECHNOLOGY AREAS: Electronics

OBJECTIVE: The primary goal of this effort is to develop the software product (algorithm) that embodies a Cyber ontology. The Cyber ontology architecture with schema and terminologies should cover the complete Cyber domain that transcends cyber security, such as notions concerning people, time, space, and network operations. It should also incorporate Cyber Events based on patterns of attributes such as behaviors, artifacts, and attack patterns. This will enable data integration across disparate cyber data sources and help to detect and characterize Cyber Events and Entities by executing precise searches and complex queries.

DESCRIPTION: Currently, there is no in-depth analysis and modeling of global Cyber sensor data. The objective is to develop the Cyber Ontology/Model for the Cyber Entities. This will also help to characterize cyber events based on patterns of attributes such as behaviors, artifacts, and attack patterns and provide Cyber situational awareness to perform necessary Cyber defensive and offensive operations.

The Cyber Ontology/Model development will be supported by the Cyber data collected from different sensors embedded in the network. This includes NTOC (NSA Theatre Operation Center), HBSS (Host Based Security System), Netflow (Router Traffic data).

Some relatively simple efforts have been made to construct an ontological model for the Malware Attribute Enumeration and Characterization (MAEC), the primary goal of which is to provide a more flexible method for characterizing malware. However, there is a need of an in-depth analysis to model all the major dimensions of a malicious cyber threat which includes Victim, Infrastructure, Capability, and Actor (the one threatening the victim). A recent foundational schema for the cyber domain is Cyber Observable Expression (CybOX). CybOX is designed for the specification, capture, characterization and communication of events or stateful properties observable in the cyber domain in support of a wide range of use cases. MAEC leverages CybOX for describing cyber objects, actions, and events.

Since then, industry and standards organizations have worked on one emerging and common language/schema, the Structured Threat Information Expression (STIX), which provides an overarching framework for describing computer threats and network security incidents. This language all share the goal of facilitating information sharing across the cyber security community.

The proposed concept shall use the existing collaborative community-driven flexible Structured Threat Information Expression (STIX) standard language to represent structured cyber threat information.

PHASE I: The desired product is the Cyber ontology architecture with schema and terminologies of the Cyber domain. This Phase will develop an initial concept for the Cyber ontology architecture and identify concepts and methods that will help to define low, middle and upper level ontology (LLO, MLO and ULO) for the Cyber domain.

PHASE II: The minimum required deliverable in this phase is to develop an initial version of the prototype software based on the Cyber ontology architecture developed in Phase 1, which will enable data integration across disparate cyber data sources and help to detect and characterize Cyber Entities and Events by executing precise searches and complex queries. This will also help in improving the Cyber ontology architecture through iterative process.

The Cyber Ontology/Model development will be supported by the Cyber data collected from different sensors embedded in the network. This includes NTOC (NSA Theatre Operation Center), HBSS (Host Based Security System), Netflow (Router Traffic data).

This will use the existing collaborative community-driven flexible Structured Threat Information Expression (STIX) standard language to represent structured cyber threat information.

PHASE III: During this Phase, the fully functional prototype software based on the matured Cyber ontology architecture will be developed through iterative process, which will enable data integration across disparate cyber data sources and help to detect and characterize cyber events based on patterns of attributes such as behaviors, artifacts, and attack patterns.

The most likely path for transition of this research and development effort to operational capability is through PM, DCGS-A as well as ARMY Cyber.

The result of this work can be made commercially available so that any US company, private or public, can use the established Cyber ontology architecture and the software algorithm, which will help them to detect cyber events and defend cyber attacks.

REFERENCES:
1. MAEC - Malware Attribute Enumeration and Characterization. [Online] http://maec.mitre.org/.

2. Ingle, J. Organizing Intelligence to Respond to Network Intrusions and Attacks. Briefing for the DoD Information Assurance Symposium. Nashville, TN, 2010.

3. Obrst, L. Ontological Architectures. [ed.] Johanna Seibt, Achilles Kameas Roberto Poli. Chapter 2 in Part One: Ontology as Technology in the book: TAO – Theory and Applications of Ontology, Volume 2: Computer Applications. Springer, 2010.

4. Swimmer, M. Towards An Ontology of Malware Classes. [Online] January 27, 2008.

5. Howard, J. D. and Longstaff, T. A Common Language for Computer Security Incidents. [Technical Report]. Sandia National Laboratories, 1998.

6. CybOX – Cyber Observable Expression. [Online] http://cybox.mitre.org/

7. STIX-whitepaper. [Online] http://measurablesecurity.mitre.org/docs/STIX-Whitepaper.pdf

KEYWORDS: Ontology, Data Model, Cyber, Malware, MAEC, CybOX, STIX

A15-037 TITLE: Cognitive Algorithm Development for Aircraft Survivability

TECHNOLOGY AREAS: 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 demonstrate a long-wave infrared (LWIR) Light Detection and Ranging (LIDAR) system for Army aircraft optimized for aircraft survivability.

DESCRIPTION: LWIR LIDAR technology offers a promising supplement to the modern Aircraft Survivability Equipment (ASE) suite. Threat warning systems are designed to detect incoming threats and provide a cue to countermeasure systems. The long-wave LIDAR system shall assess objects of interest at ranges up to 6km, and shall have a resolution of at least 50 microradians with a frame rate capable of 60Hz to determine trajectory information. All this information would then be provided to the onboard ASE suite. On-board algorithms would then correlate this information with the existing ASE suite. The system shall fit within a 12"x12"x24" box and weigh less than 30 pounds. The threshold for power is 300 Watts, with an objective of 100 Watts. The LWIR LIDAR system also offers a variety of possible secondary benefits, including possible use as a supplement to pilotage technologies in degraded visual environments.

PHASE I: The Phase I objective is to perform component analysis and architecture development for a long-wave infrared LIDAR system optimized for aircraft survivability. During Phase I, the contractor shall design a LWIR LIDAR architecture that is tailored for maximum performance in aircraft survivability applications. This may include modeling and simulation of component technologies and algorithms. The contractor shall define performance goals for the system and an overall design concept.

PHASE II: The Phase II objective is to develop, test, and, demonstrate prototype hardware based on the Phase I design with the system requirements listed in the topic description. During Phase II, the contractor shall integrate key components into a prototype system, including long-wave infrared sources and long-wave infrared detectors. The contractor shall conduct algorithm development to enable the prototype hardware to determine range and trajectory information of objects of interest. The contractor shall perform component level and prototype testing in digital simulation and in the laboratory environment, when feasible. The contractor shall provide a detailed test plan for the prototype hardware to be performed against in conjunction with the government.

PHASE III: During Phase III, the prototype LWIR LIDAR technology will be matured and integrated with the aircraft survivability equipment suite. Future objectives include integration of the LWIR LIDAR system with existing countermeasure systems and development of detection and false-alarm reduction algorithms. This operational capability will support increased aircraft survivability in a wide range of environments. Follow-on science and technology efforts will mature the LWIR LIDAR technology and support integration with the aircraft survivability suite and technology developed in the Multi-Spectral Threat Warning S&T Effort.

In military applications, the capability is expected to support the ongoing development of a holistic suite of integrated aircraft survivability equipment. The LWIR LIDAR would provide information on objects of interest to the cognitive integration algorithms in conjunction with other on-board aircraft survivability equipment. The inclusion of the LWIR LIDAR as an additional data source will improve the effectiveness of the overall suite of equipment. In addition, potential commercials applications include LWIR imaging systems for surveillance, automotive systems, and thermography.

REFERENCES:
1) Air University Library Index to Military Periodicals; Briefing: Rotary-winged protection by Streetly, Martin; Jane's Defence Weekly, vol 46, no 14, p 24-29, Apr. 8, 2009; http://www.dtic.mil/dtic/aulimp/citations/gsa/2009_152754/155880.html

2) Target Identification and Detection Using LWIR Hyperpectral Signature Transformation of Multiple Missions without Registration by Mayer, Rulon and Priest, Richard, of SFA INC LANDOVER MD; http://www.dtic.mil/get-tr-doc/pdf?AD=ADA389411

3) Properties of Photodetectors (Photodetector Series, 97th Report). Spatial Sensitivity of LWIR Detectors by Arrington, D C, Bates, R L, Eisenman, W L, and Sweet, M H, of NAVAL ELECTRONICS LAB CENTER, SAN DIEGO, CALIF. http://www.dtic.mil/get-tr-doc/pdf?AD=ADA033795

KEYWORDS: Aircraft survivability, LIDAR, cognitive algorithms, adaptive algorithms, LWIR

A15-038 TITLE: Multi-Mission Electro-Optical Sensor System

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: Design and develop an integrated multi-mission capable electro-optical sensor system to address warfighter needs in challenging multiple-threats and multiple-missions environments.

DESCRIPTION: Traditionally sensors have been developed for a specific mission profile such as a large format sensor for wide area reconnaissance, hyper spectral imager for HME detection, and high speed camera for target tracking applications. Current warfigher facing multiple threats with broad missions requires all these capabilities packaged in a single sensor system. Recent advances in sensor technology, optical design, compressive sensing, optical computing, information processing and systems engineering have opened up the possibilities to develop truly multi-mission sensor system, much like human visual system, which can easily and quickly adapt to accomplish significantly different tasks in changing environment. Such a capability is only possible through a true integration and interoperability between hardware capabilities (the eye) with processing/exploitation (the brain). Objective of this effort is however not to develop artificial eye or prototype of human visual system. The focus of the effort is to design and develop a prototype for an advanced electro-optical sensor system to include sensor hardware and associated integrated processing and exploitation. Such a system will allow flexible and adaptive real-time selection of system parameters such as spectral, spatial, temporal resolution, the field of view of the sensor system and latency in exploitation for use in different applications such as person/object/vehicle (POV) tracking, wide area search, target detection/classification/recognition and homemade explosive (HME)/improvised explosive device (IED)/POV/Activity detection. Thus, for example, for wide area HME detection the sensor system will be able to capture and exploit wider field of view, high spectral resolution imagery with lower spatial resolution at limited frame rate. However, when a suspected HME indicator is detected, the sensor re-configures to capture and exploit narrower field, high spectral, higher resolution imagery for confirmation and identification.

PHASE I: The Phase I goal under this effort is to evaluate the current state of the art in relevant technological areas including compressive sensing, optical computing/image processing, and mechatronics to conceptualize and develop a system architecture (both hardware and software) that will facilitate maximum flexibility and real-time adaptation of the sensor hardware and software for multiple applications as described in this topic. Conduct simulation studies and laboratory experiments to evaluate feasibility of critical technologies. The Phase I final report must summarize the current state of the art in relevant technological areas and provide details of the conceptual system architecture (one or more), rationale for the selected system architecture, system capabilities, and limitations and critical technology risks for the proposed architecture.

PHASE II: The Phase II goal under this effort is to design and develop a laboratory prototype of multi-mission sensor system to evaluate feasibility and potential functionality and capabilities that may be afforded by such state of the art hardware and software integration. A sensor operating in the visual spectrum (multi/hyper spectral) will be acceptable for this prototype effort. The capabilities of such a prototype system may be demonstrated for different representative mission profiles in an overhead or desktop mounted application. The Phase II final report will include detailed system design, hardware-software interfaces, system capability and limitation, detailed summary of laboratory testing and results, lessons learned and critical technology risks.

PHASE III: The Phase III goal is to develop a demonstration prototype of the multi-mission sensor system that may be mounted on a ground vehicle or an airborne platform and operated and demonstrated in relevant environment. Sensor operating in visual spectrum (multi/hyper spectral) will be acceptable for this effort. Relevant use-cases or mission profiles supported by such prototype system may include: (1) wide area search for a moving target, followed by tracking and recognition of the target; (2) wide area multi/hyper spectral search for HME indicators, followed by confirmation and identification. Multi-mission sensor system technology developed under this effort will have high potential for other commercial applications for law enforcement, border security and surveillance.

REFERENCES:
1. SBIR Topic: A13-037, Compact Full-Framing Hyperspectral Sensor for On-The-Move Ground-to-Ground Applications, SBIR Army 13.1.

2. Richard Baraniuk, Compressive sensing, IEEE Signal Processing Magazine, 24(4), pp 118-121, July 2007.

3. Rebecca Willett, Roummel Marcia, and Jonathan Nichols, Compressed sensing for practical optical imaging systems: a tutorial. Optical Engineering, vol. 50, no. 7, pp. 1-13, 2011.

4. Gordon Wetzstein, Wolfgang Heidrich and David Luebke, Optical Image Processing using Light Modulation Displays, Computer Graphics Forum, Vol 29, Issue 6, pp. 1934-1944, Sept 2010.

KEYWORDS: Compressive sensing, optical image processing, optical computing, human visual system, electro-optical sensor system, adaptable sensor, multi-mission sensor

A15-039 TITLE: Asynchronous Day/Night NIR-SWIR See-Spot Sensor Development

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: Research, develop, design and demonstrate a compact, low power near/shortwave infrared sensor capable of temporally and spatially resolving battlefield lasers asynchronously under day and night conditions.

DESCRIPTION: The US Army Maneuver Center of Excellence (MCoE) is the proponent for the Small Tactical Optical Rifle Mounted (STORM) requirement (CARDS# 02075) approved 21 September 2009. The STORM, in addition to range finding, functions as both a day and night aiming laser, illuminator, and pointer. The day pointing capability utilizes a visible laser, which is ineffective in bright sun conditions. The night pointer utilizes a near infrared wavelength which cannot be observed with thermal sights. Nearly all mounted combat platforms utilize thermal primary sights. This complicates target handoff because mounted and dismounted elements lack a common pointing capability, which functions in all light conditions and can be seen by enemy I2 devices. The Army has a desire for a low cost, low size, weight and power (SWaP) “see-spot” sensor component solution to identify battlefield lasers in the near and shortwave infrared. The objective is to provide the dismounted soldier with handheld and/or weapon mounted compatible solutions to locate designators and pointers that improves situational awareness, target coordination efficiency, and more importantly significantly reduces collateral and friendly fire risks. This topic seeks to develop affordable compact sensor concepts with small pixels, large FoV, and low power capable of detecting NATO STANAG PRF codes as well as existing Laser Rangefinder System (LRF) lower repetition LRF signals for target handoff between mounted and dismounted elements.

PHASE I: Investigate, research and design a sensor concept with the appropriate ROIC to detect NATO STANAG PRF codes as well as lower repetition LRF signals under day and night time conditions. The trade-space for a new or redesigned existing readout integrated circuit (ROIC) should focus on achieving the largest possible format / field of view (FoV) capable of operating at a high enough sampling rate to identify NATO STANAG compliant pulse repetition frequency (PRF) sources as well as lower frequency pulsed laser range finder (LRF) sources used for target handoff. The anticipated sampling rates are ~20kHz at 1.06um and single shot to ~5Hz at 1.54um with a desired FoV of ~10 degrees, a pixel pitch = 12.5um, a form factor of ~1 cubic inch, with a power draw of ~100mW, and a volume production cost target of =$1K in order to maximize transition opportunities. Provide trade-space analysis that optimizes key performance parameters such as FoV, pixel pitch, form factor, cost, and power that justifies Phase II investment. Identify key transition military and potential commercial opportunities and partners.

PHASE II: Fabricate and demonstrate a component level prototype(s) that validates predicted performance parameters based on Phase I results. Deliver prototype(s) to the government. Develop a manufacturing transition plan to include cost/volume analysis.

PHASE III: Transition the see-spot sensor component to DoD and commercial industry partners. Potential commercial applications include auto beacon detection for air and maritime navigation as well as laser alignment manufacturing or machine vision solutions.

REFERENCES:

1. Fraenkel, A., et al., SCD's Cooled and Uncooled Photo Detectors for NIR-SWIR, Proceedings of SPIE vol. 8353, Infrared Technology and Applications XXXVIII Conference, May. pp 835305 (2012)

2. Walker, James, VisGaAs Camera Sees RED...and More, R&D Magazine, March 2004 34-35 (2004)

3. Trezza, J., “Analytic Modeling and Explanation of Ultra-Low Noise in Dense SWIR Detector Arrays,” Proc. of SPIE Vol. 8012 (2011)

4. Fraenkel, A., “SCD's cooled and uncooled photo detectors for NIR SWIR” Proc. of SPIE 8353 (2012)

5. de Borniol, E., “High-performance 640 x 512 pixel hybrid InGaAs image sensor for night vision,” Proc. of SPIE 8353 (2012)

6. Rouvié, A., “InGaAs focal plane array developments at III-V Lab,” Proc. of SPIE 8353 (2012)

7. Yuan, H., “Low dark current small pixel large format InGaAs 2D photodetector array development at Teledyne Judson Technologies” Proc. of SPIE 8353 (2012)

8. MacDougal, M., “Large-format InGaAs focal plane arrays for SWIR imaging” Proc. of SPIE 8353 (2012)

KEYWORDS: Readout integrated circuit, ROIC, near infrared, NIR, shortwave infrared, SWIR, focal plane array, FPA

A15-040 TITLE: Integrated Low Latency Integrated Video Decompression Micro-display

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop an integrated video decompression micro-display with display read-in electronic architecture capable of directly receiving MPEG, H.264, JPEG or similar standard compressed video signal and providing low latency video rate video signal decompression for displaying the uncompressed video to the human eye in low power implementation

DESCRIPTION: The advent of head wearable displays in the consumer market has sparked renewed and increased interest for head wearable display applications for the Warfighter. One of the key applications of such a wearable display would be to wirelessly receive and subsequently display video, images and large amounts of text and symbol based data to the user. Due to wireless bandwidth limitations within the battlefield scenario, this application will be difficult to impossible to fully utilize without performing video compression at the transmit end and converting back to uncompressed video once the video data is received. Video decompression is usually performed by upstream video processors in the data management electronics and wearable computing hardware. This results in the need to carry and manipulate uncompressed video throughout the rest of the soldier vision system which adds to system latency and power draw. Even though technology and techniques for video compression and decompression have dramatically improved over the last several years due to the proliferation of internet based interactive video applications, the decompression function is still performed by power consuming graphics processors. By moving the decompression function directly to the display signal read-in and reformatting function in the active matrix that drives the display pixels directly, the power demand to the system should be reduced accordingly and the system latency also decreased by reducing the need for any other processor to perform the video decompression cycle. The Army seeks a low power and low latency approach to perform compressed video signal decompression as close as feasible to the point of display to the human eye to ensure the lowest power, lowest latency signal channel components.

The video decompression integrated micro-display must refresh uncompressed images to the eye at >60 hz with less than 1 frame of latency supporting resolutions from 640X480 through 1920X1080 full color. This device must do so while consuming less than 800 mW of total electrical power with a display brightness of at least 200 fL

PHASE I: Design, modeling and analysis will be conducted during Phase I resulting in a preliminary design approach for a video decompression integrated micro-display including the theory of operation, different types of modes of operation, a block diagram and/or schematic of and a detailed description of the functions in each block/schematic. Develop a simulation model of the selected video decompression integrated micro-display approach and provide simulations that identify both issues and demonstrate the general validity of the approach. The design should also address human factor issues for the selected decompression approach such as temporal and spatial image artifacts as well as the estimates of the key performance parameters of signal latency, full frame refresh rates and power consumption vs. decompression ratio. The Phase I final report will also contain an investigation of the suitability of the approach for implementation in readily achieved mixed signal CMOS drive electronics and the adaptability of the approach to multiple compression/decompression schemes.

PHASE II: Design feasibility will be demonstrated in this phase. Demonstration hardware will be provided to the Government which will include a functional packaged micro-display device with supporting hardware and software capable of demonstrating receiving the compressed video signal and performing decompression at the display. The final report for this phase will include a characterization report and supporting data on the display performance relative to the key performance parameters of latency, frame rate and decompression ratio-times-total power.

PHASE III: Low power head wearable display integrated with wireless video receiver using radio link to accept compressed video signal that is passed directly to the display for smart phone, lap top computer and tablet personal remote video displays.

REFERENCES:
1. Neogi, R.; Saha, A.; "Embedded parallel divide-and-conquer video decompression algorithm and architecture for HDTV applications," Consumer Electronics, IEEE Transactions on (Volume:41, Issue:1), 160-171 (1995).

2. Sriram, P.; Sudharsanan, S.; Gulati, A.; "MPEG-2 video decompression on a multiprocessing VLIW microprocessor," Consumer Electronics, 2000. ICCE. 2000 Digest of Technical Papers. International Conference on, 384-385 (2000).

3. Pereira, F., "Video compression: An evolving technology for better user experiences," Telecommunications (CONATEL), 2011 2nd National Conference on, pp. 1,6, 17-20 May 2011

KEYWORDS: micro-display, video compression, video decompression, MPEG, JPEG, H.264, wearable display, wireless display

A15-041 TITLE: Growth of III-V Antimonide (SB)-based Superlattice Material with Superior Performance

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: Develop molecular beam epitaxy (MBE) growth model based on innovative 3-D molecular level models leading to superior III-V strained layer superlattice materials with enhanced minority carrier lifetimes comparable to theoretically predicted numbers. These materials will ultimately lead to mid and long wavelength infrared focal plane arrays with quantum efficiency exceeding 80%.

DESCRIPTION: III-V materials offer a tremendous opportunity to revolutionize size, weight, cost and power of Infrared sensors and lasers over current state-of-the-art systems. III-V material based device and systems have significant advantages including the ability to operate at higher temperatures; higher reliability; leveraging of commercial foundries, increased electrical efficiency, increased detection wavelength ranges, affordable small packages. All these advantages enable the development of next-generation of III-V Opto-Electronic systems supporting commercial and DoD applications.

Among III-V material based Infrared focal plane arrays (FPAs), antimonide material based strained layer superlattice (SLS) absorber layers using nBn or pBp unipolar barrier device structures are a promising new technology for mid wavelength infrared (MWIR) and long wavelength infrared (LWIR) imaging. While imagers based on HgCdTe have a proven history, the SLS technology offers several advantages. The SLS technology will lead to larger array formats with smaller pixel pitch and lower overall cost for performance; the longer Auger lifetimes suggest a theoretical signal-to-noise ratio and/or operating temperature that exceeds HgCdTe; band engineering can reduce tunneling currents and increase quantum efficiencies relative to HgCdTe. In practice, the performance of SLS detectors has failed to reach the theoretical expectations especially in LWIR bands. This is in large part due to excessive Shockley-Read-Hall (SRH) generation and recombination. The unipolar barrier device structures have mitigated some of the problems associated with the SRH processes, but further reductions in SRH effects are required, especially if more traditional and simpler bipolar junction devices are to be deployed.

The ideal solution is the reduction of SRH-causing defects within the as-grown or annealed SLS material, to the point that SRH becomes a minor contributor and Auger processes dominate. To this end, an innovative model is desired that can predict SRH dark currents and lifetimes based on SLS design and MBE SLS growth parameters, to be used in conjunction with other models that predict Auger rates, photoelectric absorption and overall quantum efficiency from SLS design. The model needs to be used to develop predictive MBE growth rule sets that can improve device performance. These models aren't available, because in the past computational requirements have long limited the ability to perform realistic 3-dimensional dynamical MBE growth simulations. However, modern facilities are now suitable to perform large-scale simulations and make quantitative predictions for direct implementation in MBE growth recipes. It should be noted that realistic SLS structures possess interfacial roughness and material interdiffusion of similar length scale to the layer thickness, among other inhomogeneities that a successful model should be able to accommodate or predict. Experimental validation of the model is a necessity.

Resulting MBE growth recipes should lead to high quality infrared detector material showing theoretically predicted material characteristics such as minority carrier lifetime. Commercial III-V foundries including material growers should be able to use these recipes to develop advanced high resolution MWIR and LWIR FPAs with enhanced performance suitable integrate with US Army and DOD systems giving the tremendous advantage to US Warfighters. Commercial applications of these superior MBE grown III-V material devices include medical diagnostics and therapeutics, chemical and pollution sensing, materials processing, industrial process monitoring, food safety monitoring, aircraft anti-missile warning/protection and combustion diagnostics for high efficiency power generation. DoD applications include infrared countermeasures (IRCM), detect/locate hostile fire, detect/negate hostile imagers, sensors for persistent surveillance, helicopter landing during brownout, missile warning, laser marking and detection of explosive and chemical warfare agents.

Performers are encouraged to work with federal laboratories, federal contractor laboratories or commercial III-V foundries for validation of growth parameters and fabrication of detectors and focal plane arrays.

PHASE I: Develop a model that can accept III-V MBE growth parameters and SLS device structures as inputs and output the expected concentration of SRH centers and the associated SRH dark current and lifetime. This demonstration may consist of a single SLS structure, but should provide evidence that the model can make accurate predictions based on a variety of MBE growth parameters.

PHASE II: Develop the model into a prototype software product that can be reliably used with limited expertise. Demonstrate the use the software to predict SRH dark current and carrier lifetime as a function of common III-V SLS MBE growth parameters, such as flux ratio and substrate temperature. Provide validation through comparison with experiments. Upon successful validation, develop MBE growth recipes for improve minority carrier lifetimes and enhance quantum efficiency > 80% of MW and LWIR SLS detectors.

PHASE III: Develop the model into a software product or recipes that can be licensed or transferred and utilized with limited expertise, irrespective of the commercialization route. Commercial III-V foundries including material growers should be able to use these software to develop advanced high resolution MWIR and/or LWIR FPAs with enhanced performance suitable integrate with US Army and DOD systems giving the tremendous advantage to US Warfighters. Successful demonstration of this technology will lead to advanced MW, LW or dual-band FPAs that can be inserted into systems for next generation forward looking infrared systems, and provide important leap ahead wide area persistent surveillance systems like Joint Strike Fighter and infrared search and track capabilities for the Warfighter including Army tactical systems like the Javelin. The success of this technology will immediately improve the performance of systems requiring advanced high performance infrared sensors by significantly reducing size, weight, and power consumption requirements as well as cost. The same impact would be expected for commercial applications that would utilize advanced infrared focal plane arrays. Commercial applications include law enforcement, medical, search and rescue, and high sensitivity broad-band radiometric measuring devices.

REFERENCES:
1. L. Zheng, M. Tidrow, et al., Developing High Performance III-V Superlattice IRFPAs for Defense -- Challenges and Solutions, Proc. of SPIE Vol. 7660, 76601E, 2010.

2. C. H. Grein, M. E. Flatte, and H. Ehrenreich, Comparison of ideal InAs/InAs1-xSbx and InAs/InxGa1-xSb superlattice IR detector, Electrochemical Society Proceedings, Volume 95-28, page 211 (1995).

3. L. Höglund, D. Z. Ting, A. Khoshakhlagh, A. Soibel, C. J. Hill, A. Fisher, S. Keo, S. D Gunapala, Appl. Phys. Lett. 103, 221908 (2013).

4. B. V. Olson, E. A. Shaner, J. K. Kim, J. F. Klem, S. D. Hawkins, M. E. Flatte, T. F. Boggess, Appl. Phys. Lett. 103, 052106 (2013).

KEYWORDS: Strained layer superlattice, infrared detectors, focal plane arrays, minority carrier lifetime, III-V antimony-based material, carrier transport, superlattice absorption, background doping, Shockley Reed Hall recombination, growth kinetics modification

A15-042 This topic has been removed from the solicitation.

A15-043 TITLE: Automated Explotability Reasoning

TECHNOLOGY AREAS: Information Systems

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

foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Design and develop improved software fuzzing capabilities that incorporate high performance dynamic analysis and symbolic execution techniques that can reason on software exploitability severity and help automate software vulnerability analysis.

DESCRIPTION: Fuzzing is a software analysis techniques where random or mutated data is applied to a target application and monitored to see if it behaves in some unintentional manner (crashes, memory leaks, etc.) which could signal a vulnerability in the software that can be exploited.

The goal for this research is to enhance generic fuzzing capabilities, specifically the ability to quickly and accurately determine the severity of a vulnerability found via fuzzing. When fuzzing a large non-trivial executable without source code it is common to find crashes for which you cannot easily determine the exploitability. The exploitability of any given vulnerability is dependent on an attackers ability to control or influence values of CPU registers, stack contents, and heap memory contents and location. An attacker would ultimately control or influence these values by modifying the delivered payload to include the values needed for successful exploitation. The more values an attacker can control the more likely it is the attacker will be able to successfully exploit the vulnerability, thereby increasing the risk associated with the vulnerability.

PHASE I: Investigate properties of such techniques as dynamic taint analysis, symbolic execution, and constraint solving and determine if they can be successfully applied to provide a more concrete analysis of software exploitability.

PHASE II: Develop and demonstrate a prototype that incorporates those promising analysis techniques of analyzing exploitability determined in Phase 1. Then incorporate techniques to automate the analysis process such as through theorem provers to help provide a concise representation of an attackers control and improved understanding of the relative severity associated with the vulnerability. Conduct testing across a random set of applications to prove effectiveness and repeatability.

PHASE III: The analysis capability could be utilized to performed improved software vulnerability analysis in a wide variety of both military and commercial applications to greatly enhance security with the supply chain. Example of a military application would be the evaluation of programmable software upgrades to Army Crypto modernization compliant security devices to ensure the new software does not induce vulnerabilities. Transition path would be to Program Director Network Enabler under Program Executive Office Command, Control, Communications Tactical. A typical commercial application would include any software company and would allow them to incrementally analyze their software code as it is being written to ensure vulnerabilities that are typically induced through bad coding practices and across numerous third party coders has not occured.

REFERENCES:
1. Edward J. Schwartz, Thanassis Avgerinos, David Brumley Carnegie Mellon University Pittsburgh, PA, All You Ever Wanted to Know About Dynamic Taint Analysis and Forward Symbolic Execution (but might have been afraid to ask), 2010 IEEE Symposium on Security and Privacy.

2. Min Gyung Kang_, Stephen McCamant, Pongsin Poosankam, Dawn Song. UC Berkeley-Carnegie Mellon University DTA++: Dynamic Taint Analysis with Targeted Control-Flow Propagation.

3. Peter M. Kruse, Numerical Constraints from Combinatorial Interaction Testing, International Workshop on Constraints in Software Testing, Verification, and Analysis 2012, Montreal Canada.

4. James Newsome, Dawn Song, Dynamic Taint Analysis for Automatic Detection, Analysis, and Signature Generation of Exploits on Commodity Software, July 2005, CMU-CS-04-140, School of Computer Science Carnegie Mellon University, Pittsburg, PA 15213.

5. Cristian Cadar, Patrice Godefroid, Sanfraz Khurshid, Corina S. Pasareanu, Koushik Sen, Nikolai Tillmann, William Visser, Symbolic Execution for Software Testing in Practice - Preliminary Assessment, 2011 International Conference on Software Engineering, Honolulu, Hawaii.

KEYWORDS: Software Assurance, fuzzing, cyber, CEMA (Cyber ElectroMagnetic Activity), vulnerabiltity analysis, blue/red teaming, dynamic analysis

A15-044 TITLE: Firmware Assurance

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: Design and develop a host based defensive security capability that can be interjected into embedded firmware that provides the ability to detect malicious or unauthorized firmware modification.

DESCRIPTION: Assuring that firmware has not been tampered with or maliciously modified is critical in maintaining trust in hardware. This topic attempts to create a host-based defensive security mechanism for embedded systems. Embedded security is a key tenet of a defense in depth solution in case security anti-tamper measures fail. This effort will develop a trusted mechanism of interjecting IDS like functionality into the firmware of a device. It must be stealthy and lightweight so that it runs undetected in the background. It must sense, and alert on the unauthorized modification or attempted exploitation of the device's firmware. It will detect all software code injection attacks while providing the ability to run at the binary level so that it remains agnostic to the operating system, inner workings of its host program, and execution environment. Security overhead imposed by this capability must be kept to a minimum so that it does not impact normal host system performance.

PHASE I: Investigate alternative host-based defensive techniques to firmware update signing to ensure that the original firmware in embedded systems has not been maliciously modified.

PHASE II: Develop and demonstrate a prototype capability that incorporates techniques developed in Phase I. Conduct testing across various commercial IP based devices (i.e. printers, network switches) to assess how well it hardens and detects modification or exploitation of the firmware image.

PHASE III: Commercialize the prototype developed in Phase II and demonstrate successful integration into a Commercial printer or other IP based device. Evaluate the capability to successfully demonstrate for a test case that maliciously modified firmware within an IP based encryptor was successfully detected. Work with Program Director Network Enabler to ensure this is included as part of the evaluation criteria under the AR 700-142 cryptographic evaluation process. Commercialization could take place through licensing agreements with IP based product companies. This could also be leveraged for military embedded systems through licensing.

REFERENCES:
1. Z. Basnight, J. Butts, J. Lopez Jr, and T. Dube, Firmware modification attacks on programmable logic controllers. International Journal of Critical Infrastructure Protection, 2013.

2. Jonas Zaddach and Andrei Costin, Embedded Devices Security and Firmware Reverse Engineering, BlackHat USA, 2013.

3. Ang Cui, Michael Costello, Jatin Kataria, Salvatore J. Stolfo, "Stepping P3wns: Adventures in Full-spectrum Embedded Exploitation and Defense;" BlackHat USA, 2013.

KEYWORDS: Cyber, Hardware / firmware assurance, intrusion detection, firmware, anti-tamper

A15-045 TITLE: Channel State Feedback for Closed-Loop Multi-User MIMO System

TECHNOLOGY AREAS: Electronics

OBJECTIVE: The objective of this project is to develop algorithms and protocols for a closed-loop multi-user Multiple Input-Multiple Output (MIMO) communication system capable of realizing theoretical sum capacity limits for informed transmitters

DESCRIPTION: Recent advances in multi-user MIMO (MU-MIMO) technologies for jointly detecting and extracting signals of interest (SOIs) have produced dramatic gains in terms of supporting multiple co-band users for commercial radio systems. These systems provide higher reliability and throughput for point-to-multi-point links compared to both legacy and traditional MIMO systems.

MU-MIMO technology is currently available for commercial wireless networks with a base station-subscriber topology. In this framework, antenna resources are used to transmit multiple frames to different clients, at the same time and over the same frequency spectrum. The transmitter can direct the signal energy intended for a particular user towards that user, while simultaneously minimizing interference to other users. Either informed or uninformed strategies can be used in the downlink case for MU-MIMO, along with space-division multiple access (SDMA) in the uplink case as in the IEEE 802.11ac standard.

We expect MU-MIMO to offer significant benefits to Mobile ad-hoc networks (MANETs) used in the military environment. The expected impact on tactical networks is enhanced throughput to multiple users and increased resilience to interference by “null steering” in the direction of interference. The resulting value delivered to the Warfighter includes increased situational awareness, ability to take advantage of higher data rate applications and improved LPI/LPD.

It is intended that solutions developed are targeted for military environments with long-range, high power, highly mobile systems that are robust in the presence of noise and interference. The proposed research should be conducted with the underlying assumption that the network consists of a mixture of single antenna and multi-antenna transceivers. Specific research challenges to be considered include:

1. Scheduling of multiple simultaneous MIMO transmitters/receivers to take advantage of techniques such as “null steering” to optimize frequency reuse within the MANET

2. Scheduling and multi antenna transmission techniques for optimally supporting multicast traffic, that leverage the heterogeneous network of multi and single antenna radio nodes, specifically looking at the impact on capacity and latency.

3. Algorithms for channel estimation and channel state feedback that are optimally suited for mobile ad-hoc networks in military environments.

PHASE I: Study optimal scheduling and antenna techniques for MU-MIMO systems with multiple simultaneous MIMO links. The proposed study should include channel estimation and feedback to deliver Channel State Information at the Transmitter (CSIT), and analysis from an information theoretic standpoint considering parameters such as BER and channel capacity. Study should include analysis of optimal techniques to support multicast traffic in a network of heterogeneous nodes in comparison to broadcast/repeat architectures.

