ARMY
SBIR 08.2 PROPOSAL SUBMISSION INSTRUCTIONS

The U.S. Army Research, Development, and Engineering Command (RDECOM) is responsible for execution of the Army SBIR program. Information on the Army SBIR Program can be found at the following website: https://www.armysbir.com/.

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

Susan Nichols
Program Manager, Army SBIR
army.sbir@us.army.mil

US Army Research, Development, and Engineering Command (RDECOM)
ATTN: AMSRD-SS-SBIR
6000 6th Street, Suite 100
Fort Belvoir, VA 22060-5608
(703) 806-2085
FAX: (703) 806-2044

The Army participates in one DoD SBIR Solicitation each year. Proposals not conforming to the terms of this Solicitation will not be considered. The Army reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded. Only Government personnel will evaluate proposals with the exception of technical personnel from **General Dynamics Information Technology, Science Applications International Corporation (SAIC)**, and **Azimuth, Inc**. who will provide Advisory and Assistance Services to the Army, providing technical analysis in the evaluation of proposals submitted against Army topic numbers: **A08-121 (General Dynamics Information Technology) and A08-123 (SAIC** and **Azimuth, Inc.)**.

Individuals from **General Dynamics Information Technology, SAIC**, and **Azimuth, 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.

SUBMISSION OF ARMY SBIR PROPOSALS

The entire proposal (which includes Cover Sheets, Technical Proposal, Cost Proposal, and Company Commercialization Report) must be submitted electronically via the DoD SBIR/STTR Proposal Submission Site (http://www.dodsbir.net/submission). The Army prefers that small businesses complete the Cost Proposal form on the DoD Submission site, versus submitting within the body of the uploaded proposal. The Army WILL NOT accept any proposals which are not submitted via this site. Do not send a hardcopy of the proposal. Hand or electronic signature on the proposal is also NOT required. If the proposal is selected for award, the DoD Component program will contact you for signatures. If you experience problems uploading a proposal, call the DoD Help Desk 1-866-724-7457 (8am to 5pm EST). Selection and non-selection letters will be sent electronically via e-mail.

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

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

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

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

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

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

<u>PHASE I OPTION MUST BE INCLUDED AS PART OF PHASE I PROPOSAL</u>

The Army implemented the use of a Phase I Option that may be exercised to fund interim Phase I activities while a Phase II contract is being negotiated. Only Phase I efforts selected for Phase II awards through the Army’s competitive process will be eligible to exercise the Phase I Option. The Phase I Option, which **must** be included as part of the Phase I proposal, covers activities over a period of up to four months and should describe appropriate initial Phase II activities that may lead to the successful demonstration of a product or technology. The Phase I Option must be included within the 20-page limit for the Phase I proposal.

A firm-fixed-price or cost-plus-fixed-fee Phase I Cost Proposal ($120,000 maximum) must be submitted in detail online. Proposers that participate in this Solicitation must complete the Phase I Cost Proposal not to exceed the maximum dollar amount of $70,000 and a Phase I Option Cost Proposal (if applicable) not to exceed the maximum dollar amount of $50,000. Phase I and Phase I Option costs must be shown separately but may be presented side-by-side on a single Cost Proposal. The Cost Proposal <u>DOES NOT</u> count toward the 20-page Phase I proposal limitation.

<u>Phase I Key Dates</u>

08.2 Solicitation Pre-release	April 21 –May 18, 2008
08.2 Solicitation Opens	May 19 – June 18, 2008
Phase I Evaluations	June – August 2008
Phase I Selections	August 2008
Phase I Awards	October 2008*

**Subject to the Congressional Budget process*

PHASE II PROPOSAL SUBMISSION

***Note*! Phase II Proposal Submission is by Army Invitation only.** Small businesses are invited in writing by the Army to submit a Phase II proposal from Phase I projects based upon Phase I progress to date and the continued relevance of the project to future Army requirements. The Army exercises discretion on whether a Phase I award recipient is invited to propose for Phase II. Invitations are generally issued no earlier than five months after the Phase I contract award, with the Phase II proposals generally due one month later. In accordance with SBA policy, the Army reserves the right to negotiate mutually acceptable Phase II proposal submission dates with individual Phase I awardees, accomplish proposal reviews expeditiously, and proceed with Phase II awards.