PHASE II: Develop, model and simulation of algorithms and techniques proposed under Phase I. Primary deliverables include scheduling, channel estimation and feedback algorithms along with corresponding models and simulations. Additionally, the techniques should be implemented and demonstrated on a network of low cost SDR platforms.

PHASE III: The algorithms developed under Phase I and II have the potential to substantially improve the performance of military and commercial ground radios when used in highly mobile and ad-hoc networking. Potential military radio waveforms that can benefit from this technology include Soldier Radio Waveform (SRW) and Wideband Network Waveform (WNW). It can be expected that MU-MIMO can be incorporated into emerging cellular standards and one potential application is for its use in remote or disadvantaged areas where typical cellular towers are not practical.

REFERENCES:

1. A. Tulino, et al. “Joint Detection for Multi-Antenna Channels,” Advances in Multiuser Detection, M.L. Honig (Ed.), Wiley 2009

2. D. Tse and P. Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005

3. I.E. Telatar, “Capacity of Multi-Antenna Gaussian Channels,” European Transactions on Telecommunication, 10(6):585-596, November 1999

4. A. Soysal, S. Ulukus, “Asymptotic Optimality of Beamforming in Multi-user MIMO-MAC with No or Partial CSI at the Transmitters,” in Vehicular Technology Conference, Stockholm, Sweden, May 2005.

KEYWORDS: Multi-User MIMO, Channel Estimation, Feedback, Closed loop system, Space Division Multiple Access

A15-046 TITLE: Use of Social Cognitive Techniques to Enhance Communications at the Tactical Edge

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this topic is to develop innovative, robust and efficient methods and protocols for wireless communications and networking at the tactical edge using social cognitive techniques which are aware of the mission and the users that the network supports.

DESCRIPTION: Tactical Mobile ad hoc networks (MANETS) are central in establishing “Information Superiority” for the Army. Experience and tests indicate that Tactical MANETS can be burdened with robustness, scalability and inefficiency issues due to node mobility and the resulting protocol information exchange packets. This may slow, or even impede the realization of Information Superiority and Network Centric Warfare doctrines. Currently, tactical MANETs use variants of Link state Routing protocols such as OLSR, which are adapted for MANETs. However, even with various protocol optimizations and adaptations, the link state information can be stale due to high mobility, which would create robustness issues. Also, exchange of topological information can overwhelm wireless links in high mobility situations.

Instead of relying on exchange of topological information, new approach to networking is needed where information related to mission of the network can be exploited to facilitate data exchange. That is, a network at the Tactical Edge is usually designed to support a mission where users have well defined roles and organizational relationships. In many cases, mission planners have detailed understanding of data exchange requirements, including who talks to whom, what type of data is to be exchanged, node locations over the duration of the mission. This information can be condensed as a priori social metrics, which can be computed ahead of the mission. In addition, social cognitive information can be gathered locally at the nodes during the mission execution. Working from a richer information base, such an approach, which we call social cognitive techniques, will tend to enhance the robustness and performance of tactical MANETS.

To this end, probabilistic models of the network at the nodes which are based on social cognitive information defined above can be very valuable. These models should capture the interactions among social, information and communication networks. Augmented with locally exchanged status and social relationship information, this approach will enable the nodes to fulfill the networking functions without referring to the use of link state routing protocols. Thus, this approach avoids the use of potentially stale link state information in making forwarding decisions. Using these models, nodes can select the neighbors with which they maintain connectivity and exchange information, rationally allocate among nodes time slots used in sending packets and identify the best next hop towards the destination. This will lead to a robust methodology on the design and optimization of wireless communication networks which takes into account social relationships, mission specifics and information flows in highly dynamic environments.

PHASE I: Explore and define a mathematical model to capture the interactions between communication, information and social network associated with MANETS. Use this framework to formulate probabilistic description of the interactions and information exchange in the network. This will be used to facilitate networking functions such as neighbor selection, identification of next hop for routing and time slot allocations. Develop algorithms that make use of probabilistic models to perform networking functions. The performance and robustness properties of the chosen approach and the algorithms should be substantiated by means of modeling, simulation and analysis.

PHASE II: Develop specification of the networking protocols which make use of the algorithms from phase I. Provide with software implementation of the proposed protocols and algorithms. Devise demonstration of capabilities using a network of wireless mobile nodes under a military relevant scenario. Demonstrate scalability properties of the proposed solution using a combination of wireless mobile nodes and network emulation tools.

PHASE III: Research proposed in this topic can be used to improve the performance of Army's, as well as other Services' tactical wireless communication capabilities in terms of scalability, protocol overhead reduction and response time. This research can be used in improving the situational awareness in the battlefield. It can be incorporated in a Situational Awareness (SA) enabling system such as Nett Warrior, so that SA information can be delivered to the right people at the right time with minimal configuration and involvement from the producers of the information. In addition to military applications, MANETS are extensively used in First Respondent, Homeland Security and agriculture environments. Commercial cellular service providers are expected to introduce MANET capabilities to handheld devices that they support in the near future. Envisioned improvements resulting from this research can also be inserted in these commercial applications and thus enable broader use of their capabilities.

REFERENCES:
[1] Q. Zheng, P. Zhu, Y. Wang, M. Xu, "EPSP: Enhancing Network Protocol with Social-aware Plane", IEEE/ACM 2010.

[2] K. Wei, X. Liang, K.Xu, "A Survey of Social-Aware Routing Protocols in Delay Tolerant Networks: Applications Taxonomy and Design-Related Issues" IEEE Communications Surveys & Tutorials, 2013.

[3] Dimitrios Katsaros, Nikos Dimokas, Leandros Tassiulas, "Social Network Analysis Concepts in the Design of Wireless Ad Hoc Network Protocols" IEEE Networks 2010.

[4] W. Gao, Q. Li, B. Zhao, and G. Cao, "Social-Aware Multicast in Disruption Tolerant Networks", IEEE/ACM Transactions on Networking, 2012.

KEYWORDS: Mobile ad hoc Network (MANET), social network, information network, communication network, probabilistic modeling, multi-genre networks, routing

A15-047 TITLE: Broadband Plasmonic Meta Materials

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: The objective of this topic is to develop a new generation of highly efficient, broadband (visible through infrared regions) obscurant materials with engineered spectral characteristics based on scalable production of plasmonic metamaterials. Current obscurants are aerosolized particles of natural materials such as metals or dielectrics which scatter or absorb, and have been optimized by controlling their sizes and shapes. Existing particulates tend to agglomerate (clump together into bigger particles) which limits their observed performance from reaching the theoretical potential. Recent advances in plasmonic metamaterials have demonstrated that precisely fabricated nanostructures combining metals, dielectrics, graphene, etc. can display optical characteristics not possible with any natural material, such as enhanced resonant scattering, absorption without scattering, windows of transparency or other unique electromagnetic behaviors. Metamaterials can make use of phenomena such as Fano resonances, extraordinary optical transmission and other behavior not found in simple particles. When these resonances are excited, absorption and scattering intensities can be up to 40 times larger than identically sized particles that are not plasmonic. Plasmonic obscurants have mass extinction coefficients (MECs) as large as 70 m2/g, making this class of materials very interesting for obscurant applications. The goal of this topic is to show designs for metamaterials which display specific desired obscurant characteristics, utilizing innovative methods of synthesis and manufacturing which promise to produce such materials in volume at reasonable cost. Additionally, this topic seeks the design of metamaterial aerosols with optical properties that are independent of the angle of incident radiation, thus making randomly orientated aerosols of metamaterials more effective in reducing signatures for target acquisition.

DESCRIPTION: Optical obscurants systems have been a part of warfare for centuries. On today's battlefield however, the proliferation of optical, infrared (IR) and electromagnetic communications and light sources are easily available to our adversaries. And with state of the art sensors including night vision and thermal IR, the problem of concealing our personnel and equipment has become far more complex. For center bursting grenades, the currently most widely used IR obscurant consists of brass flakes with a scattering cross section / unit mass of 1.4 m^2/g. For visible light, TiO_2 powders show an efficiency of 4.5 m^2/g. Spectral bands where obscurants are of interest include the Visible (0.4 to 0.7um); Near Infrared, 0.7-1.2um; Short Wave Infrared (SWIR), 1.5-2um; and the Mid Infrared, 3.0 – 5.0um. Target performance for advanced obscurants should include broadband or multiband behavior, efficiencies 100X that of current materials, and the ability to engineer spectrally narrow windows of transparency at desired frequencies. The problem of agglomeration must also be addressed and the materials used should be nontoxic.

PHASE I: Develop processes and methodologies to synthesize broadband obscurant metamaterials that can block specific regions of the electromagnetic (EM) spectrum. Phase I will be directed specifically at the VIS and NIR spectral bands. 1) Use computational simulation to design plasmonic metamaterials which, in aerosolized form, will have scattering efficiencies of 20-100 m^2/g in the VIS along with a spectrally narrow window of transparency in the 900-1500 nm range. 2) Use nanofabrication methods to realize and demonstrate a first sample of the proposed design and confirm the optical characteristics by measurements. 3) Develop a detailed plan on how the metamaterial will be synthesized / produced by scalable methods for volume production, to be demonstrated in Phase II. Traditional characteristics of metamaterials have shown a very 'peaked' absorption response. This topic is seeking to broaden these absorption effects by either combining multiple response materials, or by designing a single particle that will have a broadband response. At the end of the Phase I effort, the contractor should be able to produce 5-10 grams of material to Edgewood Chemical and Biological Command (ECBC). In process testing for the Phase I program will be provided by ECBC at no cost to the contractor, however, reasonable limitations will need to be established for ECBC resources at the kick off meeting.

PHASE II: 1) Demonstrate the scaleup potential for the metamaterial developed in Phase I by producing kilogram quantities, and deliver prototype devices to ECBC for testing and evaluation. 2) Demonstrate that the properties of the novel metamaterial obscurant are not limited by agglomeration, while investigating packing effects on the material.3) Continue to focus on developing processes that will produce enough material to fabricate several full size hand grenades based on the M106 geometries. Since efficient dissemination of these materials is a problem in itself, the Phase II effort should also include packing and dissemination discussions of plasmonic materials. Specifically, to investigate any degradation effects with regard to packing, storing or transporting these novel materials. 4) Engineer dispersion techniques to accompany the special requirements of metamaterials, if any. 5) Full scale prototype devices based on the M016 grenade geometry (approximately 225cc of material) should be developed in the second year of the Phase II effort. 4) Develop a long range cost estimate to compare metamaterial obscurants with current Army materials.

Novel methods of dissemination are constantly being researched. Technologies such as pneumatic dissemination or burst disk strategies could be utilized. This program should offer some flexibility to pack materials in alternative devices should they become available.

PHASE III: 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.

REFERENCES:

1. Embury, Janon; Maximizing Infrared Extinction Coefficients for Metal Discs, Rods, and Spheres, ECBC-TR-226, Feb 2002, ADA400404, 77 Page(s)

2. W. Qiu, B. G. DeLacy, S. G. Johnson, J. D. Joannopoulos, and M. Soljacic, “Optimization of broadband optical response of multilayer nanospheres,” Optics Express, vol. 20, pp. 18494–18504, July 2012.

3. Bohren, C.F.; Huffman, D.R. Absorption and Scattering of Light by Small Particles; Wiley-Interscience: New York, 1983.

4. Obscurant Applications, S. Johnson, ISN Review, MIT, June 2012.

5. Hedayati, M. K., Javaherirahim, M., Mozooni, B., Abdelaziz, R., Tavassolizadeh, A., Chakravadhanula, V., S. K., Zaporojtchenko, V., Strunkus, T., Faupel, F. and Elbahri, M. (2011), Design of a Perfect Black Absorber at Visible Frequencies Using Plasmonic Metamaterials. Adv. Mater., 23: 5410–5414. doi: 10.1002/adma.201102646

6. Murray, B.A.; Barnes, W.L.: Plasmonic Materials, Adv. Mater. 2007, 19, 3771–3782. http://m-newton.ex.ac.uk/research/emag/wlb/AdvMat_2007_19_3771.pdf

KEYWORDS: visual smoke, plasmonic resonances, meta materials, obscurant, dissemination

A15-048 TITLE: Chemical Biological Radiological Nuclear and Explosives (CBRNE) Reconnaissance Sampling Kit

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Demonstrate a comprehensive sampling and presumptive analysis capability for traceable tagging, tracking, and geolocation of environmental samples suspected of containing chemical, biological, radiological/nuclear or explosive (CBRNE) materials of interest.

DESCRIPTION: Reconnaissance provides commanders with an understanding of the operational environment, enhancing their ability to make operational decisions. The modern operational environment is threatened with the potential for adversary use of chemical, biological, radiological and/or explosive devices. Reconnaissance teams are expected to assess the environment for the presence of these threats collect samples and to process and analyze samples and data in order to develop situational understanding. Trace samples that are suspected of containing threat materials must be packaged and transported back to an in-theater laboratory for field confirmatory / theatre validation level of analysis. Ultimately some samples are expected to be sent to CONUS and/or coalition national laboratory for definitive analysis, supporting operational and intelligence decisions at the operational and strategic level. Such missions could easily generate 100s or even 1000s of samples for laboratory analysis. CBRN Reconnaissance teams are currently burdened by manual completion of sample accountability / chain of custody documentation. Furthermore laboratories (deployed or CONUS) could potentially become inundated with quantities of samples and the associated documentation that limit the responsiveness necessary to support operational or strategic decisions. Additionally, certain threat materials are potentially fleeting in nature and may rapidly degrade during transportation for detailed analysis.

Enabling technologies in sampling, geolocation, and presumptive analytical chemistry have advanced in recent years, potentially enabling improvements and standardized, reliable practices for CBRNE exploitation / reconnaissance teams. This effort would be expected to assess the state of technology and methodology to define a standardized sampling toolkit for CBRNE reconnaissance. The technology would support site exploitation/reconnaissance missions enabling sample/information/material collection which can support operational and forensic investigations and contamination locating and marking. Additionally, the handling, packaging, and presumptive assessment (i.e. preliminary identification) of threat materials will aid in the process of preserving and prioritizing reconnaissance samples at forward laboratories or for shipment to dedicated laboratory facilities for in-depth analysis.

PHASE I: Survey the technology marketplace for available and optimal sampling tools, geolocation technology, and automated sample documentation applications for each category of threat (C, B, R/N, and E). Study the maturity and applicability of sample preservation methods and technologies to define optimal approaches and sample handling and packaging kits that enable the preservation of samples by class. In the case of biological samples, such packaging kits must accommodate the possibility of bacterial, viral, or proteinaceous materials. Study the potential for an inexpensive presumptive identification technology for CBE materials that can be integrated with the sample package to facilitate the prioritization of samples for analysis by a forward deployed or home station laboratory (R/N samples would be presumptively identified by organic radiological detection systems).

PHASE II: Design a prototype system that best integrates the proposed components into an optimized kit, and demonstrate at least four sample collection, preservation, and CBE presumptive identification iterations. Further optimize the kit specification based upon initial demonstration lessons learned.

PHASE III: Develop and perform field demonstrations for reconnaissance mission sets involving the sampling, packaging, preservation, and presumptive identification of CBRNE samples. Analyze cost-performance trade-offs for low-cost disposable and options for creation of version sets that are releasable and usable by foreign national partners while abiding by International Traffic in Arms Regulations (ITAR) restriction limitations.

PHASE III DUAL USE APPLICATIONS: Enhancements to sample preservation and transportation have wide applications in worldwide medical surveillance, detection and response markets. Other potential applications include environmental remediation, epidemiology, surveying and prospecting tools for commercial markets.

REFERENCES:
1. Liu, Bo; Yuan, Quan; Cong, Gao; et al. (JUN 2014) "Where your photo is taken: Geolocation Prediction for Social Images" Journal of the Association For Information Science and Technology, 65(6), 1232-1243.

2. Bobbitt, Rick (26 September 2009). "Photographers Have Several Camera Options for Geotagging Pictures with GPS Points", http://www.directionsmag.com/article.php?article_id=3283, Directions Magazine. Retrieved 11 June 2014.

3. Allen-Hall, A., & McNevin, D. (2013). Non-cryogenic forensic tissue preservation in the field: A review. Australian Journal of Forensic Sciences, Volume: 45, Issue:4, Pages: 450-460.

4. Budowle, B., Schutzer, S. E., Morse, S. A., Martinez, K. F., Chakraborty, R., Marrone, B. L., Messenger, S. L., et al. (2008). Criteria for validation of methods in microbial forensics. Applied and environmental microbiology, 74(18), 5599–607.

5. Hubálek, Z. (2003). Protectants used in the cryopreservation of microorganisms. Cryobiology, 46(3), 205–29. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12818211 11 June 2014.

6. Seutin, G., White, B. N., & Boag, P. T. (1991). Preservation of avian blood and tissue samples for DNA analyses. Canadian Journal of Zoology, 69(1), 82–90.

7. Feng, L.; Musto, C. J.; Kemling, J. W.; Lim, S.H.; Suslick, K. S. (2010) “A Colorimetric Sensor Array for Identification of Toxic Gases below Permissible Exposure Limits” Chem. Commun., 46, 2037-2039.

8. Feng, L.; Musto, C. J.; Kemling, J. W.; Lim, S.H.; Zhong, W.; Suslick, K. S. (2010) “A Colorimetric Sensor Array for Determination and Identification of Toxic Industrial Chemicals” Anal. Chem., 82, 9433-9440.

9. Carey, J. R.; Suslick, K. S.; Hulkower, K. I.; Imlay, J. A.; Imlay, K. R. C.; Ingison, C. K.; Ponder, J. B.; Sen, A.; Wittrig, A. E. (2011) “Rapid Identification of Bacteria with a Disposable Colorimetric Sensor Array” J. Am. Chem. Soc., 133, 7571-7576.

10. ATP 3-11.37 para. 1-4.

11. ATP 3-11.37 para. 1-5.

12. ATP 3-90.15 Para. 1-1.

KEYWORDS: Geotagging, Georeferencing, Sampling, Sample Preservation, Chemical, Biological, Radiological, and Energetic Material Reconnaissance, Presumptive Identification

A15-049 TITLE: Development of Tactile (Haptic)

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop and demonstrate hardware / software / firmware assistive augmentations to enable dynamic, interactive “visualization-by-virtual-touch” (haptics) of real-time 3-D/4-D (3-D over time) geospatial information on hand-held, location-aware commercial-off-the-shelf (COTS) device.

DESCRIPTION: Most currently fielded geospatially aware mobile devices (tablet PC, smart phone, etc.) output information-rich 3-D tactical geospatial intelligence information to the user in only 2-D and reserve the “touch” only for input (activate, pan, zoom, turn page, etc.). Recent research indicates potential to exploit the user’s sense of touch to output additional dimensions of the data’s real-time geospatially-registered information (elevation contour isolines, roadway symbols, hazard / obstruction boundaries, bodies of water, optimal routing calculations, line-of-sight concealment estimates, etc.). Current 3-D/4-D systems create a visual perception of the third dimension through use of Sizable, Weighty and Power-hungry, Costly (SWAP-C) viewing equipment, augmented with easily broken/misplaced accessory glasses or presuming the user has perfect binocular stereo vision. Glasses do not work well when the ambient lighting is too bright, too dim, or has excessive glare. Perfect binocular vision can be impaired if s/he suffers from night-blindness, flash day-blindness, eye injury, color blindness, strabismus (eye mis-alignment), etc. This Topic’s haptic visualization augmentations could enhance warfighters’ mission accomplishment, rehearsal / training and provide visually impaired warriors and others with inexpensive methods to “view” their every-day 3-D / 4-D environment through their sense of touch. Executive Order 13163 exhorted federal agencies to increase occupational opportunities for those with disabilities.

Deputy Assistant Secretary of the Army for Research and Technology, Mary Miller testified (16 April 2013) before the U.S. House Armed Services Committee for Army Science and Technology on the Army’s future needs. She articulated the need for intuitive, easy-to-use, near real-time soldier access to Intelligence, Surveillance and Reconnaissance (ISR) information and model output without adding significant burdens to their load or support infrastructure while also enhancing their cognitive understanding of tactical-scale geospatial combat terrain and physical environment details for force protection and mission command, rehearsal / training, modeling / simulation in support of Army mission requirements. Innovating some of these solutions through this SBIR Topic could advance manufacturing-related research and development through small businesses (Executive Order 13329).

This topic seeks science & technology innovations in haptic perception (through sense of touch) of geo-registered 3-D information (charts, maps, images, textures, etc.) concurrently co-registered and superimposed over the viewing surface of hand-held COTS device(s) (Windows tablet PC, Android smart phone) without interfering with its other functions. Users may prefer to interact with these devices using bare fingers, gloves or styli. Consequently proposers need to articulate any special conditions that may obtain regarding the use of their specific touch technology. This only acknowledges different user preferences and neither prohibits nor suggests any technology in preference to any other. The envisioned additional transparent haptic interface overlay and its associated controlling electronics should be neither wider nor longer than the device (< 320 mm x 230 mm for a tablet PC or < 80 mm x 150 mm for smart phone) and weigh no more than the hand-held device to which it attaches (< 3.0 kg). The haptic device must have contemporaneous knowledge of its own geospatial position (latitude, longitude, altitude) by way of one or more satellite-based global positioning systems which may be augmented by an accelerometer-based Inertial Navigation System (INS). The U.S. Navstar Global Positioning System (GPS) is the minimal acceptable satellite-based location system, which could be augmented with information derived from the Russian Glonass and/or European (Galieo) and/or Chinese (Beidou) systems. Multilateration (time difference of arrival) location technologies are explicitly excluded from this effort because many areas lack sufficient transmitter density to provide uninterrupted global service. These include cell phones, personal communications services (PCS) and local area wireless networks (WiFi, WLAN, etc.) technologies.

PHASE I: The first phase consists of determining the technical feasibility and optimal method(s) of prototyping and demonstrating an easily comprehended tactile “display” for co-registering 3-D geospatial information with its associated screen graphics on top of one or more COTS Windows tablet PCs and/or Android smart phones without impairing its normal functionality. The results of Phase I will be demonstrated to government personnel at Fort Belvoir, VA and documented in a delivered final report that compares the advantages and disadvantages of the tested solutions' readability, optical and tactile resolution, 3-D/4-D spatial resolution, processing speed, system portability, and overall usability of the displayed image product(s).

PHASE II: The second phase will consist of developing, testing, validating and demonstrating a haptically augmented prototype system on a COTS, maximum 12.5 inch (diagonal) screen, location-aware Windows PC which is "fully-rugged" (MIL-STD 810G: temperature, rain, humidity, sand/dust, vibration shock as well as IP65 certified (totally protected against dust, limited protection against water). The delivered Phase II prototype system will register and haptically display (2-D, 3-D and 4-D) at least three government-supplied geospatial information datasets delivered to the vendor in the format of the National Geospatial-intelligence Agency (NGA)'s Sensor Independent Point Cloud (SIPC), as well as in latitude / longitude (in degrees / minutes / seconds) format, as well as in the Military Grid Reference System (MGRS) format. Since the system will be aware of its own physical location from its GPS/INS, it must map and haptically "display" this within the geospatial context of the supplied data. Deliverables shall include at least one complete working prototype of the Phase II device including the augmented hand-held device with attached haptic interface, the operating manual, copies of the software, documentation of test results and the delivered system's technical specifications.

PHASE III: The third phase will demonstrate commercialization opportunities for 2-D / 3-D / 4-D haptic visualization augmentations of at least one tablet PC and/or smart phone in austere, remote, harsh and austere environmental conditions. Military exploitation opportunities include real-time, field review / monitoring / change analysis of geospatially-registered information produced by the Army's Instrument Set, Reconnaissance and Surveying (ENFIRE) system including: roads (DA form 1247), road reconnaissance (DA form 1248), bridges (DA form 1249), tunnels (DA form 1250), river fords (DA form 1251), rivers (DA form 7398), minefields (DA form 1355/1355-1-R), etc. Civil opportunities include providing real-time support to: emergency / firefighting / search / rescue responders with geospatially registered haptic 2-D / 3-D / 4-D maps, charts, imagery, etc. and/or for users with vision and/or environmental impairments.

REFERENCES:

1) Kim, S-C.; Israr, A; and Poupyrev, I.: Tactile rendering of 3D features on touch surfaces, Proc. Assoc. for Computing Machinery (ACM), User Interface Software and Technology (UIST) Symp., St. Andrews, UK (2013).

2) Sinclair, M.; Pahud, M.; and Benko, H.: 3D Touchscreen with forcefeedback and haptic texture, Proc. IEEE Haptics Symp. Houston, pp 1-6 (2014).

3) Lang, J. and Andrews, S.: Measurement-based modeling of contact forces and textures for haptic rendering, IEEE Trans. On visualization and computer graphics, 17(3), pp 380-391 (2011).

4) Giraud, F.; Amberg, M.; Lemair-Semail, B.; and Casiez, G.: Design of a transparent tactile stimulator, Proc. Symp. on haptic interfaces for virtual environments and teleoperator systems IEEE Computer Soc., pp 485-489 (2012).

KEYWORDS: Haptic, tactile visualization, touch display, dynamic 3-D, cognitive processing, touch screen, sensory substitution, low-vision/impaired display, mobile device, augmented reality, 3-D touch visualization, tablet / smart phone, point cloud visualization, assistive vision augmentation

A15-050 TITLE: Next Generation Sensors for Water Quality Testing and Fieldable Applications Using Traveling Wave Electrophoresis

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Traveling wave electrophoresis is a newly invented separation modality that has many unique characteristics that make it extremely well-suited for monitoring water contaminants. The objective of this work is to discover novel fabrication methods for traveling wave electrophoresis that will provide greater device precision and reproducibility.

DESCRIPTION: Robust and fieldable sensing systems remain a challenge for the military. More specifically, this project will specifically address the need for water monitoring technology to enable distributed water production that supports modular force sustainment. Improved systems for sample enrichment and separation are needed to improve the sensitivity and selectivity of sensors. While microfluidic traveling-wave electrophoresis is a general tool for sample enrichment and separation, the system developed here will be tailored for sensing impurities in recycled water. The defining characteristic of traveling-wave electrophoresis is that an electric field wave pushes the ions through solution as the electric field wave progresses through a microfluidic channel. The speed of the electric field wave is near the maximum speed at which the ions can move through free solution, as given by their inherent electrophoretic mobilities.

PHASE I: Phase I should explore new fabrication methods for a robust microfluidic traveling wave electrophoresis system. This method differentiates itself from other electrophoresis techniques by trapping analytes whose mobilities exceed a tunable threshold within a traveling electric field wave. The device must be capable of applying such an electric field wave and tuning the wave speed over a range that is useful for the separation of water contaminants. A further description of traveling wave electrophoresis can be found in the literature.[1-3] The device will include channels and a method for injection of narrow sample plugs. It must be possible to optically image or detect the separated analytes. Imaging is preferred, because it provides greater information than detection at a single point. The traveling wave electrophoresis device must have: microfluidic channels that are easy to fill, reservoirs that are compatible with primarily aqueous solutions, and leak-free sealing. The microfluidic channels should be connected to reservoirs with adequate volume, as is common practice in the field. The device that is anticipated to yield the best performance with the simplest approach is the most desirable. The uniformity of spacing of the electrodes (that comprise the arrays) is known to play a critical role in device performance. Greater uniformity and precision of the electrodes are known to provide improved performance. It is anticipated that at least ten devices will be produced in order to test the consistency of the novel fabrication methods.

PHASE II: Building on the fabrication methods discovered in phase I, the phase II activities are expected to create a prototype system that is inexpensive and that can be mass produced. The yield of the fabrication process, the performance of the devices, and the successful coupling with a fieldable detection system will be critical in determining if the fabrication method is suitable.

PHASE III DUAL USE APPLICATIONS: A general tool will be developed to improve the selectivity, sensitivity, and portability of fieldable sensor systems. The small size and low power requirements improve the portability and fieldability of sensors that detect contaminants in complex environments. The devices developed can be applied to the detection of contaminants in water, particularly disinfection by-products in recycled water. During phase III, traveling wave electrophoresis based sensors will be utilized to monitor contaminant levels in drinking and shower water to aid in maintaining soldier health and to reduce water consumption. Therefore, this system will support modular force water generation by developing technology to rapidly test water in the field for warfighters to insure that water is contaminant free. Additionally, these systems can be applied to the detection, biological and chemical warfare agents, environmental toxicants, and process monitoring for industrial applications.

REFERENCES:
[1] Edwards, B. F., Timperman, A. T., Carroll, R. L., Jo, K., Mease, J. M., and Schiffbauer, J. E., 2009, "Traveling-Wave Electrophoresis for Microfluidic Separations," Phys. Rev. Lett., 102(7), pp. 076103/1-076103/4.

[2] Jo, K. D., Schiffbauer, J. E., Edwards, B. E., Carroll, R. L., and Timperman, A. T., 2012, "Fabrication and Performance of a Microfluidic Traveling-Wave Electrophoresis System," Analyst, 137, pp. 875-883.

[3] Correll, R., and Edwards, B. F., 2012, "Velocity Plateaus in Traveling-Wave Electrophoresis," Physical Review E, 86(4), pp. 041916.

KEYWORDS: Sensors, traveling wave electrophoresis, water impurities, water purification, chemical and biological warfare agents, and process monitoring

A15-051 TITLE: Next-Generation Adenovirus Vaccine

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Develop the next-generation multivalent, room-temperature stable adenovirus vaccine, administered by either inhalation, parenteral or oral routes, utilizing standard widely available technology that readily permits the addition/substitution of other adenovirus types.

DESCRIPTION: The live, oral adenovirus vaccine (Barr Laboratories) is administered to all new basic recruits in the US military (Army, Navy, Air Force, Marines and Coast Guard) to prevent acute respiratory illness due to adenovirus types 4 and 7. The vaccine utilizes production methods and technology developed by Wyeth Laboratories in the 1960s and 1970s and, as a result, is increasingly challenging to sustain. The Army now seeks to support development of the next-generation adenovirus vaccine, which is intended to protect its recruits from adenovirus-associated illness and death for the foreseeable future.

This topic is intended to develop a novel, next-generation adenovirus vaccine possessing characteristics that enhance the ability to efficiently produce, store and administer the vaccine as well as to rapidly respond to emerging threats of different adenovirus serotypes. To ensure future sustainability, the new vaccine will be produced utilizing widely available, industry-standard equipment (hardware and software) and reagents. The vaccine may consist of viral subunits (e.g., virus-like particle or proteins), inactivated virus or live virus. The next-generation vaccine will continue to provide protection within 10 days of administration and possess an excellent safety profile. In addition, it will be a multivalent vaccine, including at least adenovirus types 4 and 7. The vaccine will be stable for at least 24 months at 2-8o C and will retain stability at room temperature, with excursions beyond room temperature, for at least nine months and preferably 12 months. It may be administered by self- inhalation to the respiratory tract, intramuscular injection, or oral ingestion. Vaccine production methods will be modern (e.g., closed, disposable systems; recombinant proteins, etc.), widely available and amenable to the introduction of different or additional adenovirus types, should the need arise in the future. Finally, the estimated cost-of-production should be anticipated to be less than the currently licensed vaccine. The goal is to produce a multivalent, thermo stable vaccine capable of effectively and efficiently protecting our military personnel for generations to come.

PHASE I: Develop a concept for the next-generation vaccine. For each key technological innovation, provide feasibility test results demonstrating the innovation is appropriate for this application. For instance,1) for an inhaled vaccine, provide preliminary evidence that the proposed product carrier molecule and excipients can be safely self-administered by this route and the desired particle characteristics can be achieved, 2) for a VLP vaccine, demonstrate the expression system is capable of accepting at least four (preferably five) protein gene inserts and can undergo efficient downstream processing; consider the use of transient vs stably transfected cells, 3) provide preliminary evidence to support the ability of the proposed approach to achieve the required thermo stability, with adenovirus or a similar product, 4) consider the use of adjuvants or immunomodulator molecules, 5) provide preliminary evidence that the proposed approached will support development of a multivalent vaccine. Demonstrate that the key production processes utilize widely available, industry-standard equipment (hardware and software) and reagents. Deliver a detailed report of all testing performed during this phase. Deliver a detailed estimate of the costs of production of the vaccine, manufactured with the proposed technologies.

PHASE II: For Phase II, production of a multivalent adenovirus type 4 and type 7 vaccine under non-GMP conditions is required. For non-replicating vaccines (e.g., subunit or inactivated), demonstrate immunogenicity in a small animal. For inhaled vaccines, also demonstrate pulmonary tolerability in a small animal. For oral, replicating live-virus vaccines, demonstrate potency and effective enteric coating in in vitro studies. Test stability at 2-8o C and at room temperature with transient excursions beyond room temperature. Pilot-scale production of cGMP vaccine and conduct of a small initial clinical trial is encouraged but not required in Phase II. Deliver a detailed report of all testing performed during this phase.

PHASE III: The overall goal of this Topic is to enhance the ability of Department of Defense to support production and deliver adenovirus vaccine for use in all basic recruits in the Army, Navy, Air Force, Marines, and Coast Guard. The next-generation vaccine will be more efficient to produce, sustain and deliver than the current version. The technological innovations developed for the production of the vaccine will facilitate the ultimate commercialization of the vaccine and will also be valuable for the production of adenovirus vaccine for civilian commercial markets, as well. Specifically, a multivalent vaccine will help reduce vaccine administration logistics and costs; thermo stability at room temperature will eliminate the need for a cold chain during vaccine transport and storage. The ability to add or substitute other adenovirus types to the vaccine will be valuable to its potential for use in pediatric populations in the US as well as in foreign military (e.g., Korea, Thailand, China) and civilian populations with reported adenovirus problems. The focus of Phase III should be further development of the multivalent, thermo stable vaccine to obtain FDA approval for use in U.S. military personnel at risk of acquiring adenovirus infections.

REFERENCES:
1. Food and Drug Administration (FDA), Center for Biologics Evaluation and Research (CBER), Package Insert, Adenovirus Type 4 and Type 7 Vaccine, Live, Oral. Available at: http://www.fda.gov/BiologicsBloodVaccines/Vaccines/ApprovedProducts/ucm247508.htm

2. Kuschner RA, Russell KL, Abuja M, et al. A phase 3, randomized, double-blind, placebo-controlled study of the safety and efficacy of the live, oral adenovirus type 4 and type 7 vaccine, in U.S. military recruits. Vaccine 2013;31:2963-71.

3. Russell KL, Hawksworth AW, Ryan MA, et al. Vaccine-preventable adenoviral respiratory illness in US military recruits, 1999–2004. Vaccine 2006;24:2835–42.

4. Hoke CH Jr, Snyder CE Jr. History of the restoration of adenovirus type 4 and type 7 vaccine, live oral (Adenovirus Vaccine) in the context of the Department of Defense acquisition system. Vaccine 2013; 31:1623-32.

5. Gray GC. Adenovirus Vaccines, in Plotkin SA, Orenstein WA, Offit PA (eds), Vaccines- 6th edition, Elsevier, Philadelphia, 2012, p. 113.

6. Heo JJ, Lee JE, Kim HK, et al. Acute Respiratory Tract Infections in Soldiers, South Korea, April 2011-March 2012. Emerg Infect Dis 2014;20 (5):875-77.

KEYWORDS: Adenovirus Vaccine, Biological Products, Vaccines, Virus-Like Particle, Inhaled Vaccine, Room Temperature Stability, Multivalent Vaccine, Manufacturing Processes

A15-052 TITLE: Novel Adjuvants to Enhance the Immunogenicity of Dengue Vaccine

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Develop and test novel adjuvants to enhance the immunogenicity of one dengue serotype vaccine and establish approaches to permit the addition of other serotypes as an adjuvanted tetravalent dengue vaccine

DESCRIPTION: Dengue fever is the most significant arthropod-borne viral disease of human and the most geographically widespread of the arthropod-borne viruses (Bhatt et al, 2013). Dengue fever is caused by dengue virus, a flavivirus that can be classified into four serotypes (dengue-1, 2, 3 and 4). Importance of dengue to U.S. military is highlighted by the fact that it is currently ranked 2nd in the Infectious Disease Threats to the U.S. Military Prioritization Panel (ID-TPP, 4/23/2010); elevated from its previous position at rank 3 (Burnette, 2008). There are currently no licensed vaccines to prevent dengue or drugs to treat dengue illness. Personal protective measures are ineffective unless judiciously applied, a difficult task in operational environments. It is the ultimate goal of the Department of Defense (DoD) to have an effective dengue tetravalent vaccine as the most appropriate method of protecting military personnel against this potentially mission-aborting disease. The capability gap in dengue prevention is recognized by the Military Infectious Disease Research Program (MIDRP) under the U.S. Army Medical Research & Materiel Command (USAMRMC). The global scale and magnitude of the dengue problem has made it attractive to commercial developers to support vaccine development internally and through partnerships. Leveraging external funding with commercial partners will enhance intramural MIDRP investment in dengue vaccine research and pave the way to achieve FDA licensure and meet MRMC mission.

The objective of this topic is to develop and test novel adjuvants to enhance the immunogenicity of one dengue serotype vaccine in a small animal model and a nonhuman primate model and to establish strategic approaches to permit the addition of the other three serotypes as an adjuvant-tetravalent dengue vaccine. Despite nearly sixty years of sustained effort, an effective dengue vaccine has yet to be developed, primarily because of the complications associated with the need for balanced tetravalent immunity to all four dengue serotypes (Raviprakash, 2009). The current leading candidate from Sanofi-Pasteur (CYD vaccine) is based on live attenuated chimeric viruses, requires long immunization schedule (12 months) and has shown less than desirable immunogenicity/efficacy (Sabchareon, 2012). As a potential first dengue vaccine to be licensed, this vaccine may not be ideal for US military personnel due to long boosting interval requirement and consequent inadequacy for rapid induction of protective immunity prior to deployment. Therefore, it is prudent to continue developing alternative backup candidates and strategies.

Past experience with live attenuated viruses and the recent results from Sanofi-Pasteur's CYD vaccine trial suggest that next generation dengue vaccines will be based on non-replicating virus platforms such as inactivated viruses and subunit vaccines. However shortcomings of the inactivated virus vaccines include short-lived antibody response and lack of cellular immune response (Raviprakash, 2009). One important requirement for such vaccines is an effective adjuvant. For a long time, alum has been the only adjuvant in vaccines approved by the FDA. In spite of enormous efforts to bring a variety of vaccine products to market, there have been only two novel adjuvants approved by the FDA for clinical use: Adjuvant System 03 (AS03) for H1N1 influenza vaccine and AS04 for human papillomavirus (HPV) vaccine (both GSK proprietary) (Brito and O'Hagan, 2014). Development and testing of novel adjuvants that enhance the immunogenicity of inactivated virus and/or subunit dengue vaccines are therefore important to advance dengue vaccine efforts now in addition to future vaccination strategies.

The Naval Medical Research Center (NMRC) has developed a novel inactivation platform to produce highly immunogenic dengue vaccines (Raviprakash, 2013). Initial mouse studies have shown this vaccine to be superior to formaldehyde inactivated dengue vaccines. Specifically, this vaccine retained its ability to binding antibodies whereas formaldehyde inactivated vaccine led to 30-50% decrease in binding. In addition, this vaccine mounted T cell responses similar to live, uninactivated virus. The Contracting Officer Representative (COR) will facilitate the contractors in obtaining inactivated dengue vaccines from the NMRC to test with their proposed novel adjuvants. Novel adjuvants such as nanoparticles, liposomes, emulsions and chemokine fusion proteins may be explored and compared with alum as control adjuvant. If the contractors are interested, the COR will also help them obtain other novel adjuvants developed at the Military HIV Research Program (MHRP) at the Walter Reed Army Institute of Research (WRAIR) such as liposomal monophosphoryl lipid A [L(MPLA)] to test with dengue vaccine. It will be beneficial to develop and test novel adjuvants to further enhance the immunogenicity of the NMRC's inactivated dengue vaccine to pave the way for FDA licensure of dengue vaccines that are more suited to use by US military. Due to the potential advantages of the adjuvant-inactivated dengue vaccine, we envision widespread use by regional medical clinics and nongovernmental organizations (NGOs) around the world. Development of an FDA-licensed dengue vaccine is not contemplated within the scope of Phases I or II of this effort.

PHASE I: Selecting Novel Adjuvant Candidates: The objective of Phase I is to demonstrate proof of concept by selecting a small group from among several novel adjuvants that provide sustained immune responses for a single dengue serotype, as demonstrated in a small animal model. The contractor shall propose down-selection criteria for novel adjuvants including alum as a control. Down-selection criteria can be based on test results with previous vaccines (i.e. dengue or other similar products). Suggested criteria for moving to subsequent phases: immune responses with novel adjuvants that are significantly higher than with alum, or a significant dose sparing compared to alum. The primary endpoint of immune responses would be antigen-specific antibodies; ancillary support for functional antibody endpoints such as neutralizing antibodies that are significantly higher than with alum 3 months after vaccination using a small animal model may also be considered. Cellular immune responses, as these pertain to antibodies, may also be provided as supporting evidence. The COR will facilitate the contractor in obtaining the inactivated dengue vaccine from NMRC, WRAIR, or other agencies that have been shown to have promising inactivated vaccine candidates. At the conclusion of Phase I, the contractor will deliver a report describing the design of the adjuvants and the performance data to down select one or two adjuvants for advancement to Phase II and beyond.

PHASE II: Demonstrating Immunogenicity of Adjuvanted Vaccine: The objective of Phase II is to expand pre-clinical testing of at least one down elected adjuvant from Phase I for at least one dengue serotype vaccine in non-human primates (NHP) to determine the immunogenicity of the adjuvanted vaccine. The contractor may coordinate with the COR to facilitate preclinical trials and subsequent testing for immunogenicity. The Phase II proposal must contain a comprehensive strategy for testing the best adjuvant candidates in NHP model using alum as control. For example, evaluation criteria may include measurements of antigen-specific antibodies, neutralizing antibodies, and cellular immune responses that are significantly higher than with alum 6 months in NHP after vaccination. Additional evaluation criteria could include ability to achieve antibody and T cell responses by administering 2 doses or fewer of the adjuvanted vaccine. If successful in demonstrating the immunogenicity endpoints, the testing will be extended to include additional dengue serotypes. At the end of Phase II, the contractor will provide a comprehensive report of all testing performed for the down selected adjuvants during this phase.

PHASE III: Developing Commercialization Objectives for Novel Adjuvants: The objective of Phase III is for the contractor to pursue commercialization objectives of novel adjuvants with dengue vaccine resulting from the Phase I and Phase II R&D activities. This work will have utility for military as it would leverage efforts to develop an effective vaccine against dengue for the warfighter. The COR will work with the company and MIDRP to identify other sources of funding and/or stakeholders should the chosen technology show promise, to include other companies, Army/DoD funding, Gates Foundation, Welcome Trust grants, etc. An effective adjuvanted dengue vaccine will also be ideal for non-military medical purposes, such as use by regional medical clinics or NGOs in areas of the world where dengue is endemic (e.g., most tropical regions of the world including South-East Asia and South America). This work will also be highly valuable to enhance vaccine development for other infectious diseases of military importance. The adjuvanted dengue vaccine may serve as proof-of-principle for the usefulness of novel adjuvants, and could easily be adapted to other infectious diseases, thus creating a sustainable and profitable product pipeline for the contractor.

REFERENCES:

1. Bhatt S, Gething PW, Brady OJ, Messina JP, Farlow AW, Moyes CL, Drake JM, Brownstein JS, Hoen AG, Sankoh O, Myers MF, George DB, Jaenisch T, Wint GR, Simmons CP, Scott TW, Farrar JJ, Hay SI. The global distribution and burden of dengue. Nature, 2013. 496(7446):504-7.

2. Brito, LA., O'Hagan DT. Designing and building the next generation of improved vaccine adjuvants. J Controlled Release. In Press. Available online 3 July 2014.

3. Burnette WN, Hoke CH Jr, Scovill J, Clark K, Abrams J, Kitchen LW, Hanson K, Palys TJ, Vaughn DW. Infectious diseases investment decision evaluation algorithm: a quantitative algorithm for prioritization of naturally occurring infectious disease threats to the U.S. military. Mil Med 2008 Feb; 173(2):174-81.

4. Raviprakash K, Defang G, Burgess T, Porter K. Advances in dengue vaccine development. Human Vaccines 2009; 5(8):520-528.

5. Raviprakash K, Sun P, Raviv Y, Luke T, Martin N, Kochel T. Dengue virus photoinactivated in presence of 1,5-iodonaphthylazide (INA) or AMT, a psoralen compound (4"-aminomethyl-trioxsalen) is highly immunogenic in mice. Human Vaccines & Immunotherapeutics 2013; 9(11):1–6.

6. Sabchareon A, Wallace D, Sirivichayakul C, Limkittikul K, Chanthavanich P, Suvannadabba S, Jiwariyavej V, Dulyachai W, Pengsaa K, Wartel TA, Moureau A, Saville M, Bouckenooghe A, Viviani S, Tornieporth NG, Lang J. Protective efficacy of the recombinant, live-attenuated, CYD tetravalent dengue vaccine in Thai schoolchildren: a randomised, controlled phase 2b trial. Lancet 2012; 380:1559-1567.

KEYWORDS: dengue fever, dengue virus, dengue serotypes, vaccines, inactivated vaccines, tetravalent dengue vaccines, adjuvants, immunogenicity

A15-053 TITLE: <u>Mucosal Immunity Stimulation Using Novel Vectors for Delivery of Proteins or Genes</u>

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Develop and test novel vectors for delivery of broadly neutralizing monoclonal antibodies (bmAbs), vaccines antigens, or antiretroviral (ARV) therapies to treat or prevent HIV infection at mucosal surfaces.

DESCRIPTION: Transmission of Type 1 human immune deficiency virus (HIV-1) commonly occurs at a mucosal surface (e.g., vaginal or rectal). This is also the site where infection prevention has the greatest potential for success. HIV-1 has been shown to mutate quickly after gaining entry to target cells and thus circumvent normal immune responses to infection. The relatively narrow viral diversity present very early in infection in mucosal tissue may represent an opportunity for multiple approaches to control and clearance, including a mucosal vaccine, localized antibodies produced by mucosal cells, or antiretroviral therapy that is targeted to cells infected by HIV-1.

As an understanding has developed regarding the immune response at mucosal interfaces, it has become a target for vaccine development (Haynes and Shattock 2008). Expression of HIV-1 envelope in mucosal tissue could be a component of an effective mucosal vaccine, but this has not been achieved using standard antigen delivery systems (e.g., viral vectors). What is needed is a generic, synthetic vector for vaccine antigens. In addition, the delivery of genes capable – at mucosal surfaces – of elaborating broadly neutralizing antibodies might provide a novel approach to immune prophylaxis. It is known that the administration of cocktails of broadly neutralizing antibody can prevent SIV infection of monkeys after challenge, and recently Balazs has shown that adenoassociated virus (AAV) transduction of VRC07 could protect humanized mice against HIV challenge (Balazs, Ouyang et al. 2014). However, whether these systems will be useful in humans is not clear.

In part, the slow progress in developing mucosal vaccines using biological vectors is due to the number of years in development and testing before any single construct is ready for clinical trials. If a generic synthetic material that has been modified for a specific environment (e.g., mucosal surfaces) were developed, a thorough characterization of its physical, chemical and toxicological properties would be available before the current antigen or antibody of interest has been attached or inserted. This would, potentially, cut years from the normal development timeline of cell line-based production systems, since characterization of the interventional portion and the vector portion could occur separately, with minimal bridging studies to assess changes to either once combined. Significant research with carbon nanotubes has been conducted to assess toxicity, and develop methods for targeting specific tissues for drug delivery. "Functionalization" of the material to improve cell targeting, increase biocompatibility, and reduce toxicity and half-life is well documented (Vardharajula, Ali et al. 2012, Gottardi and Douradinha 2013). Extension of this concept to mucosal vaccines represents a logical approach that has not been fully explored, but would provide an opportunity for testing of immunogens showing promise for the induction of relevant immune responses (Alam, Liao et al. 2013)

PHASE I: In the first six months, investigate ligands that effectively target a synthetic vector to mucosal and CD 4+ T cells; investigate methods to (1) deliver HIV antigens to target cells and achieve expression of bmAbs in relevant cells and (2) introduce molecular or chemical antiviral agents into HIV-infected cells. Assess the feasibility of packaging and delivering conformationally active bmAbs against HIV-1 epitopes to infected CD4+ T cells, mucosal cells and lymphoid tissue. The result of this phase should be the demonstration of packaging and delivery of potential vaccine antigen (gp120 A244Δ11, gp120 B.6240Δ11, or others), bmAb and siRNA to HIV-infected cells, and for delivery of HIV-1 antigens to mucosal cells that results in antigen-specific antibody expression.

PHASE II: This phase will build on the results of Phase 1 by testing the synthetic vector antigen, antibody, –nucleic acid combination in vivo to assess safety, pharmacokinetics and proof of concept efficacy. Assess the impact of mucosal barriers on synthetic vector access to target receptors and delivery efficacy. Modify the vector preparation, functional groups and/or delivered therapy to improve efficacy and safety as necessary. This phase may include the use of appropriate animal, humanized mouse, or non-human primate models, but is limited to a 2-year period to complete the research.

PHASE III: The above work, if successful, would represent significant progress in developing and delivering functional therapies and vaccines against HIV-1 at the primary site of initial infection, mucosal surfaces. A highly targeted delivery mechanism, perhaps delivered mucosally, using synthetic vectors could improve the ability to generate localized neutralizing antibodies against HIV-1, and provide a means to eliminate virus from infected cells. This work will have utility both for the military, as it would support efforts to develop an effective vaccine against HIV-1, and could eventually provide an alternative to ARV. Commercialization of a successful product for either indication (prevention or therapy) will require the cooperation and funding support from government agencies, industry partners, and non-governmental organizations, such as the Gates Foundation.

REFERENCES:
1. Alam, S. M., H. X. Liao, G. D. Tomaras, M. Bonsignori, C. Y. Tsao, K. K. Hwang, H. Chen, K. E. Lloyd, C. Bowman, L. Sutherland, T. L. Jeffries, Jr., D. M. Kozink, S. Stewart, K. Anasti, F. H. Jaeger, R. Parks, N. L. Yates, R. G. Overman, F. Sinangil, P. W. Berman, P. Pitisuttithum, J. Kaewkungwal, S. Nitayaphan, N. Karasavva, S. Rerks-Ngarm, J. H. Kim, N. L. Michael, S. Zolla-Pazner, S. Santra, N. L. Letvin, S. C. Harrison and B. F. Haynes (2013). "Antigenicity and immunogenicity of RV144 vaccine AIDSVAX clade E envelope immunogen is enhanced by a gp120 N-terminal deletion." J Virol 87(3): 1554-1568.

2. Balazs, A. B., Y. Ouyang, C. M. Hong, J. Chen, S. M. Nguyen, D. S. Rao, D. S. An and D. Baltimore (2014). "Vectored immunoprophylaxis protects humanized mice from mucosal HIV transmission." Nat Med 20(3): 296-300.

3. Gottardi, R. and B. Douradinha (2013). "Carbon nanotubes as a novel tool for vaccination against infectious diseases and cancer." J Nanobiotechnology 11: 30.

4. Haynes, B. F. and R. J. Shattock (2008). "Critical issues in mucosal immunity for HIV-1 vaccine development." The Journal of allergy and clinical immunology 122(1): 3-9; quiz 10-11.

5. Vardharajula, S., S. Z. Ali, P. M. Tiwari, E. Eroglu, K. Vig, V. A. Dennis and S. R. Singh (2012). “Functionalized carbon nanotubes: biomedical applications.” Int J Nanomedicine 7: 5361-5374.

KEYWORDS: HIV, synthetic vaccine vectors, mucosal surface, broadly neutralizing antibodies, antigen targeting

A15-054 TITLE: High-Throughput Bacteriophage Isolation and Characterization

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Develop and demonstrate high-throughput methods to isolate and characterize bacteriophages that kill one or more of the ESKAPE (Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter species) pathogens.

DESCRIPTION: Lytic bacteriophages may be of value to the Army in the treatment of bacterial infections, particularly those caused by pathogens that are resistant to treatment by commonly-used antibiotics. Given the perceived impracticality of preparing a therapeutic bacteriophage preparation on a patient-by-patient basis, at least one “cocktail” of bacteriophages will be needed for each bacterial species of concern; the cocktail will contain several bacteriophages in order to achieve adequate coverage of isolates of that bacterial species. Multiple cocktails may be needed to address bacterial variation according to geographic or other factors. The Army seeks development and demonstration of high-throughput methods of bacteriophage isolation and characterization. The required characterization is that of the fundamental biological activity of lytic bacteriophage, namely killing of bacteria. Here, high-throughput is likely to mean rapidity of isolation and characterization, though it is understood that high-throughput could involve appropriate trade-offs, such as sacrificing rapidity in favor of minimization of utilization of other resources, such as money. By way of example, and without intending to identify the state of the art or to establish a definite requirement, the Army may have a need to isolate 1,000 bacteriophages and characterize the biological activity of each of these 1,000 bacteriophages against a diversity panel of 300 isolates of a pathogen, in order to define the composition of one or more cocktails, each of which kills at least 85% of the isolates in a diversity panel and maximizes complementation of killing (meaning the killing of an isolate by more than one bacteriophage). Isolation, characterization of killing, and definition of cocktail(s) are to be accomplished within 10 work days, using no more than 80 hours of labor. The anticipated environment in which characterization of lytic activity will be done is a microbiology laboratory, as opposed to a more austere environment.

PHASE I: In Phase 1, the performer will, using project funding (1) assess the state of the art of bacteriophage isolation and characterization; (2) identify essential facts, materials, equipment, and procedures that impose limits or are barriers to high throughput; (3) identify general approaches to increasing throughput; (4) identify throughput performance goals; (5) provide a detailed plan for improving throughput; (6) describe how one could demonstrate a significant advance in throughput; and (7) conduct experimentation/invention/discovery activities that contribute relevant information to the goal of increasing throughput.

PHASE II: The proposal must describe how, the performer, using project funding, will in Phase II implement the plan produced during Phase I, and do so with one or more of the ESKAPE pathogens. During Phase II, the performer will (1) isolate at least 300 lytic bacteriophages, (2) characterize them against a panel of at least 100 bacterial isolates, some of which may be provided by the Government, and (3) define one or more cocktails that kill 85% of the bacterial isolates, and in so doing (4) demonstrate a significant increase of throughput over the state of the art. The performer will (5) note, record, and report the use of resources to accomplish the required isolations and characterizations. In particular, the performer will report the use of labor hours, commercially available equipment and materials, equipment and materials developed or invented especially for this SBIR project, and the costs associated with labor, equipment, and materials.

PHASE III: The proposal must include the "vision" or "end-state" of the research aimed at increasing throughput of bacteriophage isolation and characterization. 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 high-throughput bacteriophage isolation and characterization methods to the potential use of bacteriophages for treatment of particular diseases or conditions associated with one or more of the ESKAPE pathogens; the proposal might in this regard consider factors such as availability or lack of availability of alternative treatment modalities, costs of bacteriophage treatments, and resources needed to attain marketing approval for bacteriophage therapeutics. Additionally, the Phase III section must include (a) one or more potential commercial applications OR (b) one or more commercial technology that could be potentially inserted into defense systems as a result of this particular SBIR project.

REFERENCES:
1. Coverage of diarrhoea-associated Escherichia coli isolates from different origins with two types of phage cocktails. Gilles Bourdin, Armando Navarro, Shafiqul A Sarker, Anne-C Pittet, Firdausi Qadri, Shamima Sultana, Alejandro Cravioto, Kaisar A Talukder, Gloria Reuteler, and Harald Brüssow. Microb Biotechnol. Mar 2014; 7(2): 165–176. Published online Feb 14, 2014. doi: 10.1111/1751-7915.12113. “This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.”

2. Quality-Controlled Small-Scale Production of a Well-Defined Bacteriophage Cocktail for Use in Human Clinical Trials. Maya Merabishvili, Jean-Paul Pirnay,Gilbert Verbeken, Nina Chanishvili, Marina Tediashvili, Nino Lashkhi, Thea Glonti,Victor Krylov, Jan Mast, Luc Van Parys, Rob Lavigne, Guido Volckaert, Wesley Mattheus, Gunther Verween, Peter De Corte, Thomas Rose, Serge Jennes, Martin Zizi, Daniel De Vos, and Mario Vaneechoutte. PLoS ONE. 2009; 4(3): e4944. Published online Mar 20, 2009. doi: 10.1371/journal.pone.0004944. “This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.”

KEYWORDS: BACTERIOPHAGES; ISOLATION; ASSAYING: INFECTIOUS DISEASES; AUTOMATION; BACTERIA; LYSIS; THROUGHPUT

A15-055 TITLE: Modifiable Electronic Body Diagram Template to Accommodate Varying Body Shapes

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Development of a three-dimensional (3-D) electronic human body diagram model that is configured to adjust to varying body shapes while preserving the integrity and fidelity of its component parts.

DESCRIPTION: A problem in burn care and rehabilitation is the inability to graphically account for different body shapes and sizes to enact treatment strategies. Typically, when a person is burned and admitted to a hospital, a crude, static outline of the burn wound location is hand-drawn using paper/pencil and the total amount of the body surface area involved is visually estimated along with indicating burn depth. Currently, three electronic burn body diagrams are known to exist with one of these available as a 3-D model. The DoD burn center utilizes an electronic 2-D system. Moreover, all currently available body diagrams are configured as ‘one size fits all’ and therefore fail to adjust for different body shapes, and therefore do not meet current needs for contemporary burn care of burn-injured service members.

What is sought is a computer-based, dynamic 3-D human body diagram model that can be readily adjusted to account for various body shapes. It is important that this model automatically adjust for changes in the size of associated anatomical regions while preserving its relationship to other body areas, i.e. proportionately adjusting remaining areas simultaneously. For example, using a standard body diagram equaling 100% of the body surface, a computer algorithm program is desired whereby as a body diagram drawing is changed from an ‘average’ shape into the commonly referred to ‘pear’ body shape (adding girth to the hip, abdominal and buttock regions), the computer program will automatically adjust the surface area of all remaining anatomic areas such as the legs and arms to retain a 100% total body surface area. Incorporated into this idea is the concept of inclusion of previously described Cutaneous Functional Units.

As part of this body surface adjustment, further identified anatomic subunits will need to retain their respective surface area contribution of their respective parts also. For instance, if the waist area is enlarged to account for 3-times the normal surface area of this region, and the remainder of the body is proportionately adjusted downward, each remaining area will need to be able to be segmentally representative of 100% of itself. For added clarity, if one upper extremity represents 7% of the total body surface area and one-half of it is burned, for purposes of determining burn wound size of the upper extremity, the diagram would need to calculate both that 3.5% of the total body surface area is burned, along with 50% of the upper extremity regardless of what proportion the upper extremity represents relative to the remainder of the entire body surface area.

PHASE I: During this time, the contractor will explore currently available software programs to design the desired end-product. Building on currently available computer design technologies, the contractor will create and test a simple 3-D computerized sample model to demonstrate proof of concept based on the processes desired and described. During this Phase, the contractor will demonstrate the ability to produce and evolve the project into an acceptable model including graphical displays with printable outputs. Such a model will be dynamic and be able to exhibit a real-time change in object proportions with outputs of calculated dimensional changes. Partnerships within the burn community at-large and beyond will be sought for transition and commercialization of the product final version.

PHASE II: Based on Phase I modeling, the contractor will evolve the previously designed simple object computer mapping program into a 3-D human body diagram. Coincident with the body diagram, the computer program will have the capacity to ‘layer’ color diagrams representative of varying depths of burn and a table of surface areas representative of the burn locations.

Included as part of the expected outputs will be the incorporation of previously published information and described schema on cutaneous functional units. An added requirement is the ability to calculate and output percentages of surface injury based on burn depth.

Required Phase II deliverables will include a satisfactory computerized body mapping system that includes all previously noted elements that is fit for wide-area Beta testing during this phase.

PHASE III: The goal of this Phase is to finalize a first-generation body mapping system that has broad acceptance by a consensus of end-users based on feedback from Phase II. At the conclusion of Phase III, the vision is for the contractor to have developed a computerized 3-D burn body diagram that has met satisfactory reception of interested parties, including the U. S. Army burn center, for implementation as a clinical and research tool.

During this time, the contractor will seek commercial outlets to avail the final product to U.S. burn centers (127) and 100 countries internationally that have burn care facilities. Likely partners would be burn industry supporters such as a pharmaceutical company with consumption of the end-product by burn centers world-wide. The anticipated business model would be one of an initial user fee along with an annual renewable subscription for use of the burn body diagram. Advanced or improved upon versions of the computer program will create an on-going market for subsequent iterations of the program.

REFERENCES:

1. Williams RY, Wohlgemuth SD. Does the "Rules of Nines" apply to morbidly obese burn victims? J Burn Care Res 2013;34:447-454.

2. Richard, RL, Lester ME, Miller SF, et al. Identification of Cutaneous Functional Units related to burn scar contracture development. J Burn Care Res 2009;30:625-631.

3. Richard RL, Jones JA, Parshley PP. Hierarchical decomposition of burn diagram based on cutaneous functional units and its utility. J Burn Care Res 2014;35:S195.

4. Richard RL, Dewey WS, Anyan III WR, et al. Cutaneous functional unit is a better index than total body surface area related to burn patient outcome. J Burn Care Res 2014;35:S77.

5. Chapman TT, Richard RL, Hedman TL, et al. Military return to duty and civilian return to work factors following burns with a focus on the hand and literature review. J Burn Care Res 2008;29:756-762.

KEYWORDS: Burns, body mapping, burn percent, burn depth, rehabilitation, scar contracture

A15-056 TITLE: Temporary Ocular Device to Achieve Closure of Corneal Lacerations in Open Globe Injuries

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Design, develop, test and manufacture a device to be used in the temporary management of corneal injury following ocular trauma.

DESCRIPTION: Eye injuries account for significant number of combat related blast injuries. Open globe laceration was one of the most frequent ocular injuries from conflicts in Iraq and Afghanistan1. During Operation Iraqi Freedom and Operation Enduring Freedom, 80% of traumatic ocular injuries were combined globe/oculoplastic and/or globe/neuro-ophthalmologic injuries2. Although ocular injuries have decrease in recent years after the enforcement of eye protection use, eye injuries remain a significant cause of blindness and disability.

As a consequence of delicate and complicated management of open globe or corneal laceration injuries occurred during field combat, the imperfect primary surgical intervention is used. Subsequently, the injury is further managed with interaoperative temporary corneal prosthetic followed by suboptimal closure techniques resulting in unacceptable high graft failure rate in military medical treatment facilities due to greater overall severity and complexity of the injuries from combat.

This topic seeks to address the existing capability gap to provide bridge management strategy by developing and/or improving a temporary artificial corneal device. This device should be flexible enough to be used by the combat casualty care providers as a primary closure for corneal injuries too large or complex to be achieved with remaining corneal tissue and/or as a closure for anterior chamber that provides clarity until completion of secondary surgical procedures such as resolution of inflammation. Ideally, the device should be biocompatible, gas permeable, suturable, flexible, and last 45-90 days in the injured eye.

PHASE I: Phase I section will develop an approach by addressing minimal requirements and design prototypes to be tested in simulated model systems. It will also evaluate multiple approaches and identify optimum conditions in deriving at prototypes. Demonstrate that multiple prototypes meet minimal criteria. In this phase, limited but critical feasibility tests will be implemented with simulated model systems to crudely meet the minimal requirements criteria.

PHASE II: With the first 6 months of Phase I results, Phase II will develop methods of production for small-scale prototype fabrication and initiate small-scale manufacturing of multiple prototypes. The developed prototypes will be broadly tested for feasibility in multiple in vitro and animal model systems. Identify and select few prototypes for further development. Improve, refine and implement the best approach for small-scale production. Perform feasibility and toxicity test on animal model system. Develop, validate and finalize large-scale production method for further prototype testing. This phase will be limited to 2 years and will focus on further refinement of optimal criteria and improvement of prototypes.

PHASE III DUAL USE APPLICATIONS: If successful, the resulting prototypes from Phase II will be prepared for the FDA review and IDE application to initiate clinical investigation of the investigational device during Phase III. Since the ocular trauma care management in combat does not differ significantly from those followed in civilian sector, the final resulting device could be utilized in the worldwide commercial markets. More specifically a market for more permanent use of the temporary artificial cornea as a permanent or semi-permanent corneal prosthesis could provide substantial benefit to civilian populations worldwide, especially in Asia where donation of body parts is culturally less acceptable.

REFERENCES:
1. Weichel ED, Coyler MH. Combat ocular trauma and systemic injury. Curr Opin Ophthalmol. 2008 Nov;19(6):519-25.

2. Weichel ED, Colyer MH, et al. Combat ocular trauma visual outcomes during operations iraqi and enduring freedom. Ophthalmology. 2008 Dec;115(12):2235-45.

KEYWORDS: Corneal graft, Ocular trauma, Laceration, Rupture, Combat injury, Ocular injury, Prosthetic

A15-057 TITLE: Analysis of Abnormal Vocal/Speech Patterns in Traumatic Brain Injury

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: To refine and validate the ability to identify traumatic brain injury, particularly mild, based upon unique voice signatures.

DESCRIPTION: As of 2014 there remain very few promising objective assessment tools for identifying traumatic brain injury (TBI) at or near the point of injury or to follow progression and/or recovery from TBI. Due to the heterogeneity of the injury-especially mild TBI-it has become increasingly possible that there may not be one single modality of assessment that can identify all people who have suffered a TBI. Research into voice analysis in recent years has led to evidence that appropriate analytic tools can identify people under duress/stress or who are suffering from depressed mood or bipolar disorder. Meanwhile, dysarthria, dysphonia and swallowing difficulties are known abnormalities associated with moderate and severe TBI. While several groups have been investigating voice analysis for mild TBI in particular and have had compelling preliminary results, no group has to our knowledge demonstrated definitively that they can sensitively and specifically identify unique vocal signatures that are only associated with TBI. The goal of this topic is to enable developers to demonstrate feasibility and validity of a voice analysis system such that unique vocal signatures can be identified that always appear to various extents in casualties who have suffered a TBI and that do not appear when a TBI has not occurred.[1-3]

PHASE I: In Phase I, the performer will demonstrate feasibility in the form of analyses of existing data. They will develop a plan for a Phase II SBIR human study in which the goal will be to demonstrate that unique vocal signatures are found in TBI (particularly mild) that are only present in those casualties who have been separately diagnosed with TBI through a combination of existing assessments and examination by a medical professional experienced in the diagnosis of TBI. The performer will address how they will (or have) dealt with confounders such as age, gender, sleep deprivation, stress (physical and emotional), drug or alcohol impairment, mood disorders, PTSD, and neurodegenerative diseases such as Alzheimer's Disease and Parkinson's Disease. The performer will initiate discussions with the Food and Drug Administration regarding requirements and end points necessary to obtain FDA approval as a diagnostic device.[4]

PHASE II: Phase II will focus on the implementation of the human proof-of-concept study as well as continued work on refinement of the system to address the multiple potential confounders identified in Phase I. The performer can also elect to design and perform an additional proof of concept involving the ability to use voice analysis to follow the progress of the TBI victim (regardless of severity) with the goal of demonstrating feasibility of using the device to monitor patient status during treatment and rehabilitation. The primary goal of phase II will be the demonstration that unique vocal patterns exist that are ONLY associated with TBI. The performer will continue to interact with the FDA and if the phase II work is successful, additional plans for technical refinement and a clinical pivotal trial for use in TBI will be developed.

PHASE III: The performer will deliver a plan on how FDA approval will be achieved utilizing current Good Manufacturing Practices (cGMP). Confounders will be fully addressed and any necessary modifications to the device will be made. A pivotal trial to assess the technology in a sports and or sports/military training TBI population will be performed. Additional studies to validate the device for use in following the progress of a TBI casualty will also be performed. The ability to perform predictive assessments regarding patient outcome will be addressed. The device will be developed to Military Specifications for potential use in field environments. It is anticipated that a successful device will have utility forward of Role 3 medical facilities in the military and “on the sideline” utility in the civilian sector. If necessary, the device may be combined with other objective assessment devices as determined by military Program Managers. The end result of a successful Phase III will be FDA approval as at minimum a screening/decision support device for the diagnosis of TBI.

REFERENCES:
1. M. Falcone, N. Yadav, C. Poellabauer, P. Flynn, “Using Isolated Vowel Sounds for Classification of Mild Traumatic Brain Injury,” 2013 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), pp 7577 – 7581, May 2013. Accessible at: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6639136&tag=1

2. D. G. Theodoros, B. E. Murdoch, and H. J. Chenery, “Perceptual speech characteristics of dysarthric speakers following severe closed head injury,” Brain Injury, vol. 8, no. 2, pp. 101-124, February-March 1994. Accessible at: http://www.karger.com/Article/Pdf/219951

3. A. Tsanas, M.A. Little, P.E. McSharry, J. Spielman, and L.O. Ramig, “Novel Speech Signal Processing Algorithms for High-Accuracy Classification of Parkinson’s Disease,” IEEE Transactions on Biomedical Engineering, vol. 59, no. 5, pp. 1264–1271, 2012. Accessible at: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=06126094

4. Food and Drug Administration, “Medical Device Development Tools - Draft Guidance for Industry, Tool Developers, and Food and Drug Administration Staff,” Nov 2013. Accessible at: http://www.fda.gov/medicaldevices/deviceregulationandguidance/guidancedocuments/ucm374427.htm

KEYWORDS: Traumatic Brain Injury; diagnosis; voice pattern assessment; speech assessment

A15-058 TITLE: Multi-Mode Security Domain Software for Medic's EUD

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: The objective of this topic is to develop and demonstrate a multi-mode security partition software module for enabling multi-security domain applications processing and transmission of data from a Combat Medic’s Electron End User Device (EUD).

DESCRIPTION: The Army Nett Warrior End User Device (EUD) is an excellent candidate for documenting combat medic patient encounters at the site of injury or during pre-hospital evacuation and for transmitting those patient records to the next level of care and/or the receiving medical treatment facility (MTF). Current Army standing operating procedures provide for transmission of electronic medical records over the unclassified NIPRNET to the patient’s permanent medical record contained in the Theater Medical Data Store (TDMS) and the OSD Clinical Data Repository (CDR). For first responder and initial medical records which could be generated on the Nett Warrior EUD, the only available data communications path to the receiving MTF may be over a classified SIPRNET connection. This precludes further transmission of those records over the NIPRNET for upload to the TDMS and CDR without first declassifying the records via some type of “Cross Domain Solution”. A more desirable alternative solution would be to equip NETT Warrior EUDs with software which partitions the device into at least different level security domains, neither of which can physically access the other such that the user could generate the required patient encounter documentation in the unclassified partition and transmit over an unclassified network or through an unclassified “tunnel” through a classified (SIPRNET) network connection, thereby maintaining the unclassified status of the patient encounter record. Likewise the user could generate “actionable” time-sensitive medical situational awareness, telemonitoring, telementoring, and medical intelligence information in the classified partition of the NETT Warrior EUD and transmit that information directly over a SIPRNET network connection.