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

Fast Track (see section 4.5 at the front of the Program Solicitation). Small businesses that participate in the Fast Track program do not require an invitation. Small businesses must submit (1) the Fast Track application within 150 days after the effective date of the SBIR phase I contract and (2) the Phase II proposal within 180 days after the effective date of its Phase I contract.

CONTRACTOR MANPOWER REPORTING APPLICATION (CMRA)

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

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

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

- The Office of the Assistant Secretary of the Army (Manpower & Reserve Affairs) operates and maintains the secure CMRA System. The CMRA website 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 website);

- 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 website. The CMRA website 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 annually, or to be included in overhead rates.

COMMERCIALIZATION PILOT PROGRAM (CPP)

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

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

NON-PROPRIETARY SUMMARY REPORTS

All award winners must submit a Non-Proprietary Summary Report at the end of their Phase I project. The summary report is an unclassified, non-sensitive, and non-proprietary summation of Phase I results that 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. The Non-Proprietary Summary Report should not exceed 700 words, and must include the technology description and anticipated applications / benefits for government and or private sector use. It should require minimal work from the contractor because most of this information is required in the final technical report. The summary report shall be submitted in accordance with the format and instructions posted within the Army SBIR Small Business Portal at http://www.armysbir.com/smallbusinessportal/Firm/Login.aspx. **This requirement for a final summary report will also apply to any subsequent Phase II contract.**

ARMY SUBMISSION OF FINAL TECHNICAL REPORTS

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

ARMY SBIR
PROGRAM COORDINATORS (PC) and Army SBIR 08.2 Topic Index

Participating Organizations		PC	Phone
Aviation and Missile RD&E Center (Aviation)		**PJ Jackson**	**(757) 878-5400**
A08-015	Sensor Validation for Turboshaft Engine Torque Sensors		
A08-016	High Performance Computing for Rotorcraft Structural Dynamics		
A08-017	Advanced Rotorcraft Comprehensive Analysis		
A08-018	Light Weight Collective Pitch Control Systems for Swashplateless		
A08-019	Sensor Guided Flight for Unmanned Air Vehicles		
A08-020	Innovative Pitch Link Actuators for Individual Blade Control (IBC)		
A08-021	Innovative Systems for Reduction of Rotorcraft Hub Drag		
A08-022	Practical Composite Rotor Blade and Wing Structural Design Tool for Aeromechanical Assessments in Conceptual		
A08-023	Reinforced High Temperature Titanium Metal Matrix Composite Systems For Impeller Applications in Advanced Army Turboshaft Engines		
A08-024	Lightweight Metallics for Cargo Helicopter Main Rotor Shaft Applications		
A08-025	On-Line Oil Condition and Metal Wear Analysis Sensor		
A08-026	Advanced Manufacturing methods for Composite Gearbox Housings for Rotorcraft Applications		
Aviation and Missile RD&E Center (Missile)		**Otho Thomas**	**(256) 842-9227**
A08-027	Effects of High Temperature on Solid Propellants: Insights Into Their Effects on Slow and Fast Cookoff responses Toward Insensitive Munitions		
A08-028	Complementary Non-Destructive Evaluation (NDE)/Testing (NDT) Techniques for Stockpile Reliability Programs (SRP) of U.S. Army Tectical Missile Systems		
A08-029	Thermal Management in a Composite Skin Missile Airframe		
A08-030	Improved environmental protection for Zinc Sulfide		
A08-031	Advanced Adaptive Maneuvering Air Vehicle		
A08-032	Advanced Scramjet Engine/Vehicle Design		
A08-033	Transpiration Cooling Computational Fluid Dynamics Submodel		
A08-034	Low Power Electronics and Energy Harvesting for Anti-tamper Applications		
A08-035	High Aspect Ratio EMI Grid Application Technique		
A08-036	Novel Energetic Polymers		
A08-037	Low Cost Production of Domes Using Freeze Casting or Similar Technology		
A08-038	Vision Based Adjunct Navigation Technologies		
A08-039	Prognostics for the Full, Net-Centric, Plug and Fight Integration of Army Air and Missile Defense Systems (AMD)		
A08-040	Accurate and Reliable Rocket Thruster Technology		
A08-041	Improved Field of Regard for Strap Down Semi Active Laser Seekers		
Armament RD&E Center (ARDEC)		**Carol L'Hommedieu**	**(973) 724-4029**
A08-042	Novel Structural Reactive Materials		
A08-043	High Voltage, High Current, Solid State Switches		
A08-044	Innovative Tantalum Machining for Weapon Applications		
A08-045	Reusable and Adaptable Cognitive Decision Aids Components For Remote Weapon Stations		
A08-046	Novel Efficient and Compact Diode-pumped Rod Gain Modules for Ultra Short Pulsed (USP) Lasers		
A08-047	Edge-pumped Composites for Ultra-Short Pulse (USP) Lasers		
A08-048	Biogically Inspired Processor		
A08-049	Structurally Integrated Position and Orientation Sensor and Seeker Technologies		
A08-050	Novel Titanium Alloys for Improved Workability and Formability		
A08-051	High Resolution Multispectral X-ray Imaging		
A08-052	Development of Nanothermite-Based Microthrusters		
A08-053	Thermal Sensing and Responsive Materials for Environmental Monitoring		
A08-054	Spectrally and Spatially Foveated Multi/Hyperspectral Camera		
A08-055	Compact Unit for Eye-safe Standoff Explosive Detection		