The proposed multi-security domain partitioning software would be required to run on the NETT Warrior system and would be required to meet or otherwise satisfy National Security Agency standards for maintaining physical separation between classified and unclassified processing domains. The most desirable solution will require little or no additional hardware to be attached or integrated with the Nett Warrior EUD. If additional hardware is proposed, the solution should not require modification of the Nett Warrior EUD device beyond inserting a hardware chip or embedding required additional hardware into a protective sleeve for the Nett Warrior device which could be reproduced on at 3D printer.

PHASE I: Design a prototype multi-mode security partition software module for enabling multi-security domain applications processing and transmission of data from a NETT Warrior EUD that will be able to meet or otherwise satisfy National Security Agency standards for maintaining physical separation between classified and unclassified processing domains and otherwise meets the design criteria described above. Flesh out the transition and commercialization plan contained in the Phase I proposal.

PHASE II: Develop and demonstrate a prototype multi-mode security partition software module for enabling multi-security domain applications processing and transmission of data from a NETT Warrior EUD that will be able to meet or otherwise satisfy National Security Agency standards for maintaining physical separation between classified and unclassified processing domains and otherwise meets the design criteria described above. Secure transition and commercialization agreements and prepare to implement the transition and commercialization plan contained in the Phase II proposal.

PHASE III: Complete advanced development and transition of the prototype system to military acquisition programs such as the Army MC4, NETT Warrior, or Transport Telemedicine Systems. Execute commercialization plans to enable full production and sustainment of the system.

REFERENCES:

1. Secure Mobility: http://www.spaghetti-western.com/

2. "Smartphones on the battlefield", John McHale Editorial Director, Military Embedded Systems News, http://mil-embedded.com/articles/smartphones-the-battlefield/

3. "Split Tunneling" Wikipedia, http://en.wikipedia.org/wiki/Split_tunneling

4. Remote Access VPN and a Twist on the Dangers of Split Tunneling, by Thomas Shinder in "ISA Server.org", http://www.isaserver.org/tutorials/2004fixipsectunnel.html

5. An architecture for flexible multi-security domain networks. Conference manuscript. Lieutenant Colonel Tim Gibson. https://www.isoc.org/isoc/conferences/ndss/01/papers/gibson.pdf

6. Solving the cross-domain conundrum. Colonel Bernard F. Koelsch. 2013 manuscript, U.S. Army War College. http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=3&cad=rja&uact=8&ved=0CCsQFjAC&url=http%3A%2F%2Fhandle.dtic.mil%2F100.2%2FADA589325&ei=YegZVL2yPIq1ggSf54JA&usg=AFQjCNHZKoJETTEgeAuBnMo_Dni8zSUrEQ

KEYWORDS: telemedicine, cellular systems, mobile devices, Nett Warrior, cross domain solution

A15-059 TITLE: Cryopreservation for Regenerative Medical Applications

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: A capability is sought to develop cryopreservation methods that can place organs and vascularized composite tissues into metabolic stasis for at least 24 hours with full functional recovery post-cryopreservation. The ability to cryopreserve complex biological tissues in this manner will enable a wide range of medical interventions to treat trauma and disease.

DESCRIPTION: The preservation of organs and vascularized composite tissues after donor harvest is a central problem in transplant and reconstructive medicine. The feasibility of many transplant procedures is limited not by the availability of donor tissue but by the transportation time required to deliver donor tissue to the recipient [1].

There is also vast and growing shortage of organs leading to premature death for millions. Costs to society are immense and there is further suffering, death and cost due to needed immune suppression and non-ideal organ matching. Cryopreservation of tissues and organs can help solve each of these problems. It would also enable doctors to protect the ovaries of young women who become wounded or have curable cancer and enable more digit, hand, face and potentially even limb transplants for maimed soldiers, firefighters and civilians. Moreover, organ banking will be a valuable complement to and facilitator of tissue engineering, and tissue engineering will likewise increase the demand for organ and tissue banking. [2]

The development of methods to extend the viability of tissues beyond several hours post-harvest would transform the practice of transplantation and reconstructive medicine by making donor tissue available to many more recipients than is currently possible.

No methods presently exist to preserve the biological viability of most solid organs or vascularized composite tissues beyond 6-12 hours. Current practice relies on above freezing-point cooling which can only be used for very short durations. In contrast, cryopreservation has been used to successfully preserve individual cells, colonies of cells, and early human embryos for periods exceeding several years [3]. More recently, blood vessels, cartilage, corneas, and some small animal organs and limbs have been cryopreserved with some success, showing that cryopreservation is possible for tissues as well as cells [4],[5]. This solicitation calls for the development of cryopreservation methods that can be applied to volumetrically large complex biological tissues. At the same time, advances in above-zero preservation that may facilitate the use of cryopreservation by providing more time for cryoprotectant introduction and washout or even by preserving tissues or severed extremities long enough permit longer evacuation times to advanced medical facilities are also solicited.

A key physical parameter that impacts the outcome of cryopreservation is the nature of aqueous phase transition in and around cells from liquid water to either an amorphous glass state or ice [6], [7]. The formation of ice in cells can be lethal and is problematic during both the cooling and warming phases of cryopreservation. Previous studies have found that ice formation in hepatocytes can be lethal at levels as low as 2-4% of the total water in the cell [8]. The extent of ice formation depends on various factors such as the cooling and warming rates, solute concentrations, and the path of phase transition to either an ice or amorphous glass state. Two common methods to manage or avoid ice formation are slow equilibrium freezing and vitrification. Slow equilibrium freezing relies on the equilibration of water activity across the cell membrane during extracellular ice formation, thus limiting intracellular ice. In contrast, vitrification relies on ultra-rapid cooling or high intracellular concentrations of vitrifying agents (such as DMSO) to trap water in an amorphous glass state that prevents ice formation. Neither of these methods as currently practiced has shown robust success with volumetrically large complex biological tissues.

Water can be super-cooled to the ice nucleation temperature of 235 Kelvin (K) and can be vitrified by very rapid cooling below the water glass transition temperature of 136 K when cooled at rates exceeding 105 K/s [9]. However, this rate of cooling has not yet been demonstrated for aqueous systems wider than a few microns. Two significant barriers to rapid volumetric cooling are the low thermal conductivity of biological tissues (k~0.5 W/m-K) and the emergence of the Leidenfrost effect in coolants. For example, a 0.3 m3 cubic volume of tissue at 273 K that is hyperquenched in liquid nitrogen at 77 K would exhibit a very high Biot number (~60) and therefore experience significant volumetric temperature gradients leading to relatively slow cooling in much of the volume. This leads to significant ice formation.

Cooling rates necessary to achieve vitrification can be reduced greatly by adding cryoprotectants. By using a mixture of several cryoprotectants to minimize toxicity, the first paper demonstrating successful vitrification of nucleated cells used a cooling rate of only 20 K/s [10]. More recent work has shown that ~10 gram rabbit kidneys can be loaded and then unloaded with vitrification solution by vascular perfusion with subsequent long-term survival [11]. The treatment reproducibly protected the kidneys from temperatures of 45°C, but permitted survival of actual vitrification at -130°C in only one published instance [12]. Obtaining uniform distribution of the vitrification solution to all parts of the organ was a significant problem.

Another challenge occurs during re-warming from a vitrified state. Ice nucleation within a vitrified aqueous phase can occur as the temperature rises above 150 K. This can lead to large intracellular ice crystal formation. Several studies suggest that the outcome of cryopreservation is as dependent on ice formation during warming as it is during cooling [8],[13],[14]. Critical warming rates required for ice-free warming of vitrified aqueous solutions depend on the concentration of added cryoprotectants, but are always greater than the critical cooling rate necessary to initially achieve vitrification. Encouragingly, the most advanced cryoprotectant solutions for vitrification now have critical warming rates under 5 K/min [11]. Unlike cooling, warming can also be accelerated by application of penetrating radiofrequency or microwave energy [15].

Achieving an amorphous glass state in a large-volume complex biological tissue remains a challenge at the edge of current technology. Methods to accomplish such vitrification may rely on a combination of techniques that include, but are not limited to, externally applied electromagnetic fields, acoustic, optical, or mechanical inputs to increase or decrease energy content, or to monitor phase states [16], [17]. The use of one or more vitrifying agents will likely be necessary to permit the formation of a glassy state under the thermal transport constraints mentioned previously. Accessory cryoprotectants that mitigate other effects such as oxidative damage or osmotic shock may also be required (e.g. glycerol, hydrogen sulfide, nitric oxide, or trehalose). It is also known that the cold storage solution used to carry the cryoprotectant into and out of the organ or tissue can have a powerful effect on the apparent toxicity of the cryoprotectant, so optimization of the “carrier” solution may be important in some cases as well.

PHASE I: The performer will demonstrate the ability to spatiotemporally control the phase transition of a minimum forty cubic centimeter (40 cm3) volume of solution, of maximum linear dimension 12 cm, containing ten micrograms of linearized DNA (minimum length of 10,000 base pairs) such that the entire volume can be forced to transition from a liquid to an amorphous glass state and back to a liquid never containing more than 1% ice. Phase transition control using externally applied EM fields or other energetic inputs that can deeply penetrate large physiological systems is both permitted and encouraged. The solution used must be compatible with survival of living cells exposed to it, preferably documented by previous study. The performer will demonstrate the ability to control the segregation of solutes that might impose gradients (osmotic or pH) detrimental to the recovery of biological function post-cryopreservation. Quantification of DNA shearing is required. Verification of less than 1% ice content by calorimetry, imaging, or other means is required. Modeling and simulation of system performance to support follow-on in vitro or in vivo study design(s) is highly encouraged. Actual demonstration of the approach using cells or tissues is not required for Phase I, but approaches that go directly to cell and tissue constructs are welcome and can be conducted in lieu of working on the volume solution & linearized DNA test. Exploration of the possibility of stable storage at temperatures close to but above the glass transition temperature is also within the scope of studies of potential interest.

PHASE II: The performer will demonstrate the utility of the approach from Phase I in a biological setting using intact vascularized tissue of minimum 4 g mass. 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-cryopreservation. The model selected should clearly demonstrate the ability to place the biological test item under cryopreservation for 24 hours or, ideally, significantly longer and to return the test item to a fully functional biological state post-cryopreservation. Measures of functionality should be appropriate to the model selected. Deliverables will include a detailed technical profile of the approach that fully describes the methods, results, and a proposed commercialization path.

PHASE III: Cryopreservation of complex biological tissues is an open problem with a large potential market and with direct applicability across the full spectrum of medical treatment, diagnostics, and long-term unattended biologically based sensor platforms. 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 cryopreservation solutions, 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 cryopreservation of successively larger tissues and organs. This award mechanism will bridge the gap between laboratory-scale innovation and entry into a recognized FDA regulatory pathway leading to commercialization.

REFERENCES:

[1] C. Simpkins, “Cold ischemia time and allograft outcomes in live donor renal transplantation: is live donor organ transport feasible?” American Journal of Transplantation, vol. 7, no. 1, pp. 99–107, Jan. 2007.

[2] Giwa S., Tocchio A., Woods. E. Catalyzing Cryopreservation Breakthroughs to Save Millions of Lives. Abstr. World Forum Biol. Cryo 2014 Conf. June 1, 2014 (2014).

[3] J. Mandelbaum, J. Belaïsch-Allart, a M. Junca, J. M. Antoine, M. Plachot, S. Alvarez, M. O. Alnot, and J. Salat-Baroux, “Cryopreservation in human assisted reproduction is now routine for embryos but remains a research procedure for oocytes.,” Human reproduction (Oxford, England), vol. 13 Suppl 3, pp. 161–74;discussion175–7, Jun. 1998.

[4] B. Wowk, “Thermodynamic aspects of vitrification,” Cryobiology, vol. 60, no. 1, pp. 11-22, Feb. 2010.

[5] Z. Wang, B. He, Y. Duan, Y. Shen, L. Zhu, X. Zhu, Z. Zhu, “Cryopreservation and replantation of amputated rat hind limbs,” European Journal of Medical Research, 19:28, May 2014, doi:10.1186/2047-783X-19-28.

[6] P. Debenedetti, “Supercooled and glassy water,” Journal of Physics: Condensed Matter, vol. 1669, 2003.

[7] O. Mishima and H. Stanley, “The relationship between liquid, supercooled and glassy water,” Nature, 1998.

[8] S. Seki and P. Mazur, “Ultra-rapid warming yields high survival of mouse oocytes cooled to -196°c in dilutions of a standard vitrification solution.,” PloS one, vol. 7, no. 4, p. e36058, Jan. 2012.

[9] G. P. Johari, A. Hallbrucker, E. Mayer, "The glass-liquid transition of hyperquenched water," Nature, vol. 330, no. 6148, pp. 552-553, Dec. 1981.

[10] W.F. Rall, G.M. Fahy, Ice-free cryopreservation of mouse embryos at 196 degrees C by vitrification, Nature, vol. 313, no, 6003, pp, 573–575, Feb. 1985.

[11] G.M. Fahy, B. Wowk, J. Wu, J. Phan, C. Rasch, A. Chang, E. Zendejas, Cryopreservation of organs by vitrification: perspectives and recent advances, Cryobiology, vol, 48, no. 2, pp. 157–178, Apr. 2004.

[12] G.M. Fahy, B. Wowk, R. Pagotan, J. Phan, B. Thomson, L. Phan, Physical and biological aspects of renal vitrification, Organogenesis, vol. 5, no. 3, pp. 167-175, Jul. 2009.

[13] S. Seki and P. Mazur, “The dominance of warming rate over cooling rate in the survival of mouse oocytes subjected to a vitrification procedure.,” Cryobiology, vol. 59, no. 1, pp. 75–82, Aug. 2009.

[14] J. B. Hopkins, R. Badeau, M. Warkentin, and R. E. Thorne, “Effect of common cryoprotectants on critical warming rates and ice formation in aqueous solutions.,” Cryobiology, vol. 65, no. 3, pp. 169–78, Dec. 2012.

[15] M. Wusteman, M. Robinson, D. Pegg, Vitrification of large tissues with dielectric warming: biological problems and some approaches to their solution, Cryobiology, vol. 48. No. 2, pp. 179-189, Apr. 2004.

[16] C. X. Wei Sun, Xiaobin Xu, Hong Zhang, W. Sun, “The Mechanism Analysis of NaCI Solution Ice Formation Suppressed by Electric Field,” 8th IEEE International Conference on Properties and Applications of Dielectric Materials, pp. 770–773, 2006.

[17] T.H. Jackson, A. Ungan, J.K. Critser, D. Gao, Novel microwave technology for cryopreservation of biomaterials by suppression of apparent ice formation, Cryobiology, vol. 34. no. 4, pp. 363-372, Jun. 1997.

[18] Alvarez, Lt. Col. Luis M., Compendium of Organ & Tissue Banking Concepts (2015), 26 pages, uploaded in SITIS 1/15/2015.

KEYWORDS: Cryopreservation, extension of biological function, stasis, organ transplant preservation, tissue engineering, regenerative medicine, vitrification

A15-060 TITLE: Wearable Dosimeter for Personal Real-Time Assessment of Exposures to Occupational Chemicals

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Office of the Principal Assistant for Acquisition

OBJECTIVE: Demonstrate a validated, miniaturized, low power dosimeter system that measures, processes, stores, and communicates individual exposure concentrations to standard smart phone platforms and to integrated personal exposure record networks.

DESCRIPTION: To protect human health, occupational exposure monitoring has relied on demonstrating that exposures do not exceed published limits, e.g., those in the National Institute of Occupational Safety and Health, NIOSH Pocket Guide to Chemical Hazards (NIOSH 2007) and Chemical Exposure Guidelines for Deployed Military Personnel (USACHPPM Technical Guide 230). Although time-weighted average (TWA) concentration limits such as Occupational Safety and Health's (OSHA) enforceable Short- Term Exposure Levels (STELs) and Permissible Exposure Levels (PELs), and NIOSH's non-enforceable Recommended Exposure Levels (RELs) are well established, their effectiveness in protecting human health is difficult to demonstrate. Conventional workplace monitoring relies on historic best-available-technology designs that return concentrations averaged over defined time periods as required for demonstrating compliance with these TWA exposure limits. The compliance measurements often require complex sampling techniques with subsequent laboratory analyses to determine exposure concentrations. This is a time consuming process that delays communication of exposure risk data back to the military leadership, environmental safety officer, and/or medical provider.

Historic best-available-technology designs still form the basis of current exposure assessment practices that extrapolate TWA data to define individual health risks. However, monitoring is a poor substitute for individual dosimetry and the practice introduces a large amount of uncertainty into the exposure assessment process. Furthermore, traditional TWA methods provide little insight into exposure levels in real-world settings where exposures may be localized, intermittent, or transient, as well as where environmental conditions interfere with the use of traditional methods. This uncertainty leads to misclassifications that directly impact our ability to distinguish exposed individuals who may require medical follow-up from those who do not. While workplace direct-read instruments that provide real-time air monitoring and data logging abilities are currently available, these instruments are not chemical-specific. They all lack the sensitivity and/or specificity required to demonstrate regulatory compliance.

Emerging sensor technologies provide an opportunity to address the limitations of traditional TWA methods and respond to the requirements outlined by the Joint Health Risk Management Initial Capabilities Document (JFHM ICD, 2013) and the DoD-VA Individual Longitudinal Exposure Record ($19M pilot now underway) mandates.

Technology gaps: Few valid methods exist for real-time assessment of specific chemical exposures (MOM ICD 2008; JFHP ICD, 2010; JFHM ICD, 2013). As a result, force health protection and health risk management are less than optimal. Emerging technologies provide opportunities to address this capability gap. These technologies are capable of measuring individual exposure to specific organic chemicals, from both real-time and historical perspectives. Real-time alerts of excessive exposure can improve the immediate safety and operational effectiveness of military personnel, while records of individual time-history can be used to identify and manage individuals with high TWA exposures.

Emerging sensor technologies are increasingly being applied to address the gaps identified herein. A leading edge example is the use of miniature ultraviolet (UV) light sources and photodetectors to measure chemical-specific fluorescence (Hug et al. 2012; Hulla et al. 2010). These miniature, relatively low-cost, off-the-shelf technologies appear to be capable of delivering favorable signal-to-noises ratio and real-time laboratory-quality data. Progress has been made in applying this technology to the development of a near real-time naphthalene dosimeter (Hug et al. 2012). Preliminary data suggest the UV chemical-specific fluorescence method can also be used to detect other polycyclic aromatic compounds (PACs) including fluorene, phenanthrene, 1- and 2- methylnaphthalenes and other chemicals present in petroleum-related products.

Methods inclusive of real-time measurement of volatile organic chemicals (VOCs), such as benzene, toluene, xylenes, formaldehyde, perchlorethylene etc., and other chemicals of interest are needed. For example, targeted PACs and VOCs chemicals are found in petroleum-based mixtures (NRC 2003), such as fossil fuels (jet fuels and diesel), coal tar volatiles, asphalt fumes, engine exhaust, combustion byproducts, and are present in organic solvents, paints, resins, or as stand-alone solvents. In combat deployment and operational scenarios, these compounds as well as many other toxic industrial chemicals (TICs) can be found at varying levels in smoke from burning trash/wastes (burn pits), oil fires, tent heaters, truck, aircraft, and vehicle exhaust, jet fuels, gasoline, diesel fuel, cleaning solvents, and sites of industrial pollution.

Desired capability: The Army and DoD are interested in the development and maturation of integrated next-generation, miniaturized, open-architected wearable dosimetry solutions to assess individual organic chemical exposure risks. Wearable dosimeters that enable Soldiers and their leaders to detect, measure, store and transfer data relevant to a Soldier's exposure and absorbed dose to a multitude of TICs are needed.

The project deliverable is a Technology Readiness Level 6 validated system demonstration in a relevant environment. Demonstration is to include, for no less than three specific chemicals, (a) processing and storage of data generated from personal air sampling (required), (b) sensitivity sufficient to meet health-based exposure limits, (c) sufficient reliability in sensitivity and selectivity to meet the current NIOSH standards for direct-read instruments, and (d) documentation of ultra-low power requirements.

The system shall be designed to be intrinsically safe, with an open architecture that allows for the wired or wireless communication of data from the dosimetry sensors to other systems, such as the emerging Integrated Soldier Sensor System (ISSS). The use of open system architectures must enable the dosimeter device to be connected to pre-existing government wireless or hardwired networks using message formats and protocols as defined by ISSS or similar, sponsor-identified open systems.

The dosimeter device software (firmware) shall be modular in nature and crafted in such a way that allows easy changes to modules and the addition of new modules, and enables the integration of new third party algorithms as dosimetry models are developed or as mission needs change. Size, weight and power criteria requirements include the capability to sense, process, store (required), and communicate (desired) exposure data to a standard smartphone or handheld computer (required) with minimized size, weight, power requirements, cost, and minimal use of proprietary technology that restricts the use of third party sensors and algorithms. A device with ultra-low power demand is highly desirable (total average dosimeter power < 30mW (required) or <750µW (desired)). Specific chemical compounds of priority interest (inclusive of PAHs and VOCs) are those found in petroleum-based products such as fuel mixtures or standalone solvents.

PHASE I: Develop a practical plan for achieving (a) the desired hardware, firmware, network communication, miniaturization and data display capabilities of the envisioned real-time dosimeter described above, and (b) establish a plan for the system test, evaluation, and validation. No research or testing involving animal or human subjects is required.

PHASE II: Using the Phase I plans, build a real-time dosimeter capability. Through design iterations and subsequent validation, produce a real-time, wearable miniaturized integrated instrument capable of sensing, processing, and computing personal air exposures to the targeted chemicals. The instrument is to be capable of communicating chemical concentration data to integrated personal exposure record networks. It is desirable that it be capable of transmitting the data to standard smart phone platforms.

This instrument is intended for general use by Soldiers as a real-time safety alert system that informs the squad and leadership when specified types of exposure thresholds are approached. The dosimeter should have two levels of alerts (desired)-one which issues a signal when a high level of exposure over a short-time period (i.e., 15-minute STEL) is approached and a second which issues a signal when lower level but longer term exposure concentrations (i.e., 8-hour TWA PEL) exist.

Subsequent field testing involving human subjects will demonstrate that the device is reliably and accurately measuring exposure of interest. The contractor's (indirect) cooperation with investigators conducting the field validation research involving human subjects is required. These field validation efforts will be conducted to transition the sensor to a dosimeter by documenting significant correlations between measured exposure (using the instrument) and established biological markers of exposure (such as urinary metabolite biomarkers). Contractor delivery of ten intrinsically safe instruments for these field investigations is a requirement.

PHASE III: The end-state of this work effort is an ultra-low power dosimeter instrument capable of reliably collecting, logging, processing and communicating valid real-time exposure- and dose- rate information. Similar to modern real-time radiation dosimeters which translate ionizing radiation, a physical entity, into an electrical charge using a variety of technologies, the goal of the effort is development and validation of real-time chemical dosimeter. Validation efforts will assess the prototype's capacity to accurately measure exposure-rate, and calculate a corresponding human dose-rate. In this context, the deliverable will include a defined "dose-rate" capability in addition to the measurement of environmental exposure levels commonly produced with sensor and passive sampler technologies. The deliverable will also provide real-time dose- as well as exposure- rate data, neither of which is possible with sensor and passive sampler technologies. Therefore, the deliverable will determine the TWA exposure levels (for comparison to current regulatory standards) as well as enable calculation of an individual, real-time dose over time. Intended transition partners include U. S. Army Medical Materiel Development Activity, PEO-Soldier, U.S. Marine Corps, and Special Forces Program or Project Managers, and others in the Joint Military Services, to meet their requirements for use with dismounted forces' requiring situational awareness at the individual or small group-level. Additional users would be the industrial hygiene communities within DoD, and other Federal Government agencies (i.e., OSHA, CDC/NIOSH) and other civilian commercial entities, such as the commercial transportation industry.

REFERENCES:

1. NIOSH Pocket Guide to Chemical Hazards", DHHS (NIOSH) Publication No. 2005-149, 3rd edition, Sept. 2007.

2. USACHPPM Chemical Exposure Guidelines for Deployed Military Personnel (USACHPPM Technical Guide 230).

3. Department of Defense. "Initial Capabilities Document for Joint Health Risk Management". (JFHM ICD); 22 May 2013.

4. US Army Medical Research and Materiel Command. "Initial Capabilities Document for Military Operational Medicine". (MOM ICD); February 2008.

5. Department of Defense. "Initial Capabilities Document for Joint Force Health Protection". (JFHP ICD); 24 February 2010.

6. Hug, W. F., Bhartia, R., Reid, R. D., Reid, M. R., Oswal, P., Lane, A. L., Sijapati, K., Sullivan, K., Hulla, J. E., Snawder, J. and Proctor, S. P., "Wearable real-time direct reading naphthalene and VOC personal exposure monitor", Proc. SPIE 8366, Advanced Environmental, Chemical, and Biological Sensing Technologies IX, 836606, May 1, 2012; doi:10.1117/12.918945

7. Hulla, J.E., Snawder, J.E., Proctor, S.P. and Chapman, G.D., "DOD Impact Assessment and Management of Naphthalene-Related Risks", Toxicological Sciences (supplement), Volume 114, no.1, page 400, March 2010. The poster is available at: http://www.denix.osd.mil/cmrmd/upload/Naphthalene-Dosimeter-Poster-presented-at-the-2010-Society-of-Toxicology-Meeting.pdf

8. National Research Council. "Toxicologic Assessment of Jet-Propulsion Fuel 8", 2003, http://www.nap.edu/openbook.php?isbn=0309087155, Page 17

9. ACGIH, 2014 Adoptions, Naphthalene, http://www.acgih.org/resources/press/TLV2014list.htm

KEYWORDS: exposure assessment, volatile organic compounds, petroleum fuels, dosimetry

A15-061 TITLE: Topical Therapeutic for Ocular Trauma

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a topical therapeutic with anti-inflammatory and regenerative properties to promote regeneration of damaged corneal epithelial cells following various types of ocular trauma, including abrasions, burns, and punctures of the cornea.

DESCRIPTION: Explosive or incendiary devices can cause significant trauma to the eye, which can range in severity from mild to moderate abrasions, burns, and penetrating injuries, to more severe events such as ruptured globes and orbital fractures1. Currently available protocols for ocular trauma include irrigating the eye if possible, shielding the injured eye from further damage with gauze or an eye patch (but without applying pressure), and treating it with antibiotic or moisturizing drops2, 3, 4. While this may be effective in protecting the eye from further damage, it does not facilitate the healing process. Amniotic membranes have been demonstrated effective in reducing inflammation and restoring epithelial defects5, but they must be surgically transplanted in an operating room setting.

This topic seeks the development of a topical therapeutic with regenerative properties that can be administered for treatment of mild to moderate ocular wounds of the corneal epithelium (e.g., abrasions, burns, penetrating injuries), and which can easily be applied by individuals with limited medical training. The topical therapeutic will deliver small molecules, antibodies, proteins, and/or other agents that reduce inflammation and infection, and promote re-epithelialization of damaged corneal tissue. The active components should adhere to or permeate through the ocular surface for sustained activity. Ideally the topical therapeutic will be stable under a wide range of field conditions, and have an extended shelf life.

PHASE I: Phase I work will conceptualize the strategy, design the topical therapeutic(s), and test the feasibility in at least one in vitro model (e.g., corneal abrasions, burns, penetrating injuries) of corneal trauma. Appropriate markers and in vitro assays should be justified. Data obtained in Phase I will provide proof-of-concept that the active ingredient(s) will reduce inflammation and stimulate regeneration of the corneal epithelium. Appropriate controls will be used. Clinical experts with insight into ocular trauma and relevant patient populations should be consulted during design and optimization of the topical therapeutic.

PHASE II: Based on Phase I results, Phase II work will test, optimize, and validate the anti-inflammatory and regenerative potential of the topical therapeutic in at least one animal model of corneal trauma (e.g., abrasions, burns, penetrating injuries). The FDA approval pathway should be outlined and considered at each developmental stage. Parameters including optimal concentrations, biological activity, toxicity, adherence to and/or permeability through the ocular surface, stability across a wide range of field conditions, and extended shelf life will be defined. Validation of efficacy will be determined through histological examination, slit lamp photography, and/or other appropriate measures. Clinical experts with insight into ocular trauma and relevant patient populations should be consulted during optimization and animal validation. Potential commercial and clinical partners for Phase III and beyond should be identified, and a detailed explanation should be provided for how the small business will obtain a monetary return on investment within two years of completion of Phase II (e.g., sales, licensing agreements, venture capital, non-SBIR grants.)

PHASE III: If successful, Phase II work will result in a novel topical therapeutic with anti-inflammatory and regenerative properties for corneal trauma (e.g., abrasions, burns, penetrating injuries). During Phase III, additional experiments will be performed as necessary to prepare for FDA review of an IND application. A plan for protection of intellectual property should be created and executed. A detailed market analysis will be conducted, an initial application for the therapeutic will be selected, and a Phase I clinical trial will be initiated. Military application: The new topical therapeutic will be available as a treatment to military personnel who suffer from corneal trauma as a result of blasts or other battlefield or service-related injuries. This therapeutic will mitigate vision loss and/or improve recovery of vision functions, and thereby improve quality of life. Commercial application: Health professionals worldwide could utilize this therapeutic as a treatment for corneal trauma as a means of mitigating vision loss and improving recovery of vision functions.

REFERENCES:
(1) Weichel ED, Coyler MH. Combat ocular trauma and systemic injury. Curr Opin Ophthalmol 2008; 19(6):519-25.

(2) Williams PB, Crouch ER Jr., Crouch ER, Mazaheri M. Topical aminocaproic acid facilitates reepithelialization of persistent epithelial defects. Curr Eye Res 1999; 18(2):150-7.

(3) Fish R and Davidson RS. Management of ocular thermal and chemical injuries, including amniotic membrane therapy. Curr Opin Ophthal 2010; 21:317-321.

(4) Cho RI, and Savitsky E. UCLA Center for International Medicine. Chapter 7, Ocular Trauma, 303-342. (http://www.cs.amedd.army.mil/borden/book/ccc/UCLAchp7.pdf)

(5) Meller D, Pauklin M, Thomasen H, Westekemper H, and Steuhl KP. Amniotic Membrane Transplantation in the Human Eye. Dtsch Arztebl Int 2011; 108(14):243-248.

KEYWORDS: ocular trauma, cornea, corneal epithelium, abrasion, burn, penetrating injury, inflammation, infection

A15-062 TITLE: Lightweight Radiation Shielding for Transportable Rigid Wall Shelters

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Investigate and develop emerging technologies for application as lightweight integrated radiation shielding as structural elements in US Army Deployable Medical System (DEPMEDS) facility for use in Army Standard Family (ASF) Expandable ISO Shelter housing CT Scanner equipment. The US Army Medical Department (AMEDD) has several objectives in modernizing the Combat Support Hospital infrastructure. One of these key objectives is to provide radiation protection capability in field hospitals.

DESCRIPTION: Currently, the US Army Deployable Medical System (DEPMEDS) facility uses an Army Standard Family (ASF) One-Side Expandable ISO Shelter to house its diagnostic Computed Tomography X-Ray Scanner (aka. CT Scanner). The DEPMEDS facility is part of the US Army Combat Support Hospital (CSH, pronounced "cash") field hospital. The unshielded electro-magnetic scattered radiation emitted from CT scanners necessitates the shelter be located some distance away from the main body of a Combat Support Hospital (CSH) which consists of a combination of shelters providing surgical and intensive care services to the injured until evacuation is possible. The objective for Army DEPMEDS is to provide structurally integrated radiation shielding technologies to DEPMED's CT Scanner Shelters which would allow moving the CT scanner into the main body of the CSH, enable a much better workflow, and improve the medical care of the wounded. In order to accomplish this objective, the shelter walls have to be shielded from within to eliminate the time of transitioning the exposed patient from the CT scanner to the Surgical Suite and do so without increasing the weight of the system beyond the 15,000 lb threshold. The shelter is constructed using interior and exterior aluminum skins sandwiching a Nomex or WRII paper honeycomb core (See Phase 1 Table 1 for skin and core thicknesses). Current methodology to protect individuals walking near the shelter is a strip of warning tape placed around the shelter to warn them of the radiation hazard. To achieve the objective, only the sides of the shelter must be shielded since radiation through the roof or floor will not affect individuals working in adjacent spaces. This effort will provide operating room, radiology, and laboratory of the hospital with the radiation protection capabilities.

As a new generation of shelters is being developed using fiber reinforced plastic skins, a new core material and composite matrix that protect against X-ray radiation, which provides at a minimum, the same strength and thermal characteristics and weighing no more than the Alumium/Nomex or WRII paper honeycomb core sandwich panel, needs to be developed for incorporation into the walls of the ASF ISO Shelter. Several promising technologies and materials are emerging which when combined could provide the necessary shielding and weight characteristics needed to provide integrated shielding of the CT Scanner shelter and thus properly integrate it into the Medical Suite.

The SBIR would allow funding to research new materials and technologies and evaluate their suitability towards satisfying the objective of fully integrating the Medical Facilities Suite. We are seeking innovative solutions and approaches that address the challenge of accomplishing radiation protection with the least mass and volume, while maintaining current physical characteristics and integrity of the of the ISO shelter walls. Key Metrics: the goal of this effort is provide x-ray protection of zero milliroentgen (mR) measured at a distance of 12 inches or less from the entire outside walls of the ISO shelter. Notes: X-ray machines setting varies and could be up to 150 kilovolts peak (kVp) at 1000 milliampere-second (mAs) with a typical (average) setting of 140KVp at 300 mAs. X-ray radiation in the case of the CT machine is measured in terms traditionally used in radiation dosage units. For example, the CT scanner in question, during tests, is run at a capacity of 140kVp at 300 milliamp Seconds per slice. That results in an incidental radiation dose measured in certain wave propagation locations up to 28.19 micrograys. It is desired that there be no significant increase in material costs and that the cost increase be less than 10 percent.

PHASE I: The intention of Phase I of the program is to investigate materials and concepts that will provide radiation protection while not degrading other shelter properties. A trade off of evaluation factors will be required to further develop the ideal protective barrier material. A direct comparison of characteristics with a focus on radiation protection level will be used to choose the most qualified technical approach. The goal is to develop thin and lightweight barrier materials that meet the requirements stated in the Army Radiation Safety Pamphlet 385–24, and RADIATION PROTECTION SURVEY NO. 26-MF-OBTM-09 (see References Section).

The SBIR shall also:

- Develop new or innovative approach that offers potential solution and address topic goals
- Determine technical feasibility of proposed approaches and demonstrate the capability in meeting the objective.
- Investigate processes
- Develop an initial concept design and model key elements
- Produce a conceptual design and breadboard
- Develop detailed analysis of predicted performance
- Define and develop key component technological milestones
- Perform modeling and simulation

Required Phase I deliverables shall include: Phase I Study report, modeling/analyses, breadboard, clear design concept and recommended approach and breadboard sections of shelter walls for testing.

Table 1, ASF ISO Shelter Wall and Door Construction, will be provided after pre-release.

PHASE II: The focus of Phase II will be to develop, demonstrate, fabricate, integrate, test and validate the radiation protective properties of the material on full scale rigid shelters. Development of the radiation protective barrier based on the predictive analysis and the small sample testing performed in Phase I will be accomplished early in Phase II. Once the optimized barrier materials are developed, full scale sections will be fabricated, integrated into a rigid wall shelter. Testing will be conducted on the full scale shelters and a direct comparison to a standard, fielded system will be accomplished. Additional evaluations will also be conducted to look at ease of use, added weight, and special tools. Cost and radiation protection predictions will also be further refined. Finally, US Army Medical and Material Development Agency (USAMMDA) will be asked to challenge the protective material with CT radiation to measure the actual level of protection provided by the candidate materials. Successful candidates will provide the best balance of radiation protection and cost without degrading the shelter physical properties. Required Phase II deliverables shall include: Test Report, prototype sections of shelter walls for further testing, and initial Phase II plan and Final report.