Army Research Laboratory (ARL)	**John Goon**	**(301) 394-4288**
A08-056	Bio-Inspired Battlefield Environmental Situation Awareness	
A08-057	Urban Illumination for Soldier Simulations and Close-Combat Target	
A08-058	Situation Awareness Assessment Tools for Network Enabled Command and Control Field Evaluations	
A08-059	A psychologically inspired object recognition system	
A08-060	Hearing Protection Evaluation System	
A08-061	Eyesafe laser diode arrays for resonant pumping of Er-doped gain media optimized for cryogenicalled cooled operation	
A08-062	Fully Flexible Information Electronics with a Flexible Display	
A08-063	Bi-functional anode and High Temperature Electrolyte Membrane for Reforming Methanol Fuel Cell (RMFC)	
A08-064	Utilizing Computational Imaging for Laser Intensity Reduction at CCD Focal Planes	
A08-065	Desulfurization of JP-8 Fuel by Adsorption of Oxidized Organic Sulfur Compunds	
~~A08-066~~	~~Development of a Device Capable of Rapid isolation of DNA Capture Elements for Biotechnology Applications~~	
A08-067	Metamaterial Antennas for Army Platforms	
A08-068	Cold Spray Nanostructured Powders	
A08-069	Scalable & Adaptive Munitions Technologies	
A08-070	Full Field, Out-of-Plane Digital Image Correlation (DIC) from Ultra-High Speed Digital Cameras	
A08-071	Self-decontaminating materials using organocatalysts	
A08-072	A 250-W Solid Acid Electrolyte Fuel Cell Generator	
A08-073	Hydroxyl Exchange Membrane Fuel Cell	
A08-074	Development of a Fieldable Brain Trauma Analyzer System	
A08-075	Terahertz Intracavity Spectrometer	
A08-076	Nano-composite Semiconductor Lasers	
A08-077	Large Area, High Power Ultraviolet Light Emitting Diodes	

Communication-Electronics RD&E Center (CERDEC)	**Suzanne Weeks**	**(732) 427-3275**
A08-078	Detection and Location of Home Made Electro-Optical Booby Traps	
A08-079	Precision Extraction and Characterization of Lines of Communication from Moving Target Indicator (MTI) Data	
A08-080	Radio Frequency Over Fiber in Airborne Intelligence, Surveillance, and Reconnaissance Platforms	
A08-081	Persistent Multi-Intelligence Perimeter Sensing	
A08-082	Event and Temporal Reasoning Ontology's for Unstructured Data	
A08-083	Advanced Modular/Reconfigurable Cooling Techniques for Signals Intelligence/Electronic Warface (SIGINT/EW) Systems	
A08-084	High Isolation Transmit/Receive Antennas for Advanced Electronic Warfare (EW) and Communications Applications	
A08-085	Recognition of Non-Native Speakers	
A08-086	Common Aperture Ground Moving Target Indicator (GMTI) and Electro-Optical/Infrared (EO/IR) (CAGE)	
A08-087	Dismounted Combat Identification	
A08-088	Command and Control Translation System in a Service Oriented Architecture (SOA) Framework	
A08-089	Quality of Service Traffic Manager	
A08-090	High Performance Electrochemical Capacitor Using Nanomaterials for Electrodes.	
A08-091	Superior High Energy Density and High Rate Rechargeable Lithium ion Battery for Army applications	
A08-092	Automated Planning Software For A Dynamic Heterogeneous Collection Of Manned And Unmanned Entities	
A08-093	Counterinsurgency Campaign Design Tool Based on Logical Lines of Operation and Wiki-Inspired Knowledge Capture	
A08-094	Dynamic Data Model Implementation for Context Sensitive User Interface and Embedded Semantic	
A08-095	Wireless Intra-Soldier Data Reception and Transmission	

A08-096	Precision Gyroscopes for Gyro-Compassing in Man-Portable Target Locator Systems
A08-097	Standoff Detection of Improvised Explosive Devices (IEDs), Explosively Formed Penetrators (EFPs), or Landmines
A08-098	Stabilized Laser Beam Pointing
A08-099	Optimal Detection of Buried Improvised Explosive Devices (IED's) in Clutter
A08-100	Visible to Shortwave Infrared Solid State Silicon-Germanium Imagiging Camera Development
A08-101	Advanced System Tunability for Infrared (IR) Imagers Using Enhanced User-Controlled Parameters
A08-102	Cathodoluminescence Defect Characterization for Medium Wavelength Infrared (MWIR) and Long-Wave Infrared (LWIR) HgCdTe
A08-103	Passivation Innovations for Large Format Reduced Pixel pitch strained layer superlattice Focal Plane Array Imagers Operating in the Long Wavelength Infrared (LWIR) Band
A08-104	Armor Embedded Metamaterial Antenna
A08-105	Multicast Admission Control for Multi-Domain Secure Ad Hoc Networks
A08-106	Advanced Cooling for Satellite Communications On-the-Move Antennas
A08-107	Secure IPv6 Multicasting
A08-108	Software Defined Radio Tool Suite
A08-109	Enhanced Magnetic Communications
A08-110	Gallium Nitride Monolithic Microwave Integrated Circuit Power Amplifier
A08-111	All Digital Transmitter Digital to Analog Converter and High Bandwidth Signal Combiner
A08-112	Conformal Omni-Directional Antenna Design for Unmanned Aerial Vehicle (UAV)

Engineer Research & Development Center (ERDC) **Theresa Salls** **(603) 646-4591**

A08-113	Acoustic Detection and Verification of Intrusions against Military Facilities
A08-114	Large Area Spatial Urban-Noise Characterization for Anomaly Detection

JPEO Chemical and Biological Defense (JPEO CBD) **Larry Pollack** **(703) 767-3307**

A08-115	Fast-Scan, High-Performance, Portable Imaging Spectrometer for Chemical-Biological Sensing
A08-116	Integrated Power-Microclimate Cooling System for the Soldier

Medical Research and Materiel Command (MRMC) **COL Terry Besch** **(301) 619-3354**

A08-117	Imaging Device for the Assessment of Airways in Combat Casualties with Inhalation Injury due to Burns, Smoke, or Toxic Gases
A08-118	Malaria Diagnostic Methods to Replace Microscopy in Clinical Trials
A08-119	Non-invasive near-infrared devices for monitoring hemodynamics, tissue viability, and perfusion for combat casualty care
A08-120	An Integrated Physical Therapy/ Rehabilitation Robotic System for Military Healthcare Enhancement
A08-121	Unmanned Ground & Air System for CBRNE Contaminated Personnel Recovery
A08-122	Multiplexed Assay for the Detection of Wound-related Pathogens
A08-123	Prodrugs

PEO Ammunition **Seham Salazar** **(973) 724-2536**
William Sharp **(973) 724-7144**

A08-124	Highly Agile Command Deployable Vehicle Arresting System
A08-125	Advance Antenna and Processing Solutions for Multi-Functional Target Detection System