PHASE III: The focus of Phase I and II of this program is on DoD specific shelters utilized in Combat Surgical Hospitals such as the Deployable Medical System (DEPMEDS). Once developed, the radiation protective material will be integrated in rigid wall shelters during depot production, maintenance and/or, if possible, as field applications. Also, there are a number of fixed and mobile hospital applications outside of the Department of Defense that would benefit from this research. If successful in demonstrating Technology Readiness Level (TRL) of 6, this technology would transition to Project Manager Medical Support Systems (PM-MSS) for development and fielding. The initial use for this technology will be Combat Surgical Hospitals such as the Deployable Medical System (DEPMEDS). The commercial sector would likely benefit from this technology. The medical sector may use this lightweight radiation protective material in hospital setting, clinics and mobile clinics to protect both medical personnel and patients. Also, the aerospace and submarines industries may find this lightweight radiation proactive material useful in protecting occupants.

REFERENCES:

1. Army Radiation Safety Pamphlet 385–24, Rapid Action Revision (RAR) Issue Date: 22 September 2011. http://armypubs.army.mil/epubs/pdf/p385_24.pdf

2. Joint Committee On Tactical Shelters (JOCOTAS) Brochure http://nsrdec.natick.army.mil/media/print/JOCOTAS.pdf

3. Expeditionary Basing & Collective Protection (EB&CP) Fact Sheet.
http://nsrdec.natick.army.mil/media/fact/index.htm

4. Table 1, ASF ISO Shelter Wall and Door Construction, uploaded in SITIS 12/12/14.

5. Radiation Scatter and Attenuation Measurements, 1 page, 24 June 2009 (uploaded in SITIS 1/16/2015).

6. Phillips 16 CT Scatter Pattern, 1 page (uploaded in SITIS 1/16/2015).

7. Stray Radiation Dose Map, Brilliance CT Big Bore Configuration, 1 page (uploaded in SITIS 1/16/2015).

KEYWORDS: Army Family of Standard Shelter, Combat Support Hospital (CSH), Computed Tomography X-Ray Scanner (CT Scanner), Composite material, Deployable Medical Systems (DEPMEDS) facility, ISO Shelter, Joint Committee on Tactical Shelters (JOCOTAS), Radiation protective materials, Radiation shielding material, Rigid Wall Shelter

A15-063 TITLE: Conductive Network for Parachute Fabrics

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate a textile based electronic network for use in Army parachute fabric that will be able to maintain that network across fabric seams and through repeated deployment and recovery events.

DESCRIPTION: Historically, textile based conductive networks have been most successful in knitted clothing where there are limited seams and the fabric is not subjected to a high degree of wear and tear. Developing the technology to integrate a conductive network into clothing made from cut woven materials has proven much more difficult. The purpose of this SBIR solicitation is to develop materials and methods that could be used to integrate an electronic network into a parachute canopy. The challenge described here is greater than with clothing made from cut and sewn woven cloth due to three primary reasons. First, parachute cloth is extremely light weight and thin, typically made from very fine 30 denier nylon continuous multifilament yarns. Second, the network technology has to be durable enough to sustain the high shock loads experienced during parachute opening (including rapid deceleration and in-plane fabric stresses and strains), the high friction of fabric-to-fabric contact during deployment, and the repeated handling and packing of the parachute system during normal usage and maintenance. Last, parachute seams are more complex than traditional seams because they are flat felled seams. This type of seam is formed by folding in and interlapping the edges of two plies of material so that the edges of the material are concealed and seamed with two rows of stitching (see ASTM D6193, seam type LSc-2).

Despite this challenge, military parachutes would benefit by having an integrated electro-textile conductive network embedded into the parachute canopy for enabling data and power transport to sensors and actuators embedded or attached to the parachute canopy. Current and previous research has attempted to include sensor systems into the parachute canopy to measure, for example, the stress and strain in the fabric during deployment or aerodynamic pressure across the fabric. These systems often attempted to use external wires attached to fabric for power or data transmission which are easily susceptible to breakage. Alternatively, these systems have used local power and data recording (or wireless data transmission) which increase the physical size and weight of the sensor system potentially interfering with and alerting the parachute inflation. A conductive network embedded into the fabric would greatly aid in allowing for insertion of sensors and/or actuators into parachute system. Recent advances in shape memory alloy (SMA) based actuators that can actively change the geometric porosity of the canopy would be made possible by power and data transport integrated directly into the canopy itself. The Joint Precision Airdrop System (JPADS) uses GPS and a steerable cargo ram air canopy to guide a parachute to its target. Changes in lift and drag (properties that control performance and steerability) can be produced using these actuators. On-canopy connectivity between sensors and actuators would enhance the accuracy of these guided parachutes.

PHASE I: This phase will focus on establishing the technical feasibility to develop materials and/or methods to integrate a conductive network into PIA-C-44378 Type IV (or similar) parachute fabric for use in parachute applications. The network could be used to transport data and/or power. Several methods to develop the network and interconnects across LSc-2 seams (used in both vertical main seams and horizontal cross seams in round canopies and the cell formation of ram air canopies) should be investigated for their suitability and effectiveness. Test methods shall be developed to evaluate fabric strength, weight, thickness, flexibility and durability within the fabric and across seams with benchmark being a 20% maximum variance the performance of non-networked PIA-C-44378 Type IV material and seams. The networked LSC-2 seams shall retain at least 80% seam efficiency when tested in accordance with ASTM D 1683. The networked fabric shall be electromagnetic interference (EMI) shielded, lightweight, flexible, and durable to parachute manufacture, packing, deployment and recovery procedures. It is anticipated the developed material(s) will have similar performance, durability and service life expectancy characteristics as PIA-C-44378 Type IV fabric with the additional benefit of being able to sustain an electronic network. Ideally, cost would be no more than double that of traditional PIA-C-44378 Type IV materials, however, it is dependent on the type of technology used. Benchtop proof of concept demonstrations of the fabric performance (with connectors) should be performed. The most effective designs, materials, manufacturing processes and test methods will be determined and proposed for Phase II efforts. Phase I deliverables include a final report with functioning material samples to document the research and development supporting the effort along with a detailed description of materials, processes and associated risk for the proposed Phase II effort.

PHASE II: During Phase II, further development of the concepts derived in Phase I should be pursued with the ultimate goal to demonstrate the electronic network on prototype parachutes. The awardee shall develop, demonstrate, and deliver networked fabric and LSc-2 seamed prototype(s) that are in accordance with the objectives identified in Phase I. While scaled model parachutes could be part of the demonstration process, it is preferred that the technology should also be demonstrated on a full-scale parachute deployed from an aircraft in an airdrop environment. Partnership between companies with electro textile knowledge and those with experience manufacturing and developing military parachutes is encouraged. In addition to the delivery of fabric and parachute prototypes, a report shall be delivered documenting the research and development supporting the effort along with a detailed description and specification of the materials, designs performance and manufacturing processes.

PHASE III: Lightweight fabrics having a conductive network have potential commercial application in foreign military; technical clothing foruse in athletics, first responders, law enforcement; shelters; sails; kites; simple toys and novelties.

REFERENCES:
1. Eric Favini; Christopher Niezrecki; Julie Chen; David Willis; Eugene Niemi and Kenneth Desabrais; "Review of smart material technologies for active parachute applications", Proc. SPIE 7643, Active and Passive Smart Structures and Integrated Systems 2010, 76431O (April 12, 2010); doi:10.1117/12.847620; http://dx.doi.org/10.1117/12.847620

2. Eric Favini; Christopher Niezrecki; Sanjeev K. Manohar; David Willis; Julie Chen; Eugene Niemi; Kenneth Desabrais and Christine Charette; "Sensing performance of electrically conductive fabrics and dielectric electro active polymers for parachutes", Proc. SPIE 7981, Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems 2011, 798132 (April 14, 2011); doi:10.1117/12.880450; http://dx.doi.org/10.1117/12.880450

3. Mark Damplo; Christopher Niezrecki; David Willis; Julie Chen; Eugene Niemi; Srikanthrao Agnihotra; Sanjeev K. Manohar; Kenneth Desabrais and Christine Charette; "Sensing of electrically conductive textiles and capacitance sensor-embedded fabrics for parachutes", Proc. SPIE 8345, Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems 2012, 83452T (April 26, 2012); doi:10.1117/12.915342; http://dx.doi.org/10.1117/12.915342

4. E. Favini, S. Agnihotra, S. Surwade, C. Niezrecki, D. Willis, J. Chen, E. Niemi, K. Desabrais, C. Charette, S. Manohar. "Sensing performance of electrically conductive fabrics and suspension lines for parachute systems". Journal of Intelligent Material Systems and Structures, vol. 23, no. 17, pp.1969-1986. November, 2012.

5. "Surface charging limit for a woven fabric on a ground plane," Horenstein, J. of Electrostatics, vol 35, no 1, pp 31-40 (added to topic on 1/26/15).

6. "Electrostatic charging of textiles," Holme, McIntyre and Shen, Taylor & Francis online, 2009 (added to topic on 1/26/15).

7. Horenstein, J. and N. Roberts from the J. Of electrostatics, vol 34, 1995, called “The Electrostatics of parachutes” (added to topic on 1/26/15).

8. Horenstein, J. and N. Roberts (of NSRDEC) from the J. of Aircraft, vol 31, no 5, Sept 1994, called “Comparison of Electrostatic and Aerodynamic Forces during Parachute Opening.” This was also published at the 12th AIAA ADS Conf. in London (added to topic on 1/26/15).

KEYWORDS: conductive network, parachute, textile, electronic textile, e-textile, flexible connectors

A15-064 TITLE: Single Process Multiplex Detection System for Food and Water Pathogens

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Develop a multiplex detection system that can complete all processing steps in disposable assay kits without additional laboratory equipment.

DESCRIPTION: Current detection systems for food and water pathogens require multiple pieces of laboratory equipment to support preparation of samples prior to detection. Food pathogen detection systems normally include some pre-enrichment of the food sample followed by multiple steps to isolate the pathogen or DNA from the food matrix. The use of the supporting equipment to prepare these samples increases the testing time and ultimately extends the detection process.

The concept behind this proposal would utilize a single test device that can prepare, purify and detect samples without the use of other supporting equipment elements. This system would eliminate the use of separate purification kits and heating blocks for polymerase chain reaction (PCR) systems as well as magnetic bead recovery and separation kits/assays used for concentration of targets. There have been larger devices used for this type of application that are extremely effective, but these systems are too large for practical field applications. These available systems also are not used for food samples. Currently, food samples require the use of a blender and/or stomacher to break up the food and dilute it in a buffer or enrichment medium. The desired system would have to be lightweight, self-sufficient and exhibit equal sensitivity to current laboratory methods. The system could be used in the field or in a laboratory to assess the microbiological quality of both water and foods.

One issue at hand would be the need for enrichment of specific bacterial pathogens that have low or zero allowable limits. Enrichment of a food product allows one colony forming unit to grow to a detectable concentration in hours. Enrichment in the test kits would be desirable, but may not be feasible due to the desired portability of the detection instrument. Enrichment requires some sort of heating element due to the fact that most food pathogens ideally grow at a temperature of 30-37°C. If enrichment were not possible using the detection system, it could still be used for virus and parasite detection methods.

The overall size of the unit should be less than 10 pounds and also small enough to be placed almost anywhere. Shelf stability of reagents in the test kit is necessary and must not expire for at least one calendar year.

PHASE I: Research, develop, and design a concept detection system that is able to detect pathogens in water. There are three separate items of concern in water: enteric viruses, parasites, and bacteria. Viral targets would include Hepatitis A, Norovirus, Poliovirus, Rotavirus and Coxsackievirus. Parasite targets would include Giardia, Cryptosporidium, Schistomiasis, Amebiasis and Cyclosporiasis. Bacterial targets would include Shiga Toxigenic Escherichia coli (STEC), Listeria monocytogenes, Salmonella, coliform and Campylobacter. For Phase I the detection system would have to show the ability to detect one target from each group on a single test kit without using supporting laboratory equipment. Detection of the targets would occur at levels that are high enough that enrichment would not be needed for bacterial targets. Detection system in this phase will be a breadboard unit.

PHASE II: Refine the detection system and expand detection to the other four organisms in each group that were not addressed during phase I. Phase II will also include the sampling of food matrices for all of the pathogens in each group. Food samples will include spinach, strawberries, and ground beef. Phase II will also maximize detection sensitivity and minimize detection time for the assay. Shelf stability of included reagents without refrigeration would be addressed as well. Detection system in this phase will be a prototype unit. Upon completion of phase II, one prototype system will be delivered along with a user manual or training guide

PHASE III: The potential use of these detection kits will be to rapidly screen food and water for virus, bacteria, and parasite contamination. A rapid, single process, multiplex assay is the ideal detection platform for field use by veterinary inspectors. Commercially, this system can be used for rapid identification of pathogens in food and water that may be contaminated with multiple pathogens. The system may also have potential use in point of care diagnostics for these targets in a medical environment. Detection system in this phase will be a fully operational single process unit.

REFERENCES:
1. CDC water parasites; Website: http://www.cdc.gov/parasites/water.html

2. FDA Bacteriological Analytical Manual Chapter 19A: Detection of Cyclospora and Cryptosporidium from Fresh Produce: Isolation and Identification by Polymerase Chain Reaction (PCR) and Microscopic analysis; Website: http://www.fda.gov/Food/FoodScienceResearch/LaboratoryMethods/ucm073638.htm

3. EPA Microbial Methods/ Online Publications; Website: http://www.epa.gov/nerlcwww/online.html

KEYWORDS: multiplex, single-process, sensitive, detection

A15-065 TITLE: Technologies for Modular Refrigeration

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop technologies for refrigerator modules that will be part of the suite of appliances aboard the Army's new configurable kitchens. The main technology innovation areas are expected to be: control electronics, miniaturization of refrigeration components, improved insulation, and novel structural materials. The goals are to minimize weight, increase efficiency, enable operation from multiple power sources, design to military purpose, and maximize interior volume and utility.

DESCRIPTION: When mobile kitchens do not provide sufficient protection for cooks in hostile environments, the practice is to relocate appliances into buildings. The Capability Development Document for the Army's future Battlefield Kitchen (BK) also requires these man-portable modules be easily attachable to each other and kitchen platforms via standardized lockdown mechanisms. This modularity enables cooks to quickly reconfigure kitchens according to mission, and swap appliances between platforms. Modularity also significantly decreases training requirements and materiel logistics.

Development of the appliances used for cooking, sanitation and serving is progressing under the Combat Feeding Directorate's Modular Appliances for Configurable Kitchens (MACK) program. The need remains for a Modular Refrigerator (MORE). Conventional dormitory refrigerators are insufficient because they are not modular, use too much electricity, have extra components, are not robust enough to survive military transport on a regular basis, are not designed for hot and cold weather operation, and cannot be retrofitted to this application. Furthermore, opportunity remains for enhanced capability, such as the ability to simultaneously draw power from solar photovoltaics and 110 VAC kitchen circuits, and cleverly designed interiors specific to military methods, cookware and food storage containers.

The MORE will need to meet the weight limit for a two-man carry: 39.5 kg (87 lb). The volume available for the module is roughly 68-cm deep x 56-cm wide x 79-cm tall (27" x 22" x 31"). The lockdown device underneath raises the module by 10 cm, and there will be a 2.5-cm removable counter on top, thus the total working height will be 91 cm (36") -- or 167.5 to 178 cm (66-70") when stacked. The block hook that locks components together infringes on the width along the upper and lower edges by 2.2 cm. In a 57°C (135°F) environment, the MORE shall hold 3°C (38°F) and have a target coefficient of performance (COP) greater than 3. The annual average electricity consumption should be less than 450 kW-hrs in a hot climate. The design should target a production cost of <$800. Because of the confined space, it is likely the heat rejection will be out the top and ducted into the kitchen exhaust hoods, but there are other possibilities. Adjacent appliances used for cooking are expected to inflict additional thermal load; they are positioned with only a 1/16th inch (nominal) gap between them, and skin temperatures can reach 140°F. Also, if a MORE is stacked on top of another appliance, it could be subjected to neighboring steam.

It is anticipated that to meet these goals while limiting risk, respondents will consider vapor-compression cycles as the starting point; however, other proposed cooling cycles are acceptable. The primary challenge within the stated volume will be miniaturization of refrigeration components for maximizing interior space and utility, and minimizing weight. Development of key components such as microchannel heat exchangers and compact compressors packed within limited geometry without compromising performance and reliability will be key drivers for this effort and will be essential for optimal packaging. Other areas examined will include: component materials and geometries; efficient motors; variable-speed drive electronics; and advanced evaporative control valves. In their proposals, offerors shall explain and justify their choices, discussing tradeoffs and making comparisons to other approaches or technologies. Modeling and experimentation in preparation for the proposal is a plus. Innovation is important, and shall be balanced against development risk.

PHASE I: During Phase I and the Phase I Option, offerors shall develop the initial concept design; demonstrate the practical and technical feasibility of their approach virtually with 3D models, and materially via scaled-down bench-top/breadboard fabrications of the most critical component technologies; and validate empirical performance results with modeling and simulation. Phase I deliverables will be progress and final reports detailing all activities, including description and rationalization of the design process and resulting concept, successes and failures, results of performance modeling and benchtop evaluation, safety, risk mitigation measures, MANPRINT, and estimated production costs. The final report shall also specify how requirements will be met with full-scale prototypes in Phase II. Concepts will be judged on adherence to the quantitative and qualitative factors in the Description section above, innovation, and more generally on complexity, anticipated reliability, efficiency, and maintainability.

PHASE II: During Phase II, the researcher is expected to refine and scale-up the technology developed during Phase I, and further validate the concept and demonstrate how goals are being met by fabricating for delivery two or more fully-functional, full-size MORE units that have been subjected, at the contractor's facilities, to various performance and environmental evaluation exercises representative of actual field conditions. The data deliverables shall be production drawings, progress reports and a final report documenting the theory, design, safety, MANPRINT, component specifications, performance characteristics, Phase II activities, and any recommendations for future development of the technology.

PHASE III: The military application includes all legacy and future mobile containerized kitchens such as the Battlefield Kitchen, Containerized Kitchen - Improved, Expeditionary TriCon Kitchen, and -- as Joint Service Combat Feeding Equipment (JSCFE) -- the kitchens of the other Services. It is also applicable to Federal Emergency Management Agency (FEMA) operations, Soldier and electronics cooling, medical transport, the off-grid community, and civilian catering. An initial production run of 2000 units would target outfitting of the kitchens mentioned. Additional production would be necessary to fulfill other platforms and retrofits.

REFERENCES:
1. Carey, W. (2013), Future Field Kitchen, The Link (April, vol. 2013, No. 1, page 8)
http://militaryfood.org/newsite/wp-content/uploads/2013/04/The-Link-March-2013-final.pdf
Note: the Future Field Kitchen is now known as the Battlefield Kitchen (BK):
http://nsrdec.natick.army.mil/media/fact/food/BK.pdf

2. Reinert, B. (2013), Army Unveils New Line of Modular Food Service Equipment, Military Club and Hospitality, (March, pp. 14-15), http://ebmpubs.com/MCH/mch_curis.asp
Also available as Modular Appliances to Dramatically Improve Field Feeding, US Army Homepage,
http://www.army.mil/article/100177/Modular_appliances_to_dramatically_improve_field_feeding/

3. Illustrations of Modular Appliances for Configurable Kitchens (MACK) Suite, 4 pages, uploaded in SITIS 1/26/2015.

KEYWORDS: modular kitchens, food preservation, mobile refrigeration, modular appliances

A15-066 TITLE: Radiant Floor Heating Technology for Expeditionary Shelters

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop an alternate military heating system employing radiant heating technology, while exhibiting high levels of energy efficiency, safety, and user acceptance. In addition, the radiant heating system must not negatively effect shelter interior functional space, and aim to reduce the overall logistic burden of transportation and operation of a heating system. Furthermore it is the objective to investigate emerging materials which can be integrated into a lightweight, rapidly deployable radiant heating system, which is installable into highly mobile, expeditionary military shelters including both tentage and rigid-wall shelters. The approach can be either electric or hydronic based but must minimize or reduce the logistics burden associated with transportation and operation. The radiant heating system shall be capable of replacing existing environmental control units (ECU)2 in heating, and provide equal or greater heating performance at lower energy consumption rates than existing electrical (heat pump or resistance based) forced-hot air ECUs.

DESCRIPTION: Expeditionary base camps are consuming an increasingly large quantity of fuel to operate shelters and Warfighter support equipment.1 Heating base camps in cold weather conditions can be very demanding on the already limited fuel supply. Fuel transportation on the battlefield is not only a logistical and financial burden, but also puts soldiers into harm's way. With current forced air heating systems there is a tendency for energy inefficient and uncomfortable hot spots to develop within the shelter interior. These hot spots result in localized excess heat loss through the shelter walls, and an uneven thermal gradient that impacts Warfighter comfort levels. Furthermore, forced-air ECUs contribute to dispersing airborne contaminants, resulting in less hygienic field hospital conditions.

In order to reduce the logistical burden associated with fuel transportation, there is a need to develop a heating system that provides energy savings, is lightweight and portable, and does not require altering the shelter system for installation. An alternative to forced hot air heating is radiant heating, in which far infrared heat energy is projected upon the shelter occupants. Radiant heating is available in a number of different configurations, and if deployed as "flooring" may provide the added benefit of serving as an insulation barrier to the ground in cold climates. Radiant heating systems would serve as alternatives to current US Army fielded electric forced-air ECUs in cold environments. Currently deployed electric-based forced-air ECUs consume a relatively large amount of energy while heating due to the built-in, inherently inefficient, electrical resistance heater. Additionally, with a radiant heating system there is a potential for less maintenance due to the heating system remaining unexposed to environmental elements, and exhibiting a reduction in moving parts. The overall result in the utilization of a properly designed radiant heating system is a reduction in energy consumption, while improving comfort levels of Warfighters deployed in austere environments.

The goals for the radiant heating system developed under this effort are to maintain habitable interior temperatures that are "perceived" to be similar to force hot air systems (min. 65F interior @ -25F exterior4), exhibit an "all-inclusive" shipping weight under 200lbs, be deployable by 2 soldiers in under 15 minutes, be built for a HDT STAT 32 Airbeam3 shelter system exhibiting floor dimensions of approximately 18 ft. by 32 ft., and meet associated requirements set forth in the TEMPER performance specification6. Additionally, the system shall exhibit net energy consumption that is 20% lower than forced air ECUs. It is estimated that nearly 21.6kW7 of power are required to heat an Airbeam Shelter, outfitted with a Camel Thinsulate cold weather liner (component level R-value of ~3), to an interior air temperature of 65F in -25F ambient temperatures. The radiant heating system to be developed under this effort shall provide a similarly "perceived" temperature for the same conditions with only 17.28kW of energy draw or less.

Perceived Temperature: Perceived temperature in the case of radiant heating is difficult to quantify through simple instrumentation (i.e. thermostats and thermocouples suspended in air). Previous government sanctioned testing illustrated that "perceived" heat within a radiantly structure was often much higher than the air temperature (as seen by a thermostat) within that structure, indicating that radiant energy does not effectively heat the surrounding air. It is thereby important to discern air temperature from temperature as "perceived by the shelter inhabitants." For this reason, the heating system developed under this effort shall control to "perceived" interior temperature, and not simply air temperature.

One such method to quantify perceived temperature (in order to validate radiant heater performance and/or devise a thermostat control scheme) could include utilizing a thermocouple submerged in a known volume of water, placed centrally within the structure being heated. Further investigation of this strategy, and/or any other strategy is expected for Phase I in order for the government to validate the deliverable, and the temperature control scheme employed for the system in Phase II. During Phase II, the government will validate the delivered prototype system for providing sufficient and controllable perceived heat to shelter occupants in a qualitative manner, and associating the qualitative results to quantifiable data of "perceived" temperature.

In the case of a floor-based radiant heating system, the contractor shall also evaluate and investigate the effects of providing insulation between the heating system and ground. If such provision results in a significant opportunity for energy savings, the system shall be designed and built with such insulation incorporated.

A significant activity during system design and development will be ensuring system safety in all conditions, and that any water intrusion, puncture, or electrocution hazards be addressed and mitigated as priorities.

The cost target for a commercially viable radiant heating system meeting the aforementioned requirements is between $5000 and $8000.

PHASE I: Previous military efforts have conducted research and development to either convert/adapt commercial radiant floor heating methods for base camp efforts or develop new systems with similar capabilities intended for military use. Developing an innovative radiant heating system that will be durable, highly efficient, requiring little maintenance, exhibiting rapid deployment, and capable of meeting all military test and performance standards[4,5,6] presents many technical challenges.

The scope of this project will be to determine the most effective and efficient radiant heating solution for expeditionary base camps. The technologies to be considered may include electric and/or hydronic (liquid) radiant heating systems, and is open to any other form of alternative radiant heating technologies meeting the topic requirements. With further investigation of the benefits and limitations of each technology, a more detailed design concept will be developed. This design concept considers shelter application, durability, material composition, and end item cost. A functional scale bench top model representing a portion or section of the radiant heating system shall be built and demonstrated as a proof of concept.

The contractor will develop a conceptual power scheme, so that the entire radiant system can be powered by and integrate with a 60 Amp Class-L power cable, carrying 3-phase 208VAC.8 The system should also include designs for electrical safety, be properly grounded, and provide its own GFCI or breaker that trips upon electrical shorting, or when the system draws more power than it was designed for.

The conceptual system should be designed with hermetic sealing to mitigate water intrusion into the radiant heating system, or in the case of a hydronic system, mitigate the potential for leakage. Puncture resistance should be sufficient to survive potentially 100lbs point loaded on the radiant heating system by an open ended and "unfinished" (i.e. not-deburred) 1 inch by 1 inch square aluminum tube extrusion.

In addition, the contractor shall develop and demonstrate the methodology for quantifying radiant heat energy, and associating that numerical data to user "perceived" heat. The thermostat control scheme should exhibit a hysteresis of less than +/- 2F in "perceived" temperature. This methodology (and associated hardware) will be demonstrated on the prototype bench top system, in order to establish confidence in the Phase II approach and deliverable.

PHASE II: Under Phase II, the contractor is instructed to further refine the conceptual design, continue to meet requirements set forth in the Phase I effort, and build a fully functional, full-scale prototype radiant heating system to undergo government sanctioned test and evaluation. The contractor is also expected to provide the government with all the necessary power/operational interface equipment in order to test the prototype radiant heating system.

Furthermore, the contractor will build the system with a control scheme that will allow the user to "set" a perceived temperature that mimics the numerical temperature "set point" as often seen on a forced hot air heating system's thermostat. During government testing, several perceived temperature set points will be evaluated by human test subjects in a side by side comparison of a forced hot air heated tent and a radiantly heated tent.

Leveraging results from this testing, the contractor shall incorporate any necessary design changes and build two additional refined prototype shelter radiant heating systems, draft a detailed Operator's Manual, and deliver the prototype Technical Data Package.

PHASE III: Initially the radiant heating system will be used for heating fabric shelter systems deployed in austere and cold environments. Further extensions of this technology to heating rigid-wall shelter systems are likely as well. Rigid-wall structures are primarily composed of composite panels which would be conducive to a pre-installed design for the radiant heating system. Other applications of radiant heating in the commercial and residential realm include a means of rapid snow-melting, a reduction in concrete slab curing time, and food dehydration.

REFERENCES:
1. Reinert, Bob. Curbing base camps' appetites for fuel, water. 2012. http://www.army.mil/article/88113/

2. HDT F100-60K Commercial Environmental Control Unit
http://www.hdtglobal.com/site_media/uploads/files/products/data_sheets/product/HDT_F100_60K_ECU_12.pdf

3. HDT Vertigo STAT 32
http://www.hdtglobal.com/site_media/uploads/files/HDT_Vertigo_STAT32.pdf

4. MIL-STD-1472F – Department of Defense Design Criteria Standard - Human Engineering
http://www.public.navy.mil/navsafecen/Documents/acquisition/MILSTD1472F.pdf

5. MIL-STD-810G - Test Method Standard for Environmental Engineering Considerations and Laboratory Tests, http://www.wbdg.org/ccb/FEDMIL/std810g.pdf

6. MIL-PRF-44271C - PERFORMANCE SPECIFICATION TENT, EXTENDABLE, MODULAR, PERSONNEL (TEMPER), http://www.bondcote.com/military/MIL-PRF-44271C.pdf

7. Ft. Devens, Base Camp Integration Lab – Liner Experiment Emerging Results (26MAR2014)

8. 60 Amp Commercial Class L Cable Extension
http://www.lexproducts.com/products/military/military-powerflex-cable-assemblies/military-class-l-cable-assemblies/60-amp-commercial-class-l-cable-extension

KEYWORDS: military, shelter, floor, radiant, far-infrared, forced-air, fuel, electricity, habitation, comfort, temperature

A15-067 TITLE: Soldier and Small Unit (SSU) Performance and Cognitive Models for Behavior and Decision Making in Constructive Simulation

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Provide an improved analytic capability to represent Soldier and Small Unit (SSU) performance and decision-making models in extant constructive simulations.

DESCRIPTION: Cognitive human models represent information flow between input (sensory input) and output in terms of human behavior (decision making). There is a need for improved cognitive and decision-making-models in constructive simulation, allowing more realistic representations of Soldier behaviors and the impact of common operational factors on Soldier cognitive function and alertness.

The study of SSU performance requires understanding the degree to which Soldiers' skills and abilities are implemented for a particular task or set of tasks in a military operational environment. The Army and other agencies have invested in several projects to study the human factors aspects of Soldier performance as they pertain to physical performance. There is a gap in the understanding of how characterizing factors impact SSU cognitive performance and the interrelationship between these factors (e.g., understanding of how individual Soldier differences combine to affect SSU performance). Examples of characterizing factors include SSU knowledge and experience, environmental factors including the complexity of the battlespace and the weather, and internal states of cognitive workload and physiological stress.

Analytic gaps exist that require investigative research and innovative solutions. The Army continues to rely increasingly on information technology and electronic equipment to provide enhanced situational awareness to the Soldier. Improved battlefield awareness provided is the benefit. However, the high level of cognitive ability required to operate the new equipment and the fact that it can be a distraction must be considered as costs. Overall, the influx of this new and typically sophisticated equipment, along with the requisite changes to established tactics, techniques and procedures (TTPs), have combined to exacerbate both the cognitive and physical demands placed on the Soldier and his unit. The Soldier overburden problem, due to the routine carrying of heavy loads, is another major Army challenge that impacts warrior performance and survivability across the spectrum of Army operations. Soldier overburden has clear physiological and cognitive impacts. It is generally accepted that carrying heavy loads adversely impacts a warrior's cognitive and decision-making abilities, as well as his ability to perform physical tasks in complex operational environments.

Analysts require the ability to leverage human performance knowledge in simulated operational environments enabling the creation of a more complete picture of the relationship between the Soldier, his equipment, the operational environment, and the cognitive aspects of SSU performance. Better models of factors like fatigue due to Soldier overburden, distractions due to use of electronic equipment (text messaging), various psychological factors (stress), and physiological factors such as exhaustion and lack of sleep, are needed.

The Army has invested significantly in the study of Soldier cognitive performance, and this topic will leverage existing Army research in this area by designing and creating models for constructive simulation based on this research. As the Army and other research communities establish these critical linkages, an analytic capability is needed to represent and account for them to support operational context trade-offs and mission performance and effectiveness in constructive simulations.

The results of this Small Business Innovation Research (SBIR) effort will provide models, methodologies, and algorithms for constructive simulations that represent Soldier cognitive behavior and the degradation of Soldiers' cognitive function due to fatigue in simulated combat operational environments and the resulting impact on task performance, survivability, and mission effectiveness.

PHASE I: Research and develop innovative approaches and capabilities to advance Army cognitive performance modeling in constructive simulation, specifically to assess the impact of operational, physiological, and environmental stressors on Soldier cognitive and decision-making abilities. The models, methodologies, and algorithms designed and developed will enable the representation of Soldiers' cognitive function degradation due to fatigue and stress in simulated combat operational environments and examination of the impact on task performance, survivability, and mission effectiveness. The design should be scalable, flexible, and extensible to meet Army analysis needs. A proof-of-concept implementation will demonstrate the feasibility and validity of the proposed approach. Phase I process and results will be detailed in a final report identifying the recommended design approach, process, assessment, details, and rationale for recommendation.

PHASE II: Define and refine a functional prototype of the cognitive performance representation and methodologies designed in Phase I. Develop a prototype implementation in a force-on-force constructive simulation (e.g., IWARS, CombatXXI, OneSAF) and clearly demonstrate how this supports a practical implementation for conducting mobility/lethality/survivability trade-off analyses that allow for specific equipment representation and Soldier use, each impacting Soldier load and overburdening, cognitive performance, task performance, survivability, and mission effectiveness. Conduct Verification and Validation (V&V) studies to establish that the models, methodologies, and algorithms properly represent the impact of equipment and load on Warrior performance in constructive simulation and in virtual combat operations environments. Document the design, development, and resulting Phase II products. Document the development process and demonstrations of the proposed concept to include a listing and explanation of assumptions, traceability, barriers, and bounds associated with the modeling approach.

PHASE III: Technologies developed in this project may be leveraged and integrated into cognitive and human performance models for use in various DoD simulations, such as IWARS, OneSAF, and Combat XXI. Essentially, the developed methodologies will support the study of Soldier decision-making, cognitive performance, and situation awareness.

REFERENCES:

1. Allender, L. (2000). “Modeling Human Performance: Impacting System Design, Performance, and Cost." In M. Chinni (ed.) Proceedings of the Military, Government and Aerospace Simulation Symposium, 2000 Advanced Simulation Technologies Conference (Washington, D.C.) 139-144.

2. Freeman, M., Army Science and Technology Strategic Direction, October 12, 2011, accessed at http://usarmy.vo.llnwd.net/e2/c/downloads/223016.pdf

3. Killion, T. and Nash, C., An Overview of the Army Science and Technology (S&T) Program, ARMY AL&T, October-November 2007, accessed at http://asc.army.mil/docs/pubs/alt/2007/4_OctNovDec/articles/04_An_Overview_of_the_Army_Science_and_Technology_%28S&T%29_Program_200710.pdf

4. The Integrated Casualty Estimation Methodology (ICEM) Analyst Manual, ICEM version 1.0, Dec 2003.

KEYWORDS: Assessing Cognitive Readiness, Cognitive Function Degradation, Cognitive Performance Model, Decision-Making, Human Performance, Situational Awareness, Soldier Load, Soldier Overburden, Stressors

A15-068 TITLE: Innovative Non-GPS Geolocation Technologies for Hand and Remotely Emplaced Munitions

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Ammunition

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

OBJECTIVE: Develop innovative technologies that do not rely on GPS (Global Positioning System) to geolocate hand and remotely emplaced munitions. This includes technologies to transmit the geolocation data to a remote display.

DESCRIPTION: Hand and remotely emplaced munitions are required to protect troop locations and assets from enemy encroachment. However, emplaced munitions must be continuously tracked and accounted for, requiring geolocation of each munition for eventual retrieval or neutralization. This geolocation technology must be available continuously until the munition is recovered or neutralized. It shall also have the capability to transmit the munition’s location to a host station up to 10 kilometers away. The technology will use available power from the munition, so should be minimal (ideally less than 1 watt). The size of the technology shall also be minimized (ideally less than 1 cubic inch). The technology shall provide sub-meter location accuracy reliably (no less than 99%). Life expectancy of the technology shall be at least 20 years.