PEO Aviation **Iris Pruitt** **(256) 313-4975**
Rusty Graves **(256) 842-4999**

A08-126	Improved mini Ku band antenna for TCDL
A08-127	Emergency Anti-torque System for Rotary Wing Aircraft (Manned and Unmanned)

PEO Combat Support & Combat Service Support **Mark Mazzara** **(586) 574-8032**

A08-128	JP-8 Fuel Effects on High Pressure Common Rail Pumps

PEO Enterprise Information Systems		**Rajat Ray** **Ed Velez**	**(703) 806-4116** **(703) 806-0670**
A08-129	Encrypt/Decrypt Mobile Devices with Biometric Signature		
PEO Ground Combat Systems		**Peter Haniak** **Jose Mabesa**	**(586) 574-8671** **(586) 574-6751**
A08-130	Dexterous Manipulation for Non-Line-of-Sight Articulated Manipulators		
A08-131	Tools, Techniques and Materials for Lightweight Tracks		
PEO Soldier		**King Dixon** **Jason Regnier**	**(703) 704-3309** **(703) 704-1469**
A08-132	Variable Optical Transmission Lens for Integrated Eyewear Protection		
PEO Simulation, Training, & Instrumentation		**Robert Forbis**	**(407) 384-3884**
A08-133	Dynamic Terrain System Process Development		
A08-134	Game Interface for the OneSAF Computer Generated Forces Simulation		
PM Future Combat Systems Brigade Combat Team		**Fran Rush**	**(703) 676-0124**
A08-135	Development of a small LADAR sensor for a Small Unmanned Ground Vehicle (SUGV)		
A08-136	Video Compression Techniques for Tactical Wireless Networks		
Space and Missile Defense Command (SMDC)		**Dimitrios Lianos**	**(256) 955-3223**
A08-137	High Energy Laser Component Technology for Eye-Safer Fiber Lasers		
A08-138	Advanced Ferroelectric Materials for Explosive Pulsed Power for Missiles and Munitions		
A08-139	Vertical Cavity Surface-Emitting Laser (VCSEL) pumps for Reduced Eye Hazard Wavelength High Energy Fiber Lasers		
A08-140	Lightweight Electro-Optical/Infrared Payload		
A08-141	Lightweight High Altitude/On-Orbit Reprogrammable Two-Way Communications Payload		
Simulation and Training Technology Center (STTC)		**Thao Pham**	**(407) 384-5460**
A08-142	Automated Generation of Underground Structures		
Tank Automotive RD&E Center (TARDEC)		**Jim Mainero** **Martin Novak**	**(586) 574-8646** **(586) 574-8730**
A08-143	MODELING OF THE IMPACT RESPONSE OF MULTIFUNCTIONAL COMPOSITE ARMOR		
A08-144	Non-Destructive Evaluation (NDE) for Ground Vehicles		
A08-145	Semi-Autonomous Unmanned Vehicle Control		
A08-146	Rapid Field Test Method(s) to Measure Additives in Military Fuel		
A08-147	Automated Algorithm Generator for Ground Vehicle Diagnostics/Prognostics		
A08-148	Distributed Services Framework for Mobile Ad-hoc Networks		
A08-149	Sensors for Vehicle Health Monitoring		
A08-150	Smart Sensor Network for Platform Structural Health Monitoring		
A08-151	Realistic High Fidelity Dynamic Terrain Representation		
A08-152	Vehicle Dynamics and Motion Drive for Realtime Simulators		
A08-153	Improved Thermal Management Systems using Advanced Materials and Fluids		
A08-154	High Temperature Capacitors for Hybrid Electric Vehicles		
A08-155	Safe, Low-Cost Cylindrical and Prismatic Nickel-Zinc Batteries for Hybrid Vehicles		
A08-156	Exportable Vehicle Power Using Cognitive Power Management		
A08-157	Real-time In-line Water Quality Monitoring		
A08-158	Measuring Fuel Quantity in Bulk Containers		
A08-159	Advanced Additives to Improve Fire Resistant Fuels (FRF)		
A08-160	Intelligent Multi-modal Ground Robotic Mobility		
A08-161	Tactical Vehicle Underbody Blast Energy Absorber Kit		

DEPARTMENT OF THE ARMY
PROPOSAL CHECKLIST

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

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

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

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

____ 4. The proposal, including the Phase I Option (if applicable), is 20 pages or less in length (excluding the Cost Proposal and Company Commercialization Report). Pages in excess of the 20-page limitation will not be considered in the evaluation of the proposal (including attachments, appendices, or references, but excluding the Cost Proposal and Company Commercialization Report).

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

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

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

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

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

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

Army SBIR 082 Topic Index

A08-061	Eyesafe laser diode arrays for resonant pumping of Er-doped gain media optimized for cryogenically cooled operation
A08-062	Fully Flexible Information Electronics with a Flexible Display
A08-063	Bi-functional anode and High Temperature Electrolyte Membrane for Reforming Methanol Fuel Cell (RMFC).
A08-064	Utilizing Computational Imaging for Laser Intensity Reduction at CCD Focal Planes
A08-065	Desulfurization of JP-8 Fuel by Adsorption of Oxidized Organic Sulfur Compounds
~~A08-066~~	~~Development of a Device Capable of Rapid isolation of DNA Capture Elements for Biotechnology Applications~~
A08-067	Metamaterial Antennas for Army Platforms
A08-068	Cold Spray Nanostructured Powders
A08-069	Scalable & Adaptive Munitions Technologies
A08-070	Full Field, Out-of-Plane Digital Image Correlation (DIC) from Ultra-High Speed Digital Cameras
A08-071	Self-decontaminating materials using organocatalysts
A08-072	A 250-W Solid Acid Electrolyte Fuel Cell Generator
A08-073	Hydroxyl Exchange Membrane Fuel Cell
A08-074	Development of a Fieldable Brain Trauma Analyzer System
A08-075	Terahertz Intracavity Spectrometer
A08-076	Nano-composite Semiconductor Lasers
A08-077	Large Area, High Power Ultraviolet Light Emitting Diodes
A08-078	Detection and Location of Home Made Electro-Optical Booby Traps
A08-079	Precision Extraction and Characterization of Lines of Communication from Moving Target Indicator (MTI) Data
A08-080	Radio Frequency Over Fiber in Airborne Intelligence, Surveillance, and Reconnaissance Platforms
A08-081	Persistent Multi-Intelligence Perimeter Sensing
A08-082	Event and Temporal Reasoning Ontology
A08-083	Advanced Modular/Reconfigurable Cooling Techniques for Signals Intelligence/Electronic Warfare (SIGINT/EW) Systems
A08-084	High Isolation Transmit/Receive Antennas for Advanced Electronic Warfare (EW) and Communications Applications
A08-085	Recognition of Non-Native Speakers
A08-086	Common Aperture Ground Moving Target Indicator (GMTI) and Electro-Optical/Infrared (EO/IR) (CAGE)
A08-087	Dismounted Combat Identification
A08-088	Command and Control Translation System in a Service Oriented Architecture (SOA) Framework
A08-089	Quality of Service Traffic Manager
A08-090	High Performance Electrochemical Capacitor Using Nanomaterials for Electrodes.
A08-091	Superior High Energy Density and High Rate Rechargeable Lithium ion Battery for Army applications
A08-092	Automated Planning Software For A Dynamic Heterogeneous Collection Of Manned And Unmanned Entities
A08-093	Counterinsurgency Campaign Design Tool Based on Logical Lines of Operation and Wiki-Inspired Knowledge Capture
A08-094	Dynamic Data Model Implementation for Context Sensitive User Interface and Embedded Semantic
A08-095	Wireless Intra-Soldier Data Reception and Transmission
A08-096	Precision Gyroscopes for Gyro-Compassing in Man-Portable Target Locator Systems
A08-097	Standoff Detection of Improvised Explosive Devices (IEDs), Explosively Formed Penetrators (EFPs), or Landmines
A08-098	Stabilized Laser Beam Pointing
A08-099	Optimal Detection of Buried Improvised Explosive Devices (IED's) in Clutter
A08-100	Visible to Shortwave Infrared Solid State Silicon-Germanium Imaging Camera Development
A08-101	Advanced System Tunability for Infrared (IR) Imagers Using Enhanced User-Controlled Parameters
A08-102	Cathodoluminescence Defect Characterization for Medium Wavelength Infrared (MWIR) and Long-Wave Infrared (LWIR) HgCdTe