PHASE I: Develop approaches for non-GPS geolocation technologies that meet the requirements above as well as other more detailed requirements provided upon contract award. The contractor will perform and document design analyses to demonstrate compliance with requirements. The results of Phase I will include an engineering analysis of alternatives noting the design capabilities and limitations and recommendations for the Phase II effort, as well as physical prototypes built in the laboratory and subjected to laboratory functional testing.

PHASE II: Based on success in Phase I, refine the design(s) selected to meet the functional and environmental requirements. The contractor will design and build at least 10 prototypes intended to be installed and demonstrated in an actual munition system. The Phase II will culminate with a demonstration in a relevant environment (not necessarily a live fire event). Deliverables include the ten prototypes, an engineering report on the design selected, and technical data for the product in contractor format.

PHASE III: Integrate the Phase II technology in one or more munition systems for eventual fielding. Commercial applications include geolocation of multiple commercial items intended to be left unattended (such as survey markers, construction equipment, signs/markers, buoys, etc).

REFERENCES:
1. Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction, 18 September 1997

2. White House Press Release - "FACT SHEET: Changes to U.S. Anti-Personnel Landmine Policy", September 23, 2014

3. Army Field Manual FM 20-32 Mine Countermine Operations, Change 1, 30 June 1999

KEYWORDS: emplaced munitions, GPS, location, geolocation, mines, countermines, cluster munitions

A15-069 TITLE: Advanced Wireless Fuze Setter Technology for Medium and Large Caliber Rapid Fire Auto Loaders

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Ammunition

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

OBJECTIVE: Develop innovative technologies that will allow for wireless fuze setting for current and future rapid firing, auto-loading weapon systems, including artillery, mortar and medium caliber. Current fuze setting technologies are not conducive to rapid fire auto-loading weapons.

DESCRIPTION: Future rapid fire weapon systems are expected to have the capability of firing up to 16 rounds per minute or more, and as “smart” ammunition becomes more prolific there is a need to wirelessly set mutli-option fuzes as well as advanced guidance systems embedded in the ammunition as they are automatically loaded in the weapons. The purpose of this topic is to develop technologies that will quickly, reliably and accurately transfer data wirelessly from the weapon’s fire control computer to the electronics in the ammunition. This technology must work reliably with current and future multi-option fuzes as well as GPS and non-GPS guidance technologies, correctly setting the ammunition prior to firing no less than 99% of the time. The selected technology must also comply with all current and future security and encryption requirements. The solution must be of such small size as to fit within the very limited space claim of the weapon’s breech or auto-loader (ideally within a 1 cubic inch volume), and utilize existing power available at the weapon (ideally less than ten watts). Life expectancy of the technology shall be at least 20 years.

PHASE I: Develop approaches for wireless fuze setter technologies that meet the requirements above as well as other more detailed requirements provided upon contract award. The contractor will perform and document design analyses to demonstrate compliance with requirements. The results of Phase I will include an engineering analysis of alternatives noting the design capabilities and limitations and recommendations for the Phase II effort, as well as physical prototypes built in the laboratory and subjected to laboratory functional testing.

PHASE II: Based on success in Phase I, refine the design(s) selected to meet the functional and environmental requirements. The contractor will design and build at least 10 prototypes intended to be installed and demonstrated in an actual weapon system. The Phase II will culminate with a demonstration in a relevant environment (not necessarily a live fire event). Deliverables include the ten prototypes, an engineering report on the design selected, and technical data for the product in contractor format.

PHASE III: Integrate the Phase II technology in one or more weapon systems for eventual fielding. Commercial applications include programming of electronic components or products (such as memory chips) on a high speed production line.

REFERENCES:
1. US Patent 5894102, A Self-correcting inductive fuze setter

2. Inductive Settable Electronic Time Fuze for Mortars, Mike Tucker, Technical Director, Electronic Engineering, Fuchs Electronics April 2003

3. Enhanced Portable Inductive Artillery Fuze Setter (EPIAFS) Product Fact Sheet, Alliant Techsystems Inc., Approved for release to the public domain July 2014

KEYWORDS: inductive, electronic, fuze setter, multi-option fuze, artillery, mortar, autoloader

A15-070 TITLE: Locality Scanner for Helicopter Pilotage and Hazard Avoidance

TECHNOLOGY AREAS: 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 demonstrate a scanning and inertial sensor system capable of modeling the locality of the helicopter in three-dimensions to support pilotage and hazard avoidance.

DESCRIPTION: Civilian and military rotorcraft missions routinely involve flight in close proximity to hazards and in Degraded Visual Environments (DVE). Examples of hazards include vegetation, poles, wires, buildings, vehicles, personnel, equipment, nearby terrain, other aircraft, and ship superstructure. Examples of DVE include darkness, fog, smoke, dust-clouds, rain, and snow. In order to safely negotiate these hazards, the aircrew maintains a continuous awareness of static and dynamic elements around the aircraft and along its flight path. A sensor which can exploit the Christiansen feature to penetrate darkness, fog, dust, and other DVE and scan the locality around the aircraft is an essential element of a flight-critical hazard avoidance system. When coupled with a capable processing architecture and pilot-vehicle interface, a 3D scanning system could provide content for synthetic vision for pilotage through DVE. Or, as digital content, the 3D model of the locality may inform automated path planning and hazard avoidance systems in both manned and unmanned aircraft.

Achieving a spherical field of regard without penalizing aircraft performance may require novel sensor design and placement. The sensor may need to be very compact and lightweight, take the form of a surface laminate, or adopt some other means of minimizing the aircraft performance penalty. Today's fuselage mounted sensors often rely on an articulating turret, rotating beam reflector, or distributed array of transmitters. All these pointing mechanisms add complexity and weight to the system. Moreover, the fuselage itself becomes an obstruction to achieve circumferential sensing, necessitating multiple sensors around the fuselage. A rotor-based sensor would enjoy a field of regard nearly free of fuselage obstructions while the rotating blade itself provides the articulation. However, rotor-based sensors face other challenges, including: power and data transmission between fuselage and the rotating rotor system; high centripetal loading; high subsonic translational speed; complete rotations of 3 to 10 Hz plus higher harmonic oscillations. Whether mounted on fuselage or in the rotor, sensor placement may affect aerodynamic penalties; structural integrity; lens abrasion due to airborne debris; and integration complicated by the proprietary nature of fuselage and rotor designs.

A 3D scanning system includes the ability to geo-spatially locate the sensor and encompass the extremities the aircraft in its scanned field of regard. If the sensor resides in a rotor blade or includes the rotor system within its field of regard, it may incidentally provide other significant benefits. With near real-time or harmonic inertial sensing of the rotor blades' flapping, lagging, and other states or with Doppler velocimetry of inflow velocities near the rotor disk, the aircraft's flight control laws may incorporate rotor-state and inflow feedback to improve rotor control and precision of flight maneuvers in turbulence. Inertial and positional data about the blade could simplify and help automate rotor track and balance, a critical maintenance task. Inertial and vibratory blade data could support fuselage or rotor blade damage assessment in flight and condition based maintenance tasks after landing. Active scanning sensors may offer some capacity for local inter-aircraft scanning and communication that can support automated formation flight and collision avoidance.

PHASE I: Determine technical feasibility of demonstrating a three-dimensional (3D) locality scanning system whose sensors would operate with minimal degradation to vehicle aerodynamic performance and reliability. Determine a functional allocation and physical distribution of hardware between the rotor system and the fuselage. Characterize the critical design trade space between the dimensions (form factor and mass) of the sensors and their scanning range, spatial resolution, and overall effectiveness for static and dynamic hazards. Estimate the system's potential range and field of regard, using an initial benchmark for effective radial range of 200 meters in clear air, an inclination span of 45 degrees above and below the main-rotor plane, and with relative precision of 0.1 meters for the volume within 20 meters of the aircraft extremities. Determine whether the sensors could incidentally provide rotor-state feedback, inflow feedback, or capacity for bi-directional digital communication among like systems in nearby aircraft. Propose a standard for the physical interface for sensor elements with wide potential compatibility with modern helicopters and rotor systems. It is acknowledged that any integration of a sensor into a fuselage or rotor blade may require redesign; however, for a physical standard for the sensor, the proposal should strive for ease of integration, reliability, and potential compatibility with designs spanning rotary UAVs to heavy lift helicopters, with two or more rotor blades, and with straight, anhedral, or swept blade tips.

PHASE II: Develop and construct 12 prototype sensors for use in a flight demonstration in clear air and for post-SBIR testing and evaluation in DVE. Install and demonstrate at least one sensor capable of scanning the physical arrangement of stationary and moving obstructions and hazards in the volume surrounding a slow-moving, airborne helicopter. Deliver an interface control document (ICD) that encompasses physical, power, data and other interfaces necessary to incorporate the prototype sensors and their data streams into a processing system capable of rendering a digital, 3-D model of the scanned locality. The demonstration must include a 3D plus time visualization of the scanned locality from the sensor data, but this need not be a real-time or an onboard visualization. If the sensor is capable and if funding permits, demonstrate a visualization of the rotor-state or rotor-inflow over time from the flight demonstration. The helicopter used for this SBIR flight demonstration need not be military or manned. A successful Phase 2 exit produces sufficient knowledge of operational and performance potential to compose a system specification to exploit the technology in a helicopter platform; a set of TRL 6, MRL 5 sensors sufficient for testing in DVE; and technical data and rights sufficient for the government to support system integration.

PHASE III: Depending on the potential functionalities of the sensors, the military would transition the technology to support advanced flight control laws, DVE sensor systems, synthetic vision systems, and hazard avoidance systems. Phase three would extend the flight testing to a variety of DVE conditions (ex. fog and dust) and assess its compatibility with real-time, onboard image generation systems and pilot vehicle interfaces. If the sensors prove to be widely compatible, airworthy as components, easily integrated onto a fuselage or rotor system, and compatible with synthetic vision processing systems; then the government may adopt its interface standards and acquire the sensor to serve as government furnished equipment for a variety of helicopter models. Over time, increments of other sub-systems would exploit the sensors capabilities to support rotor-state and inflow feedback, organic track and balance, individually optimized blade control, autonomous low speed path planning and hazard avoidance, spherical synthetic vision of the locality in DVE, intership communication for autonomous formation control, and locality-based station keeping for urban, maritime, and mountainous applications. Transition to civilian commercial applications would similarly follow early adopters with missions such as search and rescue, urban police operations, and offshore oil drilling support. The capabilities extend, with greater relevance, to unmanned aircraft as an element of a hazard avoidance sensor system and for high-resolution geophysical mapping, including interior volumes.

REFERENCES:
1. M.A. Albota et al., "Three-Dimensional Imaging Laser Radars with Geiger-Mode Avalanche Photodiode Arrays," Lincoln Laboratory Journal, vol. 13, no. 2, 2002, pp. 351–370.

2. R.M. Marino and W.R. Davis, Jr., "Jigsaw: A Foliage-Penetrating 3D Imaging Laser Radar System," Lincoln Laboratory Journal, vol. 15, no. 1, 2005, pp. 23–36.

3. Landmark detection by a rotary laser scanner for autonomous robot navigation in sewer pipes, Matthias Dorn et al., Proceedings of the ICMIT 2003, the second International Conference on Mechatronics and Information Technology, pp. 600-604, Jecheon, Korea, Dec. 2003.

4. Laser radar (LADAR) Guidance System, <http://defense-update.com/products/l/ladar.htm>

5. Durst, Franz, Adrian Melling, and James H. Whitelaw. "Principles and practice of laser-Doppler anemometry." NASA STI/Recon Technical Report A 76 (1976): 47019.

6. Weise, Thibaut, Bastian Leibe, and Luc Van Gool. "Fast 3d scanning with automatic motion compensation." Computer Vision and Pattern Recognition, 2007. CVPR'07. IEEE Conference on.

7. Surmann, Hartmut, Andreas Nüchter, and Joachim Hertzberg. "An autonomous mobile robot with a 3D laser range finder for 3D exploration and digitalization of indoor environments." Robotics and Autonomous Systems 45.3 (2003): 181-198.

8. Siepmann, James P., and Adam Rybaltowski. "Optically extended MEMS scanning transforms imaging ladar." Laser focus world 41.7 (2005): 89-91.

9. Smithpeter, Colin L., et al. "Miniature high-resolution laser radar operating at video rates." AeroSense 2000. International Society for Optics and Photonics, 2000.

10. Siepmann, James P., and Adam Rybaltowski. "Integrable ultra-compact, high-resolution, real-time MEMS LADAR for the individual soldier." Military Communications Conference, 2005. MILCOM 2005. IEEE, 2005.

11. Geske, Jon, et al. "Miniature laser rangefinders and laser altimeters." Avionics, Fiber-Optics and Photonics Technology Conference, 2008 IEEE.

KEYWORDS: ROTORCRAFT, HELICOPTER, ROTORBLADE, DVE, BROWNOUT, FOG, LASER, FLIR, LIDAR, LADAR, RADAR, GPS, MEMS, “ROTOR STATE FEEDBACK”, HUMS, “CHRISTIANSEN FEATURE”, CBM.

A15-071 TITLE: Enhanced Targeting Sensor Technology

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: Develop sensor related technology that enhances the ability to discriminate targets in various lighting conditions and in the presence of active/passive concealment and camouflage techniques including sophisticated measures designed to defeat standard imaging technology.

DESCRIPTION: As the battlefield becomes more complex and the operator is tasked to perform an increasing number of challenging tasks, sensor technologies that complement and enhance operational requirements to decrease targeting workload become more attractive. As an example, the copilot/gunner (CPG) onboard the Apache D/E model aircraft performs many critical tasks including pilotage in addition to target recognition, engagement, and assessment. Enhanced sensor technologies will assist the crew to attain minimum acceptable standoff from targeting systems as required. Extended detection / classification range will increase situational awareness and recognition / identification at extended ranges and permit accurate and rapid tactical decisions to focus combat power and conduct decisive operations.

The operator must have a high degree of confidence in detecting the presence of critical targets within the field of regard (FOR) and field of view (FOV). This level of confidence increases combat effectiveness and survivability while reducing crew workload. A high recognition/classification probability is needed to distinguish between track and wheel vehicles, fixed and rotary wing aircraft, physical structures, and man-sized targets of interest without increasing crew workload. This must be achieved in the presence of active/passive concealment and camouflage techniques including sophisticated measures designed to defeat standard imaging technology.

This topic addresses the implementation of improved target discrimination using innovative sensors coupled with image processing algorithms for use onboard the helicopter platform. Innovative sensor technologies that combine new sensing modalities with standard radiometric imaging for real time display are of particular interest. The overall goal is to rapidly acquire targets of interest with reduced search times between FOR and different FOV magnifications, leading to achievement of Mission-Enhancing and Mission-Essential capabilities. While the display of the information is a critical piece of technology, new displays or techniques to display the information are not the focus of this topic.

PHASE I: Demonstrate proof of principle for the proposed sensor technology. This is a low fidelity sensor using ad hoc laboratory equipment to demonstrate that the proposed technology will function as expected. Preliminary data collected in this phase should indicate significant potential to reduce operator workload through improved target discrimination compared to standard radiometric images. Backyard data collections of scenes inspired by prevalent combat scenarios shall be used (city terrain, camouflaged vehicles, operationally relevant situations, etc.).

PHASE II: Develop notional system prototype for the Apache platform and collect simulated operationally relevant data from either a fixed or moving platform. System size, weight, and power should be within reason for the intended platform as should the operational characteristics; e.g., LN2 dewars are typically not feasible to replace with cryo-pumps due to cooling capacity limitations. The resulting processed imagery should demonstrate how the raw sensor data could be automatically processed to highlight potential targets in real time. Real time is defined as 30 Hz display; use of statistical / analytic data from the previous frame is acceptable as long as it remains unnoticeable by the gunner and doesn't detract from his cognitive ability.

PHASE III: Extend the technology to a full targeting system prototype by optimizing the hardware and software developed in the previous phase. Refine the design to minimize size, weight, power and to survive the harsh conditions experienced in a military environment (MIL-STD-810). Create a partnership with industry to manufacture the technology. Commercial applications of the technology may include remote crop health, crude oil pipeline spill detection, oil under ice detection, or other remote sensing applications.

REFERENCES:
1. Button, Keith, "Armed Scouts", 3 April 2009, www.defensenews.com, 'http://www.defensenews.com/print/article/20090430/C4ISR02/904300314/Armed-scouts'

2. Harris, Tom. "How Apache Helicopters Work" 02 April 2002, HowStuffWorks.com, 'http://science.howstuffworks.com/apache-helicopter.htm'

3. Hicks, Jamison S., Durbin, David B. Durkin, Sperling, Brian, US Army Research Laboratory, "AH-64D Apache Longbow Video from UAS for Interoperability Teaming Level II (VUIT-2) Aircrew Workload Assessment", Final Report, July-August 2007, 'http://innopac.library.drexel.edu'.

4. Boeing Defense, Space & Security, "AH-64D Apache Overview", September 2013, 'http://www.boeing.com/boeing/rotorcraft/military/ah64d/'

5. Army-Technology.com, "AH-64D Apache Attack Helicopter", 'http://www.army-technology.com/projects/apache/'

6. Additional information from TPOC for SBIR Topic A15-071 in response to inquiries during Pre-Release, 3 pages, uploaded in SITIS 1/21/2015.

KEYWORDS: Infrared, Targeting, Hyperspectral, Polarization, Sensors, FLIR (Forward Looking Infra-Red), MWIR (Mid Wave Infra-Red), LWIR (Long Wave Infra-Red, SWIR (Short Wave Infra-Red), Workload

A15-072 TITLE: Advance Brake Fade Warning System and Test for Wheeled Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop road and laboratory tests to safely quantify brake temperatures for severe mountain environments. These new tests will enable evaluation of light, medium, and heavy tactical vehicles to operate in these environments. The PEO has identified removing this gap in vehicle performance evaluation as very important due to the recent strategy of upgrading armor, and therefore weight, on existing tactical vehicles. Safety of testing on the road requires development of appropriate sensors and algorithms to accurately predict dangerous levels of brake fade to provide advance warning to the test operator. Advance warning system must be comprehensive regarding sources of brake fade and adaptable to vehicle and brake system types.

DESCRIPTION: Product Director, Light Tactical Vehicles (PD-LTV) Engineering requires a road test that adequately identifies the brake fade performance of its vehicles in a severe mountain environment. The HMMWV has been up-armored to meet mission requirements. The additional weight has resulted in performance concerns with the legacy brake system. However, the scope of this project is not limited to Light Tactical Vehicles, but medium and heavy military wheeled vehicles as well, such as Mine Resistant Ambush Protected (MRAP) vehicles, Army M915 line hauler, and Heavy Equipment Transporter (HET). Brake system types vary considerably among these vehicles including disk and drum; inboard and outboard; air, air over hydraulic, and hydraulically actuated; S-cam, single wedge, and double wedge applied.

Safely testing brake systems of these vehicles on a public mountain road with steep descent will require advance sensing and brake fade warning capability. Because the test is intended to measure brake temperatures and brake fade, the advance warning system cannot prematurely recommend aborting the procedure. It is expected that in the development of an advance brake fade warning system that the potential sources for the brake fade (e.g. fluid temperature for hydraulic systems, pad/lining temperature, pad wear, pneumatic and mechanical effects), and changes in the conditions of these factors, would need to be monitored. These system states could be compared to brake pedal force, grade of descent, vehicle speed, and other parameters as necessary to accurately predict if and when the vehicle may not have sufficient reserve to stop. It is conceivable with sufficient research that the level of sensing may be reduced and system adaptation to unique vehicles simplified. This research project must determine the appropriate sensing techniques and algorithms, and may require capability to learn and adapt to the characteristics of the specific vehicle on which it is implemented.

Existing mountain braking performance assessments ATPD-2354A and ATPD-2383 are laboratory brake component tests that mimic the Jennerstown Mountain Highway Brake System Test defined in US Army Developmental Test Command (DTC) Test Operations Procedure (TOP) 2-2-608 with a prescribed number of repeated decelerations on a mountain grade. The existing tests were found to not sufficiently identify the limitations of the HMMWV brake system. A road test measuring and quantifying performance in a realistic severe mountain descent brake fade challenge needs to be defined. A new lab test procedure and data processing based upon and correlated to the mountain descent braking road test is also to be delivered. Ultimately brake system hardware is to be developed that enables the HMMWV to successfully meet the requirements identified by an Integrated Product Team for performance in the road and lab test that are developed.

It is assumed that the severity of the test environment should be at least be equivalent to the MRAP Family of Vehicles (FoV) Capability Production Document (CPD) requirement that was developed to meet the needs of the warfighter in Afghanistan. This CPD requirement states that the vehicle should safely stop at GVW (threshold)/GVWR (objective) after descending a 10 mile long, 6% grade at an average speed of 45 mph. Because there are no U.S. Government road test facilities that have the grade and distance characteristics to evaluate this, it is necessary to investigate the characteristics of public roadways as potential braking performance evaluation sites.

Potential evaluation sites have already been identified and documented in a previous TARDEC study. This study consisted of identifying and evaluating test procedures and test sites utilized by automobile manufacturers, Nevada Automotive Test Center, Aberdeen Test Center, and the University of Michigan Transportation Research Institute. Potential mountain road test venues documented by R&R Publishing were examined for severity by estimating the brake temperatures resulting from the length and grade of the road, and the speed limit using a fundamental analysis documented by UMTRI. The severity of these roads was compared to the estimated temperature from executing the

MRAP CPD requirement. The report, "Mountain Braking Test Venue Study," recommends several mountain road candidates for evaluation as test sites based upon estimated brake temperature and safety considerations. These venues will be considered for this SBIR project as they present the severe mountain descent environment that the PEO is interested in evaluating performance of its vehicles.

PHASE I: Preliminary Brake Fade Warning Device and Mountain Descent Test Venue Selection

Deliverables:
1. Preliminary brake fade advance warning system that, with some safety margin, determines that the vehicle must be stopped immediately due to only having sufficient capacity to stop once.
2. Definition of preliminary road test procedure, including sensors and data acquisition, to evaluate severe mountain descent environment brake temperatures on four mountain descent test venues identified by a Government Integrated Product Team (IPT) prior to contract award.
3. Evaluation of preliminary test procedure with two vehicles identified by the Government IPT on the four test venues referenced in deliverable 2 to determine severity as measured by brake temperatures, repeatability of results, and robustness to test operator variation.
4. Down selection to two road test venue locations for evaluation and demonstration of preliminary brake fade warning device and road test procedure that meet the mountain descent braking severity required by Government Integrated Product Team (IPT).

Detail:
Prior to selection of the contractor, the Government will assemble and convene a meeting of an IPT to make decisions and recommendations to define the direction of the project. The scope of the project defined in this proposal is sufficient for perspective contractors to determine Phase I and II costs. Prior to selection of a contractor, the IPT will select four mountain highway venues and two vehicles for use in the development of a preliminary brake fade warning device and Mountain Descent Braking road test. The contractor will have the option to include other vehicles to help develop the advance brake fade warning system for other vehicle applications. This could help ensure applicability of the advance brake warning system to vehicle or brake system types otherwise not represented for which the contractor wants to market the product. The IPT will also make recommendations on test procedure prior to contractor selection to be subsequently discussed and agreed upon with the selected contractor.

Although the contractor will have a primary Government SBIR project point of contact (POC), this IPT will identify appropriate contacts and communication links to address any questions the contractor may have regarding the project. The IPT will initially consist of representatives from TARDEC Analytics, TARDEC Physical Simulation and Test, Program Executive Office (PEO) Combat Support & Combat Service Support (CS & CSS) to include PD-LTV and possibly JLTV and MRAP, and the Army Test and Evaluation Center (ATEC). Any post-award IPT meetings will include participation by the contractor.

Prior to involvement by the contractor, decisions on the following issues will be made by the IPT to ensure consistent and definitive mountain highway braking venue evaluation results:

- Selection of four mountain descent brake fade evaluation venues from among the sites identified as having greatest potential in the Government report, "Mountain Braking Test Venue Study" or others proposed by the IPT. Sites previously identified include:
  - o SR-190, Townes Pass to Death Valley, CA
  - o Pikes Peak Highway, Cascade, CO
  - o AZ-260, AZ-87 to Camp Verde, AZ
  - o US-395, Bishop Grade, CA
  - o I-80 from Parley's Summit, Parley's Canyon, UT
  - o AZ-68 from Kingman to Bullhead City, AZ
  - o CA 168 from Prather to Shaver Lake, Fresno, CA
  - o I-68 EB from MD-546, Frostburg, MD
  - o US 421 SB from the Parkway, Deep Gap, NC
- The IPT would consider whether test site proximity to APG and YPG is a priority.
- Determine four vehicles that will be used for Phase II evaluation of the brake fade warning device, and road and lab test procedures.
  - o These should be determined based upon variety in vehicle Gross Vehicle Weight and brake system types including disk and drum; inboard and outboard; air, air over hydraulic, and hydraulically actuated; S-cam, single wedge, and double wedge application.

o Consideration should include, but not be limited to these vehicle lines: the Oshkosh Family of Heavy Tactical Vehicles (FHTV) Heavy Equipment Transporter (HET), the Army M915 line haul truck, the Oshkosh MaxxPro Recovery Vehicle (MRV), the Navistar Defense MaxxPro MRAP, the Oshkosh MRAP All-Terrain Vehicle (M-ATV), and AM General HMMWV.

• From the four vehicles selected for Phase II evaluation, select and obtain two test vehicles for preliminary fade warning device, road test, and data processing development in Phase I.

Prior to involvement by the contractor, the following issues will be discussed by the IPT and recommendations recorded. Once the contractor has been selected, the IPT will meet with the contractor to discuss and come to a final decision on these issues to ensure consistent and definitive mountain highway braking venue evaluation results:

• What parameter information is sufficient to determine safe capacity to stop
  o Consider assumptions about changes in environment (e.g. changes in grade or ambient temperature)
  o Maximum brake pedal pressure available from operator
• Define vehicle ballast, occupant, fuel level condition for road test
• Identify tire and brake pad/shoe wear states and allowable range for test
• What vehicle performance assessment is performed before/after each venue evaluation
  o Coastdown (SAE J1247 section 6 and figure 14)
  o Brake Effectiveness (SAE J1247 sections 5.4/5.6 and figures 4/6)
• What and when brake temperatures are recorded
• Number of test event repeats
• Limits on speed control (straight and in turns)
• Deceleration rate approaching turns
• Transmission gear
• Number of test drivers
• Number of nominal vehicle speeds
• Data to be recorded

A mountain braking road test scenario ideally should not include artificially inserted brake applies to increase brake temperature as this reduces real world validity. Worst case realistic scenarios for high brake temperatures may likely be steep grades of sufficient length that can be traversed at a constant speed. It is conceivable that brake applications due to curves or other impediments could be spaced such that brake temperature is increased, but seems unlikely. More likely the real world frequency of braking for turns during a descent would decrease brake temperature as a result of decreasing average speed.

The contractor will conduct trial road test runs with the two preselected vehicles to develop a preliminary test development procedure at the four preselected sites. The test procedure should be evaluated to determine test to test variability and sensitivity to driver variability. Procedure should result in realistic severe mountain descent brake temperatures that are robust to typical driver-to-driver and test-to-test variability. The relationship of brake temperatures to ambient temperature should be understood and considered in the development of this preliminary procedure. Robustness of the advance brake fade warning system to different sources of fade should be explored.

PHASE II: Complete Brake Fade Warning Device and Mountain Braking Road and Lab Tests Development

Deliverables:

1. Demonstration of advance brake fade warning system on four vehicles that were selected by the Government prior to Phase I along with any others the contractor recommends to include. The advance warning system shall, with some safety margin, determine that an emergency vehicle stop must be initiated within 30 s due to only having sufficient capacity to stop once in the current environment. It must be robust to brake degradation as effected by fluid fade, mechanical fade, friction fade, and other causes. Two of the four vehicles will be those utilized in Phase I.

2. Road testing of the four vehicles on the two mountain descent test venues referenced in deliverable 4 of Phase I with test course definition to include elevation, latitude, and longitude coordinates sufficient to support laboratory and computer modeling.

3. Laboratory test procedure that provides peak temperatures that correlate to the road test procedure within 10 percent for the four vehicles selected by the Government. The lab test and correlation will be based upon one of the two venues in deliverable 2 as decided by the IPT.

4. Documentation of final road and lab test procedures, including hardware definition and specification, sensors, data acquisition and processing, and all specifications necessary to construct a laboratory to execute the lab test.

5. Complete report on how road test and lab test were developed to include quantification of test variation based upon typical input variation such as driver input and ambient conditions for the road test, and air flow and other ambient conditions for the lab test. Report should describe how test variation is minimized by following the road and lab test procedures and rely upon the testing conducted on the four vehicles selected by the Government.

6. A complete set of specifications for construction of a laboratory to execute the final mountain descent braking test.

7. All materials purchased or developed to support this SBIR project will be the property of the U.S. Government.

Brake Fade Warning Device:
The warning device should be highly visible and audible by the driver to attract immediate attention. It must warn of impending brake system degradation due to pad/lining and rotor/drum temperature, brake fluid boiling, insufficient remaining pad/lining thickness, excessive pad to rotor, and lining to drum clearance, and any other brake degradation sources the contractor identifies that could cause imminent loss of brake system ability to stop the vehicle in the current environment. Brake fade prediction algorithm should utilize warning system specific sensors and data available from the vehicle CAN bus as necessary. The warning device must warn the driver at least 30 s prior to potential brake function loss such that there is sufficient capacity for one complete stop in the current environment. These demonstrations shall take place on the two road test venues down selected during Phase I and utilized in Phase II testing. The demonstrations must show the warning device alerts the driver to impending brake function loss (as described above) due to overheated pads or linings, rotors or drums, and excessive brake fluid temperature.

Mountain Braking Road Test Development:
Using the information gained in Phase I, testing of a range of tactical wheeled military vehicles should commence to finalize the road test procedure, data acquisition, and data processing. Test development shall include the four vehicles determined by the IPT prior to Phase I to encompass a range of military vehicle sizes and brake system types to ensure compatibility, adaptability, and robustness. The contractor will have the option to include other vehicles to assist in development of the advance brake fade warning system for other vehicle applications. This could help ensure applicability of the advance brake warning system to vehicle or brake system types otherwise not represented for which the contractor wants to market the product. Each vehicle will be tested with new Original Equipment Manufacturer (OEM) brake fluid (hydraulic systems), new pads and/or linings burnished to the manufacturer's procedure, and all other brake system components within OEM specification. These vehicles will be tested on the two road test venues determined in Phase I. The final road test definition shall be based upon the one location selected by the IPT upon review of the road test results on the two venues tested in Phase II. The U.S. Government shall provide the vehicles, but shipping will be the responsibility of the contractor and meet any applicable U.S. Government shipping requirements.

Mountain Braking Lab Test Development:
A logical and desired conclusion for a mountain braking test is to conduct the procedure in a laboratory where the environment and inputs are tightly controlled to provide more consistent results than a road test. Once the road test has been defined as proposed including one specific mountain braking venue as selected by the IPT from the two evaluated in this phase, the IPT shall be reconvened to answer contractor's questions regarding the development of a mountain descent braking laboratory test. Considerations need to be given as to whether or not such a test should be conducted on a full vehicle, a brake subsystem, or both. For laboratory test development, the mountain road braking test should be conducted on the four vehicles utilized in the Phase II road testing. These vehicles will have been identified prior to Phase I. Lab test development should include a study of correlation to road test results of these vehicles. The laboratory test shall result in peak brake lining temperatures and, for hydraulic and air-over-hydraulic systems, brake fluid temperatures for each axle within 10 percent of those measured on the road test it emulates. Brake fluid temperatures will be measured at the master cylinder (hydraulic systems) and each wheel cylinder. Ambient and initial brake lining temperatures shall be the same as for the road test or otherwise factored into the calculation of the peak temperatures. The contractor will demonstrate this correlation based upon statistics for multiple runs of the road and lab tests as specified in the test procedures.

A complete set of specifications for construction of a laboratory to execute the final mountain descent braking test that is documented for Phase II will be provided by the contractor.

PHASE III: Further develop and demonstrate capability of advance brake fade warning that robustly includes all forms of brake fade and can be adapted to a variety of automotive vehicles from heavy commercial trucks and semi-tractor trailers to light trucks and SUVs. Trailer towing at a vehicle's Gross Combination Weight Rating offers a significant challenge to brake systems and safety could be substantially enhanced with an advance brake fade warning system. Develop and demonstrate capability of upgraded brake system for U.S. Army up-armored tactical vehicle. It is recommended that the contractor consider the ability to retrofit the HMMWV and/or M-ATV vehicles as these are in wide use within the military and offer significant sales opportunities.

PD LTV has identified the need to explore and implement new technology to improve performance in severe mountain braking environments. PD-LTV would benefit from a contractor's development of new brake technology for a light tactical vehicle to meet performance requirements for mountain descent braking. These technologies include Electronic Brake Distribution, alternative pad materials, caliper & rotor redesign, and in-board and out-board brake system configurations. Of these technologies, PD LTV indicated their recommendation for Phase III focus would be to advance the state of the art for brake pad material solutions in particular for the uparmored HMMWV.

The ability to execute the laboratory test procedure developed by this SBIR may require a new or unique laboratory facility according to the laboratory specifications provided by the contractor in Phase II.

REFERENCES:

1. Norman, K.D., Lynett, J.W., Singh, A., et al, "Mountain Braking Test Venue Study," 12 December 2013, TIC Registration No. 24377.

2. Department of Defense Army Tank Purchase Description, "Off-Vehicle Brake Testing for Military and Militarized Commercial Ground Wheeled Vehicles Over 3,500 kg (7,716 U.S. Lbs.) Gross Vehicle Weight Rating," ATPD-2354A, 2007-11-27.

3. US Army Aberdeen Test Center Test Operations Procedure, "Braking, Wheeled Vehicles", TOP 2-2-608, 2008-05-20.

4. Miller, R.W., "Mountain Directory East for Truckers, RV, and Motorhome Drivers," R&R Publishing Inc., 2006-01-05.

5. Miller, R.W., "Mountain Directory West for Truckers, RV, and Motorhome Drivers," R&R Publishing Inc., 2006-04-04.

KEYWORDS: STOPPING, BRAKING, MOUNTAIN, DYNAMIC TEST, TEST FACILITY, LABORATORY TEST, ROAD TEST, HEAT TRANSFER

A15-073 TITLE: Multi-Sensor Radar Processing for Unmanned Convoys

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop a multi-sensor radar processing system for unmanned convoy operations.

DESCRIPTION: AMAS (Autonomous Mobility Appliqué System) uses multiple platform kits that integrate low-cost sensors and autonomous control systems onto U.S. Army and Marine Corps tactical vehicles to assist drivers or enable autonomous operation in convoys. Robotic systems like AMAS will be highly dependent on sensor performance to complete their defined mission. The accuracy of these sensors and their ability to perform in various weather and environmental conditions (smoke, fog, dust) will have a large impact on mission success. At a time of decreasing budgets, price becomes a major issue and the ability for these sensors to leverage commercial markets, like the automotive market, provides both a major opportunity and incentive for cost reduction.

For environmental sensing three major sensor types have been popular; radar, lidar and camera systems. Radar's advantage over electro-optical systems (lidar, camera) is that its performance is only minimally degraded in inclement weather conditions or in dust, smoke and other obscurants. Automotive or similar millimeter-wave radars are low cost and can provide accurate range and velocity estimation of moving obstacles under most environmental conditions. Current automotive radar's main disadvantages are that it has poor azimuth discrimination, poor object sizing, and a poor ability to classify static obstacles. Because of the size limitations, automotive radars typically have antenna arrays less than six inches wide. This size limitation, combined with the limits in transmit power (<10mw in the 77 GHz band), results in angular resolutions of around 2 degrees in azimuth. This is often barely sufficient to estimate if an object is in the vehicle's lane and is not reliable for estimating the size of an object and the location of its edges, in order to sufficiently avoid the obstacle. Furthermore, automotive radars typically cannot distinguish between vehicles and nonthreatening objects (like soda cans) based on radar return alone, so typically they use motion of the object (for moving objects) and camera fusion (for stationary objects) to determine if an object is another vehicle or not. Some automakers have incorporated the fusion of multiple radars at the object track level to improve performance and the field of view of the radar system, but this approach is still lacking the performance of lidars and higher end radars.

As mentioned previously, one of the major limiting factors in the performance of a radar is the size of its antenna array. Radar performance can be enhanced, without increasing the antenna array size, by combining the data from multiple radars at the return level in a MIMO (multiple input multiple output) fashion. The goal of this project is to examine the performance of wide-scan angle (> ± 20 degrees) and narrow beam radar or to use multiple low cost radar "front-ends" to mimic the performance of higher end radar systems, while still maintaining the cost advantages of using automotive components. Particular goals of this project would be focused on improving the size and location estimates of target objects, improving the classification of static obstacles, and using the radar data for localization of the host vehicle. In situations where target discrimination cannot be accomplished based on the radar's range and cross-range resolutions, target identification and discrimination may be accomplished by radar polarimetric techniques. Nominal goals would be to achieve object size and localization within 10 cm at a 50 m distance 99% of the time and object classification into categories bins (large truck, car, motorcycle, person, other) with 99% accuracy.

PHASE I: Design and demonstrate system feasibility in a simulation environment, by using multiple radars on a single truck to improve size and location estimates of target objects and improve classification of static obstacles based on wide angle scanning radars and radar polarimetry. The system should be able to use all the radars within a multi-vehicle convoy synergistically to map roadside structure, to assess terrain structure (road surface conditions), to detect vehicles, hazardous obstacles, and pedestrians, and to estimate vehicle location within the convoy. The Phase I deliverables shall include a report describing the system sensing hardware requirements, an analysis of expected system accuracy across a range of mission conditions, and an analysis of computation and communication requirements.

This system should use frequencies and power levels acceptable for automotive applications. The use of the allocated 79 GHz band (77 to 81 GHz) spectrum is preferred. Nominal range would need to be 150 m or greater and field of view should be as good as or better than existing automotive radar sensors (16 degrees).

PHASE II: In this phase a prototype implementation of the Phase I design will be expected, initially as a benchtop implementation that can be evaluated at a sensor range. If this proves successful, the next step would be installation on one of the AMAS tactical Army trucks and its performance compared against the existing AMAS sensor suite. Phase II deliverables include the prototype system and a report detailing the activities in the project.

PHASE III: In this phase a commercialization path will be implemented. Manufacturing partners shall be identified and initial commercial customers identified. Cost and volume targets shall be aligned with commercial/automotive needs (i.e. less than $300 at 100,000 units/year). The project has application both to military and civilian automotive applications, including efforts in convoying and platooning.

REFERENCES:
1. https://itunews.itu.int/en/3935-Future-trends-for-automotive-radars-Towards-the-79GHz-band.note.aspx

2. Curlander, J.C. and R.N. McDonough, Synthetic Aperture Radar, Wiley Interscience, New York, 1991.

3. Goodman, J.W., Introduction to Fourier Optics, McGraw-Hill, New York, 1968.

4. ARS 300 Long Range Radar Sensor 77 GHz, <http://www.conti-online.com/www/industrial_sensors_de_en/themes/ars_300_en.html>

5. Delphi Electronically Scanning Radar, <http://delphi.com/shared/pdf/ppd/safesec/esr.pdf>

6. Bosch Handbook for Safety, Comfort and Convenience Systems, <http://www.bentleypublishers.com/bosch/engineering-and-motorsports/bosch-hdbk-safety-comfort-systems.html>

KEYWORDS: Autonomy, Unmanned Ground Vehicles, Convoy, Sensor Fusion, Vehicle Control

A15-074 TITLE: Development of Nano-Reinforced 7075 Derivative Alloy For Structural Components

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

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: Development of Nano-Reinforced 7075 Derivative Alloy For Structural Components

DESCRIPTION: Structural components for the military are produced from a variety of materials, from steel to iron to different grades of aluminum. There is considerable opportunity to reduce weight of combat vehicles if there was a strong, casting-friendly aluminum alloy. The strongest cast aluminums available today are A206 or A201. Currently, the final drive housings and covers for the Bradley are produced from A206 aluminum heat treated to the T4 for maximum damage tolerance with nominal mechanical properties of 50,000 tensile, 30,000 yield and 10% elongation in designated areas. A201 can be produced to the T43 temper with nominal mechanical properties of 60,000 tensile, 35,000 yield and 15% elongation in designated areas. While castings having these properties have functioned successfully on the M2 Bradley, the M1 Abrams uses a steel final drive housing. The estimated weight of the housing is 150 pounds. The opportunity with nano 7075 is to reduce this weight by as much as 50%. At two housings per vehicle, the weight reduction opportunity is 150 pounds. Once the alloy and process are ready, a number of other components could be evaluated for conversion, such as the sprocket. The sprocket may require iron inserts for high wear areas and these inserts could be integrated into the casting.

Complicated geometries are prone to hot tearing and elongation can be variable, depending on local solidification conditions. In casting of 7075 alloys, it is important to minimize the iron and silicon content of the alloys, to achieve high elongations and mechanical properties. The alloy may be less sensitive to impurity levels by substituting some or all of the copper with Nickel as in the Nickalyn alloys combined with the addition of low levels of nanoparticles to improve hot tearing, elongation and corrosion performance and weldability.

With nanoparticles, the number of particles for a given weight percentage is very high, due to their very small sizes. Particle numbers beyond what is required for strengthening or hot tear arrest is a waste of particles. From a practical standpoint, reinforcement levels of over 2% are difficult to maintain, due to particle agglomeration. Once particles agglomerate, they begin to act as though they are a single larger particle, which defeats the purpose of nano-particles. [If more particles are desired to increase stiffness, for example, hybrid composites that use both nano and micro particles would be more appropriate. That is not the essence of this SBIR topic. While hybrid nano/micro composite materials have very high strength, their elongations are limited. The typical elongation of a typical micro-particle metal matrix composite is less than 1%, making it impractical for structural housings.]

PHASE I: Phase I will develop 7075 and variants (including but not limited to Nickalyn), with the addition of (e.g. 1%-2%) nano-particles, to assess cast-ability and mechanical properties performance. This initial work will be done using cast coupons, to determine what is possible. The root cause of the lower elongations in this alloy system is assumed to be the formation of intermetallics during solidification, which cannot be dissolved during heat treat. The process of the addition of the nanoparticles using an electric field is one possible way to break up primary silicon in the alloy. This same mechanism could be successful to break up the iron and silicon intermetallics in 7075, resulting in higher elongations than for the non-reinforced alloy. Success in this phase (using castings in a step plate mold) is defined as achieving minimum mechanical properties of 75 ksi UTS, 65 ksi YS, and an anticipated range of 3-9% elongation (nominal 6%). [65ksi Yield Strength is approximately 3 times better than A-356 (a commonly cast grade of aluminum). 65 ksi YS is comparable in strength to ductile iron, at 1/3 the density].

PHASE II: In Phase II, a casting of significant complexity will be produced, (such as the M1 Abrams Final Drive Cover). The final drive should be designed and analyzed as an aluminum casting, taking into effect the stiffness, strength and density of aluminum vs. steel). Cast-ability and mechanical properties will be assessed, along with corrosion performance and weld-ability. Also, a study on homogeneity of microstructure/ properties shall be performed, to help determine the effects of casting thickness on solidification rate.

PHASE III: After determining a feasible, production ready composition for achieving the desired properties, the final demonstration product/ component will be evaluated by the proper PM, to compare to the anticipated potential 50% weight reduction.

REFERENCES:
1. Ultrasonic Cavitation Based Dispersion of Nanoparticles in Aluminum Melts for Solidification Processing of Bulk Aluminum Matrix Nanocomposite: Theoretical Study, Fabrication and Characterization Journal: AFS Transactions 2007, Vol. 115, Paper 07-133(02). Author: Li, X.; Yang, Y.; Weiss, D.

2. High Strength Cast Al-Zn-Cu-Mg Aluminum:Solution Treating and Aging Study Journal: Transactions of the American Foundry Society, 117th Annual Metalcasting Congress, Paper No. 13-1568, P231-241, April 6-9, 2013. Author: Druschitz, E., Foley, R.D., Griffin, J.A.

3. Wrought Alloys: A New Gateway for Casting Designers Journal: MetalCasting Design & Purchasing, Vol. 12, No. 5, P 34-38, September/October 2010. Author: Gibbs, S.

4. High Strength Cast Al-Zn-Mg-Cu: Tensile Properties Journal: Transactions of the American Foundry Society, 117th Annual Metalcasting Congress, Paper No. 13-1569, P243-251, April 6-9, 2013. Author: Druschitz, E., Foley, R.D., Griffin, J.A.

KEYWORDS: Aluminum, Casting, 7075, high elongation, nano-particles, lightweight, 75ksi

A15-075 TITLE: LOw TRavel Isolated Floor (LOTRIF)

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop an innovative isolated floor solution that attenuates energy from underbelly blast using the minimum floor stroke to maximize package efficiency.

DESCRIPTION: Concepts for isolated flooring systems have shown promise for attenuating the energy from underbelly blasts and helping to prevent occupant injuries. One of the primary challenges of integrating an isolated flooring system into a vehicle design is the packaging space required and the impact this has on overall vehicle size and weight.

This project is intended to develop innovative isolated floor solutions that achieve the benefits of injury mitigation while minimizing the overall impact on vehicle size and weight. The development of the isolated flooring systems will explore potential architectures and technologies that can achieve these goals.

Specifically the isolated flooring system shall be contained within a minimum overall package space, and attenuate energy within a 2"(O) to 4"(T) additional vertical "stroke" during the event for the targeted vehicle and blast threat. At a minimum the flooring system shall be able to eliminate lower leg injuries given a 350G global input (to the vehicle system), and survive a 5G (vertical), 4G (lateral), 3G (transverse) road loads for a typical military vehilce driving profile.

PHASE I: Phase I of the project will include a system to evaluate the effectiveness of concepts through simple modeling and simulation. Throughout the project, the goal of the effort will be to maximize the effectiveness of attenuating underbelly blast energy while minimizing the travel and package space required. Simple simulations will include some evaluation of the effectiveness of the system to varying acceleration input levels and pulse shapes. Additionally, identification of key design parameters with performance sensitivities could be developed. At the end of the first phase, a leading architecture will be down selected.

PHASE II: Phase II of the project will include integrating the down selected, top performing concept into a vehicle design and developing a representative sub-system test. The objective of the second phase will be to design, build, and test a sub-system to further develop the low travel isolated flooring system. It is expected that performance would be predicted through modeling and simulation and all testing be correlated to the model. Phase 2 could also include additional refinement of a proposed design to include improvements identified through modeling and simulation and testing.

PHASE III: LOw TRavel Isolated Floor (LOTRIF) could be integrated by designing the system into an existing Military platform and including the benefits of the energy attenuation of the flooring system in the overall strategy to prevent occupant injuries from underbelly blast. Phase III of the program will choose a PEO/PM platform in need of increased occupant survivability with limited package to accomplish the goal, and integrate the solution on to that platform such as; Joint Light Tactical Vehicles (JLTV), Mine Resistant Ambush Protected (MRAP) Family of Vehicles, Bradley Fighting Vehicles, Stryker, AMPV, Marine Personel Carrier (MPC), etc.

If developed into a COTS system as a commercial technology it could be potentially inserted into defense systems as a result of this particular SBIR project.

REFERENCES:

1. "Retractor-Based Stroking Seat System and Energy-Absorbing Floor to Mitigate High Shock and Vertical Acceleration". Babu, Thyagarajan, and Arepally 2014-04-15, presented at NATO AVT221 Meeting 2014-04-7.

2. "The Evolution of Energy Absorbing Systems For Crashworthy Helicopter Seats". Desjardins.

3. "Ares I Thrust Oscillation meetings conclude with encouraging data, changes". NASASpaceFlight.com. 2008-12-09. Retrieved 2010-02-07.

4. "Shock Absorber Plan Set for NASA's New Rocket". SPACE.com. 2008-08-19. Retrieved 2010-02-07.

5. "Protecting Against Blast" Modern Day Marine Expo, AUSA 2007.

6. "Encapsulated Air Energy Absorbing Flooring". http://www.sbir.gov/node/385802. Retrieved 2014-05-07.

KEYWORDS: Isolated Floor, Damper, Shock Absorber, Blast, Energy Absorbing Device, Floor, Stroke, Stroking Floor, Energy absorbing floor, travel, package space, tension, mechanical deformation, mine blast, blast mitigation, occupant floor, energy absorption, increased blast threats, ground vehicle, force protection, occupant protection

A15-076 TITLE: <u>New Mid-IR Laser Power Scaling Technology via Fiber Combiner</u>

TECHNOLOGY AREAS: Electronics

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

foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop an innovative power scaling technology for the amalgamation of different wavelength (2 - 5 microns) mid-wave infrared (MWIR) laser beams that provide high-power beam delivery on a single optical fiber or aperture and meet military environmental specifications.

DESCRIPTION: Next generation Infrared Countermeasures (IRCM) and other systems will require multi-wavelength, high power (25 to 50 watts) lasers in the mid-wave infrared (MWIR). There are current laser sources, such as quantum cascade lasers (QCLs), which cover the entire MWIR spectral range, but they are limited in the output power (2-10 watts) that can be delivered. A new optical fiber technology is sought for the combination of MWIR laser sources having different wavelengths. The technology will enable the production of wideband laser systems having an increased total output power. Free-space bulk optics and complex packaging are not desired. A compact design is desired that can meet military environmental specifications, such as temperature and vibration requirements. A fiber optic combiner is preferred. Considerable progress has been made with fused fiber combiners using Chalcogenide low loss mid IR optical fibers. Chalcogenide fibers have also shown a high laser damage threshold. All MWIR lasers shall be amalgamated under this technology into a common fiber aperture for power of ~50 Watts. The system must have low insertion losses, < 5% (<-0.2dB), and good beam quality (M^2 < 3).

PHASE I: Develop a design and perform initial proof-of-principle tests and analysis of a laser power scaling technology compatible with current laser sources in the MWIR spectrum range of 2–5 microns. Assess and model the losses and powers that can be coupled in the optical fiber combiner for various input laser combinations and power scaling. Assess and perform IR Laser Damage Threshold of the IR fibers to be used for beam combining.

PHASE II: Based on the design proposed in Phase I, produce laser power scaling Chalcogenide fiber technology that is capable of coupling 50 watt mid-wave infrared lasers operating in wavelengths between 2–5 microns into a common aperture with low insertion loss and good beam quality. Test and evaluate the new laser power scaling technology performance, losses, and beam quality.

PHASE III: MILITARY APPLICATION: This technology has applications in infrared missile countermeasures, development of high-power mid-infrared lasers, long-range target identification, and remote sensing of biological or chemical agents.

COMMERCIAL APPLICATION: Commercial applications of this technology include remote sensing of industrial effluents, gas leaks detection, mineral/petroleum prospecting, medical and dental surgery, LIDAR and free space optical communications.

REFERENCES:
1. Lee, Benjamin G., et al., “Wavelength beam combining of quantum cascade laser arrays for remote sensing,” Proc. of SPIE Vol. 7460. pp. 746004-1-746004-9 (2010).

2. Xiao, Q., et al., “Tapered Fused Fiber Bundle Coupler Capable of 1 kW Laser Combining and 300W Laser Splitting,” Laser Physics, Vol. 21, 8, pp. 1415-1419, (2011).

KEYWORDS: mid-wave infrared, power scaling, countermeasure, Infrared Countermeasures, IRCM

A15-077 TITLE: Optical Aperture Synthesis for Airborne ISR Platforms

TECHNOLOGY AREAS: Sensors

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

OBJECTIVE: Determine the feasibility of replacing traditional airborne optical ISR sensors with optical aperture synthesis (OAS) technology in order to increase spatial resolution capability and detection range while simultaneously reducing sensor size, weight, and mitigation of gimbaling complexity and cost.

DESCRIPTION: Airborne platforms and particularly aerostats have proven themselves to be a highly effective and survivable Persistent Surveillance ISR tool during recent war efforts. Aerostats offer many unique force multiplying attributes, however to fully leverage these attributes it is necessary to look to improved sensor technologies that blend synergistically into the aerostat environment and leverages the natural advantages that aerostats offer. Today's sensors are leveraged principally as off the shelf solutions that were developed for use in other airborne platforms that have vastly different performance envelope requirements that drive both their higher cost and weight/size considerations.

The imagery arena is one area that may benefit significantly from a fresh look at sensor technologies and requirements. Aerostat sensors need to be extremely light weight. The aerostat airborne environment is significantly more benign than aircraft environments, motion stabilization and "g" loading is much less severe. Aerostats by their nature pose some risk of loss to the "tether up" portion hence consideration is needed for split processing to off load as practical this to the ground shelter. The "tether up" loss risk also drives more emphasis on cost reduction for the "tether up" portions. To that end Aerostats compared to other airborne platforms offer significantly improved ground power, shelter environments to house advanced signal processing, because of shelter infrastructure they offer opportunity for network centric solutions and connectivity.

Optical Aperture Synthesis has been employed in such domains as optical astronomy since the turn of the century; it represents an interferometric technique in which the output from a number of optical sensors separated by a significant baseline is combined to produce images with the equivalent spatial resolution as a single sensor occupying the size subtended by the entire collection of individual sensors. In order to accomplish this both the incident amplitude and phase of incoming light must be determined for each individual optical sensor. Given the high frequencies of visible and near infrared this determination cannot be made solely by post-processing software; the actual light must be propagated by very accurate optics and must undergo optical interference. Such a system must also compensate for atmospheric wavefront aberrations. Key critical technical risks include instrument calibration, accurate pointing and beam-feeding, and optical path length adjusting.

Individual optical sensor element pairs produce fringes with specific periodicity, orientation, visibility, and phase. If performed properly, the point spread function will lead to fringe reinforcement on axis and cancellation off axis (constructive/destructive interference), resulting in an overall improvement in spatial resolution. Challenges in applying this technique on a military airborne platform include, but are not limited to the fact that targets often occupy a complex cluttered scene and are of low contrast and the OAS must have each individual optical sensor image ‘locked’ on the same target to result in satisfactory interference. Further, mounting on an airborne platform such as an aerostat will require significant inter-sensor separation while still allowing the airframe to remain aerodynamically efficient and permitting the addition of other unrelated mission instrumentation to the airframe. This will require accurate wave guides and dispersion control. Additionally, image processing must take place in near real time meaning significant processing capability will be required. Distances to small targets in military applications can be significant and will require active laser illumination in some cases; that is, illumination beyond ambient sunlight. Boresight stability can be adversely affected by airframe flexure, vibration modes, etc. Optical waveguides will require excellent dispersion control in order to maximize signal coherence length and fringe visibility.

The use of active illumination would increase platform standoff range and allow for nighttime operation. Employing an OAS array to project interference fringes onto a target and integrating the return allows for optimal imaging. The employment of Fourier telescopy (inverse transform of the return data) would facilitate the mitigation of anisoplanatic effects due to atmospheric disturbances while allowing for a relaxation of pointing accuracy (precision gimbaling).

PHASE I: Develop a design and perform initial proof-of-principle of an optical aperture system utilizing an optimal number of dispersed optical sensors via modeling and simulation for optimized performance on representative Army airborne platforms.

PHASE II: Based on the Phase I results, produce an optical bench breadboard demonstration using scaled components. The demonstration should actively employ Fourier Telescopy methods, and illustrate active real time compensation for flexure or torsion that results in sensor deviation and baseline changes as a function of time, in order to demonstrate suitability for aircraft, aerostat, or UAV applications.

PHASE III: MILITARY APPLICATION: This technology has military applications in the design of a new generation of visible and infrared precision aerial full motion video imagers and cameras to be used in intelligence, surveillance, and reconnaissance, force protection, precision geolocation, small target identification at large standoff distances, aircraft survivability, and reduction in size, weight, and optical complexity/expense that would be required were a single optical sensor deployed possessing the same spatial resolution.

COMMERCIAL APPLICATION: Commercial applications of this technology include search and rescue, facility protection, 3D facility imaging, remote sensing, agriculture, forestry and geological studies, and aerial mapping, precision geolocation.

If Phase II demonstrates a significant degree of success in the areas of technical achievement, improvements in SWAP and significant cost reduction over the current state of the art and best of breed, PM Sensors Aerial Intelligence would seek to team with PM Terrestrial Sensors in funding Phase III for the development and commercialization of this sensor technology. The resulting technology would be utilized on both ISR airborne manned and unmanned platforms as well as aerostats.

REFERENCES:
1. Greenaway, Alan H, Johnson, Anne Marie, Harvey, Andy, Mudassqar, Asloob, Ball Ken, “Optical Aperture Synthesis,” 1st EMRS DTC Technical Conference, Edinburgh, 2004, pp. 1-5.

2. Saha, Swapan K. “Aperture Synthesis: Methods and Applications to Optical Astronomy” Springer, ISBN: 144195709X, 540 pp. 2010.

3. Wang, Dayong, Fu, Xiyang, Guo, Hongfeng, Tao, Shiquan, Zhao Bo, Zhen, Yijia, “Analysis of Field-of-View of Optical Aperture Synthesis Imaging Interferometry”, Proceedings of SPIE Vol. 5636, pp. 40-47.

4. van der Avoort, Casper, Dissertation: “Optical Aperture Synthesis: A Comparison of Techniques for Wide-Field Interferometric Imaging”, Technische Universiteit Delft, 2005, pp. 1-212.

5. Malbet F, Kern P, Schanen-Duport I, Berger J, Rousselet-Perraut K, and Benech P, “Integrated Optics for Astronomical Interferometry”, Astron. Astrophys. Suppl. Ser. 138, 1999, pp. 135-145.

KEYWORDS: optical aperture synthesis, interferometry, fourier telescopy, reconnaissance, surveillance, aerostat

A15-078 TITLE: See-through-the-Sensor Ballistic Wind Measurement

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: Identify methods to extract meteorological measurements from Counter-fire Target Acquisition (CTA) radar echoes to provide the radar and counterfire weapon with ballistic trajectory correction estimates and the crew with hazardous weather warnings. This capability is needed for when joint meteorological data from the US Air Force is not available due to downed communications, or when the US Air Force's radar coverage isn't available or isn't at the granularity or pedigree required to improve CTA radar performance and improve counter-fire locations.

DESCRIPTION: Study and develop algorithms to reduce target location error as a function of wind and refractivity measurement. Send wind estimate to Army Field Artillery Tactical Data System (AFATDS) for ballistic correction of indirect fires. Display hazardous weather conditions to the soldier including precipitation, wind, and thunderstorms. Distribute to consumers within the Brigade Combat Team (BCT) and Field Artillery (FA) Brigade meteorological data of weather effects that impact tactical warfighting functions. This includes but is not limited to ballistic meteorological data for indirect fires as stated above, real-time data for more accurate reporting and prediction of nuclear, biological and chemical agent conditions and downwind hazards, the employment of obscurants and non-lethal munitions, and real-time weather conditions for employing manned and unmanned aerial platforms in the brigade operational environment.

PHASE I: Analyze and conduct modeling and simulation to determine the feasibility of utilizing see-through-the-sensor technology for ballistic trajectory correction and hazardous weather warning. Develop an initial concept design and model key elements to conduct proof of concept.

PHASE II: Design and develop a see-through-the-sensor prototype. Conduct testing to prove feasibility over extended operating conditions.

PHASE III: Develop tactical software and/or hardware changes to modify a PEO M&S CTA radar to provide See-through-the-Sensor Meteorological Measurement for Ballistic Correction and Hazardous Weather Warning. Complete development for ready transition to fielded software and an engineering change proposal.

Potential commercial application includes the development of a see-through-the-sensor capability for Air Traffic Control radars which would warn of wind shears, tornados, lightening and other hazardous weather.

REFERENCES:
[1] Multifunction Surveillance Radar Testing – HWDDC and the SPS-48E Meteorological and Aircraft Surveillance Capability, Timothy Maese, H. S. Owen, J. A. Hunziker, F. Yezril, L. Wagner, R. Case, 26th Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology; 01/2010

[2] A New Method for Compressing Quality-Controlled Weather Radar Data by Exploiting Blankout Markers Due to Thresholding Operations, W. David Pan, Paul R. Harasti, Michael Frost, Qingyun Zhao, John Cook, Timothy Maese, Bryan T. Akagi, Claude Hattan, Lee J. Wagner, 27th Conference on Interactive Information Processing Systems (IIPS), 01/2011

[3] Extracting Weather Data from a Hybrid PAR, Timothy Maese, Randy Case, MPAR Symposium 2, Norman, OK; 11/2009

[4] HAZARDOUS WEATHER DETECTION AND DISPLAY CAPABILITY FOR US NAVY SHIPS, Timothy Maese, Jim Hunziker, Henry Owen, Mike Harven, Lee Wagner,Richard Wilcox, Kim Koehler, Cdr Gerald Cavalieri, 23rd Conference on IIPS, 01/2007

KEYWORDS: See-through-the-sensor weather, radar, counterfire target acquisition, Chemical, Biological, Radiological, Nuclear, CBRN, Ballistic Correction, Army Field Artillery Tactical Data System, AFATDS, Brigade Combat Team, BCT, Field Artillery, FA

A15-079 TITLE: Beam Director for Ultra Short Pulse Laser Long Range Target Acquisition, Targeting, and Engagement

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: The objective of this effort is to define and develop novel ultra short pulse laser beam directing technology to permit the outside testing of ultra short pulse lasers (USPL). The primary focus of this effort will be to develop and demonstrate a beam director capable of directing and delivering a USPL burst at an outdoor target ~2 km from the test site in a ground to ground test or 15 km in a ground to air test.

DESCRIPTION: Ultra short pulse laser (USPL) technologies are being developed in the laboratory for fixed range fixed aim point testing. These sources may have alternate applications as electromagnetic (EM) wave sources to probe long range targets for hazardous materials or for counter ordinance applications. Pulses generated by a single USPL source produce large amounts of EM energy on target to either probe for hazardous materials or to cause damage in flight of flying munitions by removing the traditional energy losses associated with electromagnetic propagation. USPLs used in their native mode, can be used to produce an intense "white light" spectral source for a variety of sensing and counter munition applications and because of the nature, power, and angle of the delivery, these sources can also be used as a non-conventional probe for the defeat of standard EW countermeasures such as Digital RF Memory (DRFM) Jammers.

Combined with the appropriate sensors, USPL sources may provide a number of unique capabilities for the spectroscopic detection of Chemical, Biological, Radiological, or Nuclear (CBRN) threats at long range. For example, the output could be directed and swept over a threat object to provide an on target white light source while removing small amounts of material to provide a spectrographic profile for the identification of surface materials on the object or in nearby atmospheric clouds. In addition, the pulse characteristics could be effective against stealth-type targets or DRFM technology by scanning a suspected area or object to see if it really exists from the white light return or to create confusing signals that would give away a DRFM jammer.

Additionally, USPL systems can be used to damage guided and nonguided munitions. This is accomplished by causing physical damage to the round which would either burn the guidance package or fusing of the round. More details will be provided at the start of a contract as to the target wavelength. A DD254 and classification guidance will be provided with any contracting package.

PHASE I: In this phase the feasibility of an USPL beam director will be investigated. Several candidate designs will be developed and evaluated at a system block diagram level. The designs will be traded with respect to their technical feasibility and performance advantages and disadvantages. One of the candidate designs will be chosen and a more detailed design will be developed. If it appears that USPL beam director concept has merit a Phase II and Phase III development plan will be formulated.

PHASE II: Based upon the Phase I results demonstrating a physical implementation of the beam director capable of delivering multiple ultra-short pulse laser pulses to multiple targets 2 km from the beam director off axis from the bore site of the laser. The test targets will be determined during the Phase II development and mutually agreed upon.

PHASE III: For Phase III, based upon the Phase II and available funding, a version of the beam director that meets military specifications will be developed for outdoor testing at government test ranges. Potential applications include remote testing for hazardous materials at government test facilities, remote sampling of mineral deposits, and various other remote sensing capabilities.

REFERENCES:
[1] F. Krausz et al., "Femtosecond solid-state lasers", IEEE J. Quantum Electron. 28 (10), 2097 (1992)

[2] P. J. Delfyett et al., "High-power ultrafast laser diodes", IEEE J. Quantum Electron. 28 (10), 2203 (1992)

[3] P. M. W. French, "The generation of ultrashort laser pulses", Rep. Prog. Phys. 58, 169 (1995)

[4] S. Backus et al., "High power ultrafast lasers", Rev. Sci. Instrum. 69, 1207 (1998)

KEYWORDS: Ultra Short Pulse Laser, white light source, receivers, CBRN sensor, counter missile, plasma

A15-080 TITLE: <u>Variable Video Compression for Training Data Capture</u>

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

OBJECTIVE: Develop intelligent video compression software that automatically adapts to video scene content when encoding video for transmission and archival. The goal is to limit the average and peak bitrates while preserving data quality to support re-transmission of video feeds from mobile units during live training events. An innovative approach is desired that provides automated analysis of video content to extract parametric data which is used to adjust compression settings.

DESCRIPTION: The number of available video feeds from ground and airborne sources is proliferating in training exercises for both Blue Forces and Opposition Forces. This data is collected to support situational awareness and generation of an after action review (AAR) including selectively captured video segments of interest. Given the magnitude of current video data rates, data collection options are limited to backhaul via point-to-point microwave and static fiber connection points. The US Army Maneuver Combat Training Centers are being modernized with a 4G LTE cellular Range Communication System (RCS). A mobile solution is desired that would support UAS video data collection and dissemination over the RCS wireless access network. It is anticipated that the RCS will be bandwidth constrained and will be stressed if tasked with transporting multiple video feeds. Present bandwidth reduction methods use pre-selected generic frame rate reduction or manual feed down-selection to reduce the amount of data archived, neither of which can automatically adapt to changing content.

This solicitation seeks innovative methods to capture video at a quality commensurate with the activity present in the scene along with use of out of band data to adapt and queue the analysis algorithm. “Events of Interest” include, but are not limited to, vehicle and dismount movement, tactical engagements, and detection of concealed units. Periods of less interest are when there is no activity, personnel or material in the field of view. The solution is expected to develop algorithms for analyzing video content and automatically adjusting compression parameters to minimize average and peak bandwidth use.

The proposed effort should include:
1. Automated analysis of video content and other data to classify the captured activity. Activity classes should be related to the content important for AAR tasks.
2. Apply a video compression algorithm (output format should be an industry standardized video codec such as h.264 or MPEG-4) with parameters and a bitrate goal that takes the activity analysis results into account.
3. Support interactive operation blending automated outputs with manually selected regions or times of interest based on AAR focus.
4. Post exercise after action review (AAR) and data analysis support.
5. Quantification of approach and alternatives.

The objective system will operate on a mobile ground platform and receive video feeds from existing equipment (e.g. via One System Remote Video Terminal (OSRVT) or Ground Control Station). The feeds may include additional metadata along with the video feed. The solution is envisioned to be mobile/portable and be hosted on a processor co-located with an OSRVT or Ground Control Station in a live training field environment. The output from the video processor will be transmitted via the RCS back to the control center where it will be archived in the Data Center subsystem. The archived video data format should conform to existing video encoding standards to enable viewing and post-processing with existing Video Monitoring Recording and Editing (VMRE) tools.

PHASE I: Conduct research on automated analysis of video content and dynamic data compression methods. Identify "events of interest" to extract parametric data which is used to dynamically adjust video compression settings based on context of the video scene. The research should treat the number of video streams as a dependent variable, along with characterize and parameterize the frequency and duration of “events of interest”. Research methods of incorporating out of band data to adapt and queue the analysis and compression algorithms. Develop and demonstrate a prototype algorithm on a representative video feed. Example performance metrics include average data rate, peak data rate, and ability to capture and tag "events of interest".

PHASE II: Develop a prototype variable video compression software to run using feeds from a mobile video source (e.g. OSRVT or specified ground station). Conduct tests to demonstrate and quantify performance. Demonstrate the application to Subject Matter Experts for feedback and concept iteration.

PHASE III: Upon completion of Phase II, an automated video re-transmission system will have been demonstrated using typical video feeds. Demonstrate a high Technology Readiness Level (TRL) system in the final form factor integrated with objective equipment and integration with the RCS. The technology developed resulting from this research would be applicable to commercial applications involving video surveillance in the realm of security, law enforcement and public safety.

REFERENCES:
1. ISO/IEC JTC 1, “Coding of audio-visual objects – Part 2: Visual,” ISO/IEC 14496-2 (MPEG-4 Part 2), Jan. 1999.

2. Sullivan, Gary J.; Wiegand, Thomas (January 2005). "Video Compression—From Concepts to the H.264/AVC Standard" (PDF). Proceedings of the IEEE 93 (1).

3. C. Fenimore, J. Irvine, D. Cannon, J. Roberts, I. Aviles, S. Israel, M. Brennan, L. Simon, J. Miller, D. Haverkamp, P. F. Tighe, and M. Gross, “Perceptual study of the impact of varying frame rate on motion imagery interpretability,” SPIE Conference on Human Vision and Electronic Imaging XI, San Jose, CA, SPIE 6057–17 Jan. 2006.

4. Young, D. Yen, J, Petitti, F, Bakir, T., Brennan, M., Butto, R., Video National Imagery Interpretability Rating Scale critera survey results, Proc. SPIE 7307, Airborne Intelligence, Surveillance, Reconnaissance (ISR) Systems and Applications VI, 73070G (April 28, 2009); doi:10.1117/12.816546

KEYWORDS: training, video compression, video analytics, video archival, adaptive compression, automated analysis, after action review, UAS

A15-081 TITLE: Non-Contact Hit Sensing

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

OBJECTIVE: Develop an optic based non-contact sensor that projects a detection field capable of determining ballistic penetration, its location, its velocity, and can accurately identify munitions types. The sensor must support identification and tracking of supersonic, transonic, and subsonic munitions.

DESCRIPTION: The optic based non-contact sensor should utilize common off the shelf elements used in ballistic detection to reduce cost and increase availability. The sensor should support supersonic, transonic, and subsonic detection, using an optic based solution, ultra-violet, radio frequency, or electromagnetic field based technology. The sensor must be capable of integrating into an existing (TCP/IP) live fire range network. The sensor must not be fixed to a target system, and must be capable of operating either in conjunction with a target or in a stand-alone mode (monitoring of windows, ground locations, and other points of interests).

The non-contact ballistic penetration and identification sensor must:
• provide accurate penetration location identification (10mm or one caliber, whichever is greater)
• not rely on an external trigging device to time assessment of the penetration
• able to identify and differentiate between objects penetrating the assessment area (based on a defined list of munitions being used in training)
• be scaleable to address 2-dimensional and 3-dimensional areas
• be portable and allow for expansion (increase area of coverage)
• should be protected from live fire effects without degradation of capabilities
• capable of tracking multiple simultaneous engagements and penetrations (up to 10 rounds per sec)

The sensor will provide improved feedback for multiple uses within live training, and support Live-Virtual-Constructive integration and interoperability.