A08-103	Passivation Innovations for Large Format Reduced Pixel pitch strained layer superlattice Focal Plane Array Imagers Operating in the Long Wavelength Infrared (LWIR) Band
A08-104	Armor Embedded Metamaterial Antenna
A08-105	Multicast Admission Control for Multi-Domain Secure Ad Hoc Networks
A08-106	Advanced Cooling for Satellite Communications On-the-Move Antennas
A08-107	Secure IPv6 Multicasting
A08-108	Software Defined Radio Tool Suite
A08-109	Enhanced Magnetic Communications
A08-110	Gallium Nitride Monolithic Microwave Integrated Circuit Power Amplifier
A08-111	All Digital Transmitter Digital to Analog Converter and High Bandwidth Signal Combiner
A08-112	Conformal Omni-Directional Antenna Design for Unmanned Aerial Vehicle (UAV)
A08-113	Acoustic Detection and Verification of Intrusions against Military Facilities
A08-114	Large Area Spatial Urban-Noise Characterization for Anomaly Detection
A08-115	Fast-Scan, High-Performance, Portable Imaging Spectrometer for Chemical-Biological Sensing
A08-116	Integrated Power-Microclimate Cooling System for the Soldier
A08-117	Imaging Device for the Assessment of Airways in Combat Casualties with Inhalation Injury due to Burns, Smoke, or Toxic Gases
A08-118	Malaria Diagnostic Methods to Replace Microscopy in Clinical Trials
A08-119	Non-invasive near-infrared devices for monitoring hemodynamics, tissue viability, and perfusion for combat casualty care
A08-120	An Integrated Physical Therapy/ Rehabilitation Robotic System for Military Healthcare Enhancement
A08-121	Unmanned Ground & Air System for CBRNE Contaminated Personnel Recovery
A08-122	Multiplexed Assay for the Detection of Wound-related Pathogens
A08-123	Prodrugs
A08-124	Highly Agile Command Deployable Vehicle Arresting System
A08-125	Advance Antenna and Processing Solutions for Multi-Functional Target Detection System
A08-126	Improved mini Ku band antenna for TCDL
A08-127	Emergency Anti-torque System for Rotary Wing Aircraft (Manned and Unmanned)
A08-128	JP-8 Fuel Effects on High Pressure Common Rail Pumps
A08-129	Encrypt/Decrypt Mobile Devices with Biometric Signature
A08-130	Dexterous Manipulation for Non-Line-of-Sight Articulated Manipulators
A08-131	Tools, Techniques and Materials for Lightweight Tracks
A08-132	Variable Optical Transmission Lens for Integrated Eyewear Protection
A08-133	Dynamic Terrain System Process Development
A08-134	Game Interface for the OneSAF Computer Generated Forces Simulation
A08-135	Development of a small LADAR sensor for a Small Unmanned Ground Vehicle (SUGV)
A08-136	Video Compression Techniques for Tactical Wireless Networks
A08-137	High Energy Laser Component Technology for Eye-Safer Fiber Lasers
A08-138	Advanced Ferroelectric Materials for Explosive Pulsed Power for Missiles and Munitions
A08-139	Vertical Cavity Surface-Emitting Laser (VCSEL) pumps for Reduced Eye Hazard Wavelength High Energy Fiber Lasers
A08-140	Lightweight Electro-Optical/Infrared Payload
A08-141	Lightweight High Altitude/On-Orbit Reprogrammable Two-Way Communications Payload
A08-142	Automated Generation of Underground Structures
A08-143	Modeling Of The Impact Response Of Multifunctional Composite Armor
A08-144	Non-Destructive Evaluation (NDE) for Ground Vehicles
A08-145	Semi-Autonomous Unmanned Vehicle Control
A08-146	Rapid Field Test Method(s) to Measure Additives in Military Fuel
A08-147	Automated Algorithm Generator for Ground Vehicle Diagnostics/Prognostics
A08-148	Distributed Services Framework for Mobile Ad-hoc Networks
A08-149	Sensors for Vehicle Health Monitoring
A08-150	Smart Sensor Network for Platform Structural Health Monitoring
A08-151	Realistic High Fidelity Dynamic Terrain Representation
A08-152	Vehicle Dynamics and Motion Drive for Realtime Simulators
A08-153	Improved Thermal Management Systems using Advanced Materials and Fluids