PHASE I: Determine the feasibility of developing a ballistic penetration, identification and detection sensor that involves supersonic, transonic, and subsonic objects. The study shall determine limitations to accurately detect, identify and locate ballistic objects entering into the detection field/area, impacts of open range conditions, and the means to distribute the data to control or network systems. Solution can address either a single per target solution, or a multi-target solution approach.

PHASE II: Develop a prototype modular ballistic penetration, identification, and detection sensor that can be utilized in conjunction with 2-D or 3-D areas. Demonstrate its ability to identify munitions by caliber, detect multiple objects at a rate of at least 10 per second, have a probability of detection (Pd) of 97% or greater for objects penetration, provide an accuracy of penetration identification of within one width measure of the object, and have a 98% probability for correct classification/identification of objects. Demonstration will be at TRL 6.

PHASE III: Military application: Transition technology to the Army Program called Future Army System of Integrated Targets (FASIT). Technology would be viable for both digital and non-digital ranges, urban operations ranges, and other live fire training ranges where non-contact, point of intersection information can be utilized in engagement scoring at the qualification trainings ranges, battle damage assessments, lethality and engagement scoring at the test and evaluation ranges and cross domain information sharing. The military application could also include a reverse trajectory location of fire.

The ballistic penetration, identification, and detection sensor could be integrated at the system level and utilized in a broad range of military and civilian security applications where automatic detection of high speed grid penetration is required.

Commercial applications include sports applications, gaming applications, and law enforcement applications.

REFERENCES:

1. Donald R. Snyder and Frank M. Kosel; "Applications of high-resolution still video cameras to ballistic imaging", Proc. SPIE 1346, Ultrahigh- and High-Speed Photography, Videography, Photonics, and Velocimetry '90, 216 (January 1, 1991); doi:10.1117/12.23352;

2. Measures, R. M., Laser Remote Sensing: Fundamentals and Applications, Kreiger Publishing Co., Malabar, FL, 1992. ISBN: 0-89464-619-2

3. Susan F. A. Bender, Phil J. Rodacy, Randal L. Schmitt, Philip J. Hargis, Jr., Mark S. Johnson, James R. Klarkowski, Glen I. Magee, and Gary L. Bender. “Tracking Honey Bees Using LIDAR (Light Detection and Ranging) Technology”; SANDIA REPORT, SAND2003-0184, January 2003

4. Training Circular (TC) 25-8, Training Ranges; https://atiam.train.army.mil/soldierPortal/atia/adlsc/view/public/6851-1/TC/25-8/toc.htm

5. Field Manual (FM) 7-1, Battle Focused Training; https://atiam.train.army.mil/soldierPortal/atia/adlsc/view/public/11656-1/fm/7-1/fm7_1.pdf

KEYWORDS: Ballistic penetration location, identification, and detection; Non-contact hit sensor

A15-082 TITLE: Novel Sensors and Data Fusion Methods for an All Weather Tracker

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: To develop new sensors and new methods for combining existing sensor technologies that when employed in a pointer/tracker for a high power laser weapons system, are robust in performance in a battlefield environment that includes rain, snow, fog, or sandstorms. The proposed system should be of size, weight, power and thermal control commensurate with being an integrated component into the beam control system of a mobile weapons platform such as the High Energy Laser Mobile Demonstrator (HEL MD).

DESCRIPTION: Degraded Visibility Environment (DVE) due to weather and battlefield conditions can drastically affect the ability to detect and track RAM (rockets, artillery, and mortars) targets, unmanned aerial vehicles, and cruise missile targets. The HEL weapon system concepts for counter-RAM have used passive MWIR sensors for target acquisition and active NIR imaging sensors for fine track and aimpoint selection. These sensors and their wavebands were selected for operation in clear visibility conditions, and provide performance margin down to hazy and light fog conditions, but the detection range and battlespace can degrade under heavy fog, rain, snow, sand and dust storm conditions. The objective of this effort is to identify wavebands, sensors, and/or image processing techniques that promise to extend the acquisition and track ranges and HEL battlespace in the degraded visibilities environment. Maximum detection range performance against a 60 mm mortar is a key performance metric. A variety of active and passive sensors and sensor wavebands from millimeter wave to LWIR to MWIR to near Infra-red wavebands are of interest. Studies have indicated that data fusion from multiple sensor wavebands may offer the best potential of meeting acquisition and track requirements over the variety and intensity of weather phenomenon.

The purpose of this topic is to develop either (1) an enhanced sensor that is capable of decreasing sensitivity loss for one or more of the weather types, or (2) a method of application, architecture of sensors, or image processing algorithms that can take conventional sensor data and compensate for the weather effects. The latter can concentrate on a single sensor channel or consider a sensor fusion approach that could lead to a single system that can compensate for multiple weather types.

The goal will be to develop a breadboard (hardware and software) to demonstrate acquisition and fine track operation in these degraded visibility environments to these ranges for a 60 mm mortar target:

Clear – 23 km Visibility at >= 10 km
Fog – 400 m Surface Visibility at >= 3 km Range
Rain – 10 mm/hr at >= 6 km Range
Sand and Dust Storm – 56 mph wind at >= 6 km Range

A 90% probability of detection is the objective goal. The probability of false alarm should be 3.7 X 10-6 or less.

PHASE I: Conduct research, analysis, and studies on the selected sensor or data fusion/ architecture and develop measures of performance potential and document results in a final report. Provide analysis supporting expected max range capability. The Phase I effort should include modeling and simulation results supporting performance claims. Algorithms will be fully described and documented. The effort should also produce a preliminary concept and draft testing methodologies that can be used demonstrate the algorithms and components proposed during the Phase II effort.

PHASE II: During Phase II, a breadboard design should be completed. Critical components and algorithms are to be developed and bench tested to verify the performance prediction of the design concept. This will require innovative weather condition simulator design and development. Testing should be conducted to quantify performance against the full range of weather type and intensity goals for the technology. The data, reports, weather simulators, and tested component hardware and software will be delivered to the government upon the completion of the Phase II effort.

PHASE III: There are many applications of an imaging sensor capable of robust operation in inclement weather. Civil, commercial and military applications include scientific remote sensing, laser communication, search and rescue, facility security, and outdoor sports broadcasting. 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. The Phase III effort would be to design and build a robust device that could be integrated into the Army’s HEL TD vehicle. 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.

REFERENCES:
1. Welman Gebhart, "Weather-Degraded Optical Sensor Performance Trades for a Mobile, Ground, Tactical HEL Weapon System," Sixteenth Annual Direct Energy Symposium, Huntsville, AL, 14 March 2014

2. Terry Bauer, "High Energy Laser Mobile Demonstrator (HEL MD) High Power Test Summary," Sixteenth Annual Direct Energy Symposium, Huntsville, AL, 14 March 2014

3. Annual Directed Energy Symposium Proceedings available at: http://www.deps.org/DEPSpages/forms/merchandise.html

KEYWORDS: Degraded Viewing Environment, Sensor Fusion, Image Processing, Tracking Sensor, High Energy Laser

A15-083 TITLE: High Energy Density Solid State Batteries for Military Vehicle Applications

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: To develop solid state battery technology viable for military vehicle applications. This technology has the potential to yield batteries which are safer and more energy dense than current state-of-the-art lithium ion technologies.

DESCRIPTION: Solid state batteries are a research area of high interest in the battery field due to their potential for both high energy densities and high intrinsic safety characteristics. Unlike the lithium ion batteries currently used in automotive applications, these batteries contain no liquid electrolytes. Instead, solid state batteries conduct ions between their electrodes through a conductive, solid electrolyte which is typically made of either a polymeric or ceramic material. Because liquid electrolytes are highly flammable, the elimination of this component removes a major contributor to battery thermal runaway and safety hazards. Moreover, solid state battery designs allow for higher energy densities due to both the intrinsic properties of the materials used to build them and the possible removal of some of the external safety measures that would be required for liquid electrolyte based systems, which add weight to the battery system as a whole.

However, these systems tend to suffer from low power capabilities, especially at low temperatures, due to poor solid state electrolyte conductivity and poor conductivity across solid state interface boundaries within the cell. The development of solid state anode, cathode, and electrolyte materials which interface well together and have sufficient ion conductivities to allow for high power operation at a wide range of temperatures remains a challenge. Current solid state battery technologies are not sufficient for most vehicle applications due to the high power draws required for vehicle starting or hybrid vehicle modes of operation.

This SBIR topic will investigate new materials and improvements to the performance of solid state batteries in order to achieve the power needed for military vehicle applications while retaining the strong safety and energy characteristics of these systems. The goals for this topic are to develop a solid state battery cell with a specific energy of at least 350 Wh/kg, a energy density of 700 Wh/l, a specific power of at least 600 W/kg, and a cycle life of at least 1000 full charge/discharge cycles at a 1C/1C rate (all at 25°C). The performance of the cell should be examined from -46°C to +71°C. The phase I effort would culminate in the demonstration of the technology at the electrolyte and small lab cell levels, while the phase II effort would develop prototype cells (>2Ah).

PHASE I: The phase I effort shall consist of the initial proof of concept for a solid state battery design. This design should include selection of cathode, anode, and electrolyte materials and demonstration of this concept through testing in laboratory scale cells, showing progress toward the goals with a specific energy of at least 350 Wh/kg, a energy density exceed 700 Wh/l, and a specific power of at least 600 W/kg. Cycle life shall be demonstrated over at least 50 cycles at room temperature. Testing should include cycling at low temperatures -18°C to verify the viability of the design for military vehicle applications. The deliverables during this portion of the program will consist of bimonthly reports culminating in a final report.

PHASE II: The Phase II effort shall continue the development of the solid state battery technology demonstrated in Phase I. The technology shall be incorporated into larger scale cells (>2Ah) which exhibit performance goals with a specific energy of at least 350 Wh/kg, a energy density exceed 700 Wh/l, a specific power of at least 600 W/kg, and a cycle life of at least 1000 full charge/discharge cycles at a 1C/1C rate (all at 25°C). Additionally, the cells shall have a power capability of at least 200 W/kg at -18°C. Deliverables in this phase will include bimonthly reports leading to a final report and prototype cells.

PHASE III: The technology developed under this program can be used to develop standardized solid state battery for military vehicle applications. This technology could enable much longer or more energy intense silent watch capabilities for future military systems, while decreasing safety risks and continuing to enable Starting, Lighting, and Ignition (SLI) applications. Moreover, this technology may have use in a number of commercial applications like electric and plug in hybrid electric vehicles and small portable electronics.

REFERENCES:
1. J. B. Goodenough and Y. Kim, Chem. Mater., “Challenges for Rechargeable Li Batteries”, 22(2010)587.

2. M. Armand, & J. M. Tarascon, "Building better batteries". Nature 451(2008)652.

3. Electrochemical Energy Storage Technical Team Roadmap, http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/eestt_roadmap_june2013.pdf/program

KEYWORDS: Battery, Power, Energy, Solid State, Anode, Cathode, Electrolyte

A15-084 TITLE: Gallium Nitride (GaN) Bi-Directional Battery Isolator Unit

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

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 28 VDC 500 amp bi-directional current-limiting device utilizing commercially available Gallium Nitride (GaN) electronic switching devices.

DESCRIPTION: In current military ground vehicles, there are typically two separate banks of batteries. Separation of the two battery sets is accomplished by using battery isolating diodes, which are heavy, inefficient, and prone to failure. One set of batteries is responsible for powering electronic loads, while the other set of batteries is allocated to starting the engine. The existing interface between these two sets of batteries is a manual switch that is controlled by the crew to either connect or disconnect the battery sets. This arrangement does not allow for dynamic use of the full energy storage capabilities of the vehicle to either improve the engine start or increase the duration of silent watch.

A need exists for a device that will allow current to flow in a controlled manner between two MIL-STD-1275E-compatible energy storage devices more efficiently than battery isolating diodes allow. Depending on vehicle use, either energy storage device could be at a higher voltage than the other. The device would be required to transfer current from one energy storage device (source) to the other energy storage device (destination), regardless of which device has a higher voltage. The device should accept commands via J1939 CAN and be capable of transferring a maximum current of 500 amps continuously in either direction when not bucking or boosting voltage. A lower current rating is acceptable while the device is bucking or boosting voltage. The device should be able to accept commands for current flow in either direction. In addition, to ensure the voltage on the source device does not drop below a minimum commanded value and the voltage on the destination device does not exceed a maximum commanded value, the device will limit its current flow. The proposed device should be designed for implementation in a modular fashion with like devices (up to 4 total) in parallel to facilitate integration into scalable power architectures. A successful solution will minimize size, weight, and cooling requirements by taking advantage of commercially available Gallium Nitride (GaN) devices.

PHASE I: Develop a proof of concept for a modular Gallium Nitride (GaN) bi-directional current limiting device 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: The scope of the Phase II will be to develop and demonstrate a prototype of the phase I proposed current limiting device. This demonstration shall show that the prototype can meet expected performance capabilities in conditions representative of military ground vehicle operations (TRL 5).

PHASE III: Mechanical packaging, integration, and demonstration of the solution in an existing military vehicle at TRL 6.

REFERENCES:

1. MIL-STD-1275E

2. MIL-STD-810G

3. MIL-STD-461

KEYWORDS: Gallium Nitride, GaN, battery, energy storage, power management, power conversion, buck, boost, DC/DC, bidirectional

A15-085 TITLE: In-Situ Thermal Properties Measurement Instrument

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Measure the thermal properties (i.e., thermal resistance and capacitance) of layered material stack-ups in situ using a NDE (non-destructive examination) technique.

DESCRIPTION: Obtaining the thermal material properties of military vehicles is important for heating/cooling (HVAC) simulations and infrared (IR) signature modeling. Since the exterior hull and armor directly affect HVAC and IR signature, obtaining these material properties are critical. Conventional measurement techniques require destructive sample removal. This is a problem for a hull or armor structure, especially on threat vehicles obtained by the intelligence community. The goal of this topic is to develop a commercial-quality measurement device to measure the properties in-situ, preferably from only one side of the material. There are many non-military needs for such a device as well, including characterizing building material properties on existing structures or measuring the bulk thermal properties of assembled automotive components like batteries or fuel cells.

Military ground vehicles can be especially difficult to characterize from a thermal (and subsequently an IR signature) perspective because they are typically outfitted with one or more layers of armor that can significantly affect the heat transfer between the vehicle and the environment. In addition, the material make-up of these armor panels, including the thermal properties associated with them, are often not readily obtainable due to the inherent sensitive nature of their composition (from both a proprietary and intelligence/security standpoint). Armor stack-ups can vary from vehicle to vehicle, even among vehicles of the same type; therefore field testing of a particular vehicle of interest is the ideal method for obtaining material thermal properties. However, traditional testing techniques are not employable for components that cannot be removed from the vehicle or damaged in any way (e.g., to drill into the specimen, or to cut away an appropriately sized specimen). Armor plates themselves are usually composed of layered materials, so the NDE techniques must be able to handle multiple layers that have differing thermal properties. The method must also not require access to more than one side of the armor panel since the face in contact with the vehicle is often not accessible.

A NDE thermal measurement device is useful in any application for which thermal properties are needed, but not readily available. This device should find extensive use in the commercial automotive and the building construction industries. For example, automotive manufacturers have been rapidly expanding into the EV (Electric Vehicle) market, where much of their focus has been on the thermal management of Li-ion batteries for which the properties of battery cells are difficult to obtain. The building construction industry needs to be able to characterize the thermal properties of existing buildings prior to renovation and expansion efforts, as well as for sizing new HVAC systems.

PHASE I: Develop and demonstrate a reliable innovative method for in situ NDE measurement of the thermal resistance and capacitance of sheet homogenous and stacked materials that are representative of armor plate construction.

PHASE II: Develop, build, and demonstrate a commercially-manufacturable prototype of an in-situ NDE measurement device capable of measuring the thermal resistance and capacitance of individual layers in stack-ups that are representative of those used on armor plates for military vehicles. Document the reliability and accuracy of the device.

PHASE III: Extend the functionality of the measurement device to handle materials found uniquely in building construction, aircraft, and ship hulls as applicable. Build commercial devices suitable for use by engineers and scientists, as well as NDE technicians in the field.

REFERENCES:
1. Model, R. (2005). Thermal transport properties of layered materials: identification by a new numerical algorithm for transient measurements. International journal of thermophysics, 26(1), 165-178

2. Belattar, S. and Sahnoun, S. (2003). Thermal non-destructive characterization by the thermal transfer function and the numerical method of control volumes. Aug 2003, Vol. 8 No. 8. Accessed at NDT.net.

3. ASTM E1225, “Standard Test Method for Thermal Conductivity of Solids by Means of the Guarded-Comparative-Longitudinal Heat Flow Technique”

4. ASTM E1530 “Standard Test Method for Evaluating the Resistance to Thermal Transmission of Materials by the Guarded Heat Flow Meter Technique”

5. ISO 8302 “Thermal insulation – Determination of steady-state thermal resistance and related properties – Guarded hot plate apparatus”

6. ASTM C177 “Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus”

KEYWORDS: In-situ, thermal, material properties, non-destructive, testing, infrared, IR, signature, temperature

A15-086 TITLE: Tactical Behavior Mining of a Soldier-Based Gaming Environment

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Using a first-person shooter type game, develop the ability to autonomously identify positive tactics and concepts of operation for “S&T widgets” from a crowd of game players.

DESCRIPTION: The goal of this project is to develop a prototype crowdsourcing game to harness the collective intelligence of soldiers. Given that so many soldiers in the field are game players and that they often have detailed local knowledge about the battlefields they operate within, this project will work to leverage that knowledge to inform technology developers. In essence, this environment will allow the Soldiers to “kick the tires” on virtual concepts before metal has been bent. This is different than previous efforts because never before has a persistent “always-on” gaming environment been constructed to allow Soldiers and engineers to collaborate on innovative technology solutions which are tuned to the tactics of use.

It is not the intent of this project to develop a new gaming engine, and it is preferable to leverage an existing game engine. The current Army training solution from PEO STRI is VBS3, but any gaming code is acceptable. The scenario(s) developed should specifically include humans playing blue force (friendly) ground vehicles. Many-on-many play scenarios are preferable where humans play both blue force and the opposing force. The opposing force may include any combination of dismounts, vehicles, air platforms, and robots.

The main research questions that will need to be addressed are:

1. Game structure. How do you structure a game that will make Soldiers want to play the game? What reward and scoring structure would be provided? Would they log in and wait in a "waiting room" for enough opposing force players to arrive? How do you simulate mission planning and a command structure? Does the player with the most "experience points" get first dibs on being the commander?

2. Behavior mining. There is a need to autonomously understand what behaviors and tactics will work. The weakest link in systems engineering is often the link between what the warfighters need and what the development team thinks they need, together with a shared understanding of the operational environment and associated constraints and dependencies. DARPA's Mind's Eye program seeks to develop the capability for visual intelligence by automating the ability to learn generally applicable and generative representations of action between objects in a scene. It may be possible in the gaming environment to similarly generate an understanding of action between objects in a virtual environment that lead to successful or detrimental outcomes. Also, players in a crowd may behave quite differently and the validity of successful tactics may require additionally classifying player types (example Dirty Harry versus a chess player persona).

3. Physics fidelity. We need to represent ground vehicles in a way that captures real-world experiences with the vehicle/technology. For example, since there is no vehicle motion, how do you represent going over potholes in the game? Real drivers would slow down in rough terrain. How do you determine vehicle mobility realistically? How do you validate the detectability of vehicles in the game? There needs to be research on the believability of the data in terms of correct engineering fidelity. Also, how do you capture vehicle costs, weight, cooling, energy, etc.?

PHASE I: Develop and demonstrate an overall methodology for a game structure, behavior mining, and validation of physics fidelity. Offerer should provide reference data and/or conduct simple experiments to validate the approach. A demonstration of deep understanding in the field be shown, including looking at what methods are used in successful commercial games.

PHASE II: Develop a demonstration gaming environment and evaluate a notional ground vehicle concept with a small crowd of players. The prototype will gather behavior data to capture concepts of operation and evaluate what works or doesn't work for those players during gameplay. Rather than focus solely on a more immersive single-player mission, initial game designs should evaluate a "real time strategy" (RTS) style of gameplay that allow soldiers to configure vehicles and teams for particular kinds of encountered in different settings. This allows players the opportunity to experiment and succeed or fail rapidly, providing a sandbox environment where players can iterate rapidly with configurations. All of this data will be collected as part of the application, providing analytics on the back-end for improving the game, as well as better understanding the emergent configurations that players develop that may prove to be more effective designs. The demonstration should use at least 15 persons evaluation who run approximately 1500 virtual games. The environment should demonstrate and validate the behavior mining, game structure, and chosen physics fidelity.

PHASE III: The developed behavior modeling methods in particular will have applicability for the commercial gaming community. The gaming community seeks to make games fun by balancing the play and eliminating quirks. The military seeks to find tactical/technology quirks that aren't artifacts simply of the game that causes a decisive victory.

REFERENCES:
1. http://www.arcic.army.mil/Articles/cdld-ARCIC-to-Leverage-Early-Synthetic-Prototyping-to-Shape-the-Future-Army.aspx

2. Smith, Robert E. "A Proposed 2025 Ground Systems Engineering Process." Defense Acquisition Research Journal: A Publication of the Defense Acquisition University (July 2014 issue).

3. http://www.slideshare.net/acagamic/game-metrics-and-biometrics-the-future-of-player-experience-research

4. http://www.darpa.mil/Our_Work/I2O/Programs/Minds_Eye.aspx

5. http://tomchatfield.net/2010/07/16/tom_chatfield_7_ways_games_reward_the_brain/

6. https://www.youtube.com/watch?v=KyamsZXXF2w

7. Keena, Joshua. “Demonstration of Decision Support Tools for Evaluating Ground Combat System Survivability, Lethality, and Mobility at the Tactical, Operational, and Strategic Levels of War.” PhD Dissertation. University of Texas - Austin, August 2011.

8. Korfiatis, Peter, and Robert Cloutier. "USING 3D GAMING TECHNOLOGIES TO IMPROVE THE CONCEPT OF OPERATIONS (CONOPS) PROCESS."

9. Not Just a Game: Virtual Domain Influences Vehicle Design. http://viewer.zmags.com/publication/b1d7b9bd#/b1d7b9bd/46

KEYWORDS: Tactics, Gaming, Analytics, Virtual Environments, Mind’s Eye, ground vehicle, fidelity, video game, Early Synthetic Prototyping

A15-087 TITLE: High Performance Switched Reluctance Generator Controller

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Develop an inverter to drive a Switched Reluctance (SR) machine with a reduced audible noise signature.

DESCRIPTION: The Switched Reluctance (SR) machine topology is under consideration for power generation applications in military ground vehicles at the 100kW power level. Advantages include low cost due to the simple structure and relatively low cost materials, however there are also disadvantages including lower torque/power densities, increased audible noise, and increased torque ripple when compared to state-of-the-art permanent magnet synchronous machines. The audible noise and torque ripple are due to factors which include deformation of the stator structure under operation and pulsations due to attraction of complementary stator and rotor poles. The hollow stator structure is deformed during excitation, and is the source of acoustic noise when compounded by mechanical resonance. The nonlinear control approach also makes difficult to achieve smooth torque production.

SR machines operate on the reluctance principle, rather than conventional topologies which leverage magnetic torque. Torque generation occurs as current is applied to a stator winding while the amount of overlap between that stator pole with the adjacent rotor pole is changing. While the stator structure is similar to a permanent magnet or induction machine, the rotor structure is considerably simpler and less costly due to the absence of permanent magnets, a cast squirrel cage or windings. The rotor can tolerate higher temperatures than a permanent magnet machine without the risk of demagnetization. The SR machine is also considered fault-tolerant, since it will not produce a back-EMF voltage while spinning unless excitation is present.

The audible noise and torque ripple in an SR drive are influenced by the electromagnetic and mechanical design of the machine, including the number and shape of rotor and stator poles and stiffness of the stator structure, and the circuit topology of the power electronic inverter along with its control algorithm design. The research necessary in this effort is focused on both the inverter and control algorithm designs [1-3]. A successful inverter design shall include the best electrical circuit topology and control algorithms to drive a 100kW, 24/16 (stator/rotor) pole SR machine with 6 external terminals (3 phases) as a generator while minimizing the audible noise signature. The primary objective is to minimize audible noise while maintaining torque/power, with a secondary objective of minimizing torque ripple. The contractor shall decrease audible noise across the entire torque-speed operating range by 25%/50% (T/O) and quantify the improvement on the torque-speed plane using isolines supported by test data. The deliverables should also include recommendations on electromagnetic/structural design improvements in the SR for machine which complement the inverter and control algorithm improvements which have the potential to further reduce the audible noise.

PHASE I: A successful Phase I shall result in a feasibility study and small scale breadboard demonstration at approximately 2.5 kW power level with an inverter and generic SR motor under load. The demonstration will include characterizing the performance and audible noise using conventional methods as well as the optimized circuit architecture and developed algorithms. Modeling and simulation results, validated through experiment, should be delivered. Inverter schematics and drawings, and a detailed description and analysis of the control strategy along with inverter source code and Graphical User Interface (GUI) source code and executables shall be delivered at each phase of this effort.

PHASE II: A successful Phase II shall scale up the inverter and control algorithms to be suitable for a 100 kW (continuous), 24/16 (stator/rotor) pole SR machine with 6 external terminals (3 phases) [4]. The inverter shall be water proof (per 3.5.1.2 from MIL-S-3785E(AT)) and be capable of position feedback with a resolver (10kHz excitation, direct-drive, primary) and hall-effect sensors (secondary/redundancy). The power quality shall conform with MIL-PRF-GCS600A (ARMY), Characteristics of 600 Volt DC Electrical Systems for Military Ground Vehicles. The inverter shall also be capable of operation using only CAN bus communication, leveraging a CAN ICD agreed upon with the Government for the target vehicle application. A full scale demonstration will characterize the improvements using the optimized hardware and algorithms compared to the baseline control.

PHASE III: A successful Phase III shall further improve the inverter to be suitable for a ground vehicle application, as either an upgrade to an existing platform such as Stryker or Bradley Fighting Vehicle, or integration onto a future fighting vehicle platform. This will be achieved through conformance with the shock and vibration requirements in MIL-STD-810G, and low-temperature of -50C and high-temperature capability of 85C / 105C (threshold / objective) inlet coolant (50/50 EGW) and 125C ambient air temperature at rated power on a continuous basis. The inverter shall conform with MIL-STD-461F (including connectors, grounding, cabling, insulation, and shielding). The volumetric power density shall exceed 6kW/l / 8kW/l (threshold/objective).

REFERENCES:
1) Hofmann, A.; Al-Dajani, A.; Bosing, M.; De Doncker, R.W., “Direct instantaneous force control: A method to eliminate mode-0-borne noise in switched reluctance machines,” IEEE Electric Machines & Drives Conference (IEMDC), Pg. 1009-1016, 2013.

2) Long, S.A.; Zhu, Z.Q.; Howe, D., “Effectiveness of active noise and vibration cancellation for switched reluctance machines operating under alternative control strategies,” IEEE Transactions on Energy Conversion, Pg. 792-801, 2005

3) Omekanda, A.M.; Gopalakrishnan, S.; Klode, H., “Acoustic Noise of Switched Reluctance and Permanent Magnet Motors: A Comparison in the Context of Electric Brakes,” 42nd Annual IEEE Industry Applications Conference, Pg. 2147-2153, 2007

4) W56HZV-09-D-0148 Integrated Starter Generator development.

KEYWORDS: Generator Controller, Motor Drive Inverter, Switched Reluctance Control Optimization

A15-088 TITLE: <u>Energy Absorbing Seat For All Occupant Sizes and Blast Conditions</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: The objective of this SBIR is to develop an energy absorption seat system for use on a currently fielded seat or a new energy absorbing seating system for all occupant sizes (central 90% occupants) and all underbody blast conditions. The technology shall protect the central 90% unencumbered and fully encumbered occupants to meet injury criteria during a prescribed upward threshold delta-V and up to seven (7) times the threshold delta-V.

DESCRIPTION: The current problem is, that there is not a blast mitigating seat with an energy absorption (EA) system that will protect the central 90% of occupant population, unencumbered 5th percentile female up to a fully encumbered 95th percentile male, during a simulated vertical upward change in velocity prescribed by an upward threshold delta-V up to seven (7) times the threshold delta-V. This system shall provide occupant protection without manual system reconfiguration or manual adjustments by seated occupants. Occupant protection will be determined by using anthropomorphic test devices (ATDs) in computer simulations and in physical testing. The goal is to have all the ATD injury values below the injury values listed in the paper Biomechanical and Scaling Bases for Frontal and Side Impact Injury Assessment Reference Values1 written by Harold J. Mertz, Annette L. Irwin, and Priya Prasad.

PHASE I: Define and determine the technical feasibility of developing a blast attenuating seat or an energy absorption system for use on a fielded seat that will provide protection and energy absorption for an unencumbered 5th percentile female through a fully encumbered 95th percentile male without any manual system reconfigurations or adjustments by the seated occupant. The effort should further define the manufacturing processes, including the support of theoretical and past performance data to ensure manufacturability and to validate the desired occupant protection results.

PHASE II: Develop and test five (5) prototype seats that can protect and accommodate the central 90% of occupant population, unencumbered 5th percentile female up to a fully encumbered 95th percentile male without any manual system reconfigurations, resets or adjustments by the seated occupant. 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: Commercialization to all Armored/Uparmored Tactical Wheeled Vehicles, Light Armored Vehicles (LAV's), Mine Resistant Ambush Protection (MRAPs), Strykers, Bradley Fighting Vehicles, etc. Potential military applications include, but are not limited to: multiple vehicle platform integration, streamline light weighting deployment to military vehicles via modular technologies, significant improvement to vehicles fuel economy, setup standards for core seat technology and cross functionality over multiple vehicle platforms. The information gathered from this project will help private industry create the product needed to protect the occupant.

REFERENCES:

1. Biomechanical and Scaling Bases for Frontal and Side Impact Injury Assessment Reference Values, Harold J. Mertz and Annette L. Irwin of General Motors Corporation and Priya Prasa from Ford Motor Company, Stapp Car Crash Journal. Vol. 47 (October 2003). pp 155-188, Copyright 2003 The Stapp Association

2. TARDEC Occupant Protection Seat, Katrina Harris and Joseph Melotik, TARDEC, 8/12, http://www.dtic.mil/dtic/tr/fulltext/u2/a563581.pdf

3. Application of Mathematical Modeling in Potentially Survivable Blast Threats in Military Vehicles, Sudhakar Arepally, Dr. David Gorsich, Karrie Hope, Stephen Gentner, Kari Drotleff, 9/08, http://www.dtic.mil/dtic/tr/fulltext/u2/a496843.pdf

4. Selected aspects of the control of the human body motion in the vehicle subjected to the blast load, Artur Iluk, 2012, http://ircobi.org/downloads/irc12/pdf_files/48.pdf

5. Design and Development of Variable-Load Energy Absorbers, Svoboda, Craig M.; Warrick, James C., 6/81, http://www.dtic.mil/docs/citations/ADA103206

KEYWORDS: Energy absorbing seat, energy absorbing system, protect

A15-089 TITLE: <u>Advanced, Robust, and Simple Pretreatment to Reverse Osmosis</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Under this topic, the Government invites proposals for the development and demonstration of two enabling technologies for the future development of a small, man portable, seawater reverse osmosis water purification system: an advanced pretreatment process; or a high pressure pump system with energy recovery technology.

DESCRIPTION: The Army requires the capability to purify water at the extra small contingency base (<299 soldiers) and small unit (below Company) level. The smallest Army system weighs 1,500 pounds and requires a HMMWV for transport. Current COTS systems do not produce the desired product water flow rates, require extensive maintenance, and have energy demands that are difficult to support in a field environment. The Army plans to develop a small, man portable (<80 pounds), energy efficient (<15 watt-hr/gallon) reverse osmosis (RO) based water purification system that produces a minimum of 30 gallons per hour. To achieve this goal, a novel advanced pretreatment process must be developed and integrated with a new high pressure pump with energy recovery. Commercially available energy recovery devices and integrated high pressure pump/energy recovery devices are not readily available at the flow rates required. Therefore, new technology is needed to capture the brine energy and thereby decrease the energy requirements for systems of this size. Commercially available pretreatment technology at this scale requires frequent cleaning leading to a maintenance burden and produces a product water quality that may damage fragile pumps or foul reverse osmosis membranes. New technology is needed that produces ultrafilter/microfilter membrane quality product water but is as robust and simple to operate and maintain as multimedia and cartridge filtration

The proposals should identify either:
- Cutting edge pretreatment technology that is able to produce water with a 15-minute silt density index value (ASTM D4189-07) of less than 3.0 and a turbidity value less than 1.0 NTU when operated on all surface and ground water sources, with a Total Dissolved Solids (TDS) concentration less than 30,000 mg/L and a turbidity less than 150 NTU, not including chemical, biological, radiological and nuclear (CBRN)-contaminated sources.
Or
- Cutting edge high pressure pump/energy recovery technology that can reduce the system energy requirement to no more than 15-watt-hr/gallon while operating at a flow rate range of 60-100 gallons per hour (GPH) at up to 1200 psi of pressure (produce 30 GPH RO product water). The unit should require minimal technical expertise to operate.

PHASE I:
Pretreatment Technologies: Demonstrate feasibility of the proposed technology in a laboratory setting. Verify the technology can meet the requirements while showing a pathway to meet the full scale integrated RO system weight (<80 lbs) and energy metrics (15-20 watt-hr/gallon or less) while producing treated water that has a 15 minute silt density index value (ASTM D4189-07) of less than 3.0 and a turbidity value of less than 1.0 NTU. Complete a conceptual design for a full scale pretreatment system prototype that, when combined with an appropriately sized RO system meets the production rate, weight, and energy requirements listed above and is suitable for use by military units across the range of small unit operations.

High Pressure Pump/Energy Recovery Technologies: Demonstrate feasibility of the proposed technology in a laboratory setting. Verify the high pressure pump/energy recovery technology can reduce the system energy requirement while showing a pathway to meet the full scale integrated system weight (< 80 lbs) and energy metrics (15-20 watt-hr/gallon or less). Complete a conceptual design for a full scale high pressure pump/energy recovery prototype combined with an appropriately sized pretreatment and RO system that meets the production rate, weight, and energy requirements listed above and is suitable for use by military units across the range of small unit operations.

PHASE II: Based on the design parameters defined in Phase I, design, fabricate and demonstrate a full scale prototype pretreatment system or high pressure pump system with energy recovery which can be used by various military and other defense and support organizations for military, humanitarian assistance, and disaster relief operations when integrated with an RO system.

Pretreatment System - The delivered pretreatment prototype 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. The pretreatment prototype, before requiring cleaning, shall be able to treat 800 gallons of 75 NTU source water at a flow rate of 60-100 gph to 15-minute silt density index values (ASTM D4189-07) of less than 3.0 and turbidity values less than 1.0 NTU while meeting the weight, production rate, and energy metrics of a combined system based on the Phase I conceptual design.

High Pressure Pumping System - The delivered high pressure pumping system prototype 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. The prototype shall, in conjunction with an appropriate sized RO system, operate at a reverse osmosis product flow rate of 30 GPH while meeting the weight and energy metrics of a combined system based on the phase I conceptual design.

PHASE III: Commercialization – 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.

REFERENCES:

1. http://www.epa.gov/safewater/contaminants/index.html

2. http://www.foresight.org/challenges/water001.html

3. http://www.astm.org/Standards/D4189.htm

4. http://www.epa.gov/safewater/contaminants/index.html

KEYWORDS: Water Purification, Energy Recovery, High Pressure Pumps, Reverse Osmosis (RO), Advanced Pretreatment, Silt Density Index (SDI)