A08-154 High Temperature Capacitors for Hybrid Electric Vehicles
A08-155 Safe, Low-Cost Cylindrical and Prismatic Nickel-Zinc Batteries for Hybrid Vehicles
A08-156 Exportable Vehicle Power Using Cognitive Power Management
A08-157 Real-time In-line Water Quality Monitoring
A08-158 Measuring Fuel Quantity in Bulk Containers
A08-159 Advanced Additives to Improve Fire Resistant Fuels (FRF)
A08-160 Intelligent Multi-modal Ground Robotic Mobility
A08-161 Tactical Vehicle Underbody Blast Energy Absorber Kit

Army SBIR 082 Topic Descriptions

A08-015 TITLE: Sensor Validation for Turboshaft Engine Torque Sensors

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: The objective of this SBIR is to design and develop an accurate, cost effective method for on-board sensor validation in Army rotorcraft turboshaft engines. An inaccurate sensor can lead the engine controller to believe components are not working properly. This then leads to the false removal of components and a large percentage of engine down-time which could have been avoided.

Therefore, there is a need for a system that can: 1) validate whether or not the sensor is functioning accurately and 2) if the sensor is in fact generating readings outside accurate tolerance limits, the system should be able to generate a synthetic signal from the remaining sensor data and provide this to the engine controller. This capability would allow for the maintainers to recognize if the sensor is at fault, not the actual component. In addition, this capability will allow for the crew to understand the current state of health of their rotorcraft, regardless of a degraded sensor reading. It is intended that this technology have significant positive implications on sensor reliability, redundancy and accuracy.

DESCRIPTION: This effort will develop improved methodologies and algorithms for the synthesis of engine signals that will replace inaccurate sensor measurements. As a validation method, torque sensors will be used to address inaccurate measurements and the use of remaining signals to provide a synthesized signal. Compensation for factors that lead to error or scatter in the measurement of engine torque shall be considered. Implementation issues such as data capture, processing, and data availability for the pilot shall be addressed. Additional weight and pilot responsibility should be minimized.

PHASE I: Phase I of this effort will develop and validate the proposed technology. A feasibility demonstration of the system should be conducted on a laboratory scale and should validate the concept's achievement of topic objectives. The proposed system should confirm the method in which torque sensors are noted to be producing inaccurate engine torque readings, and then synthesis a signal to the engine controller in its place.

PHASE II: Phase II involves further design and development of the proposed sensor validation method. The coordination with an engine manufacturer to fully portray the operating characteristics is preferred. The design during the Phase II effort should be implemented using a relevant hardware platform and display the ability to send synthetic signals to the engine controller in order to compensate for inaccurate engine torque measurements. These capabilities should be validated using additional bench or rig tests. In this Phase, a fully functioning prototype shall be tested to assess the accuracy and repeatability of the method.

PHASE III: The application of a sensor validation system will have relevance in all commercial and military rotorcraft. Once this technology is successfully demonstrated, it would be suitable for installation into the CH-47/T55, ARH/HTS900-2, UH-60/T700 and AH-64/T700. This Phase should show integration into an appropriate platform's engine control unit. This effort must follow the latest revision of software specification DO-178.

REFERENCES:
1. Model-Based Decision Support Tools For T700 Engine Health Monitoring, Peter Frith and George Karvounis, Defence Science and Technology Organization International Conference on Health and Usage Monitoring, February 2001.

2. Aviation Diagnostic and Engine Prognostic Technologies (ADEPT) for the Chinook's T55 Engine, Andrew Stramiello, Richard Ling, Gregory Kacprzynski and Michael Roemer, 58th Meeting of the Society for Machinery Prevention Technology, April 2003.

3. A Model-Based Approach To Engine Health Monitoring Of Military Helicopters, Peter C. W. Frith, George Karvounis, and Samuel H. Carte, Third Australian Pacific Vertiflite Conference on Helicopter Technology, AHS, July 2000, Canberra, Australia.

KEYWORDS: Sensor validation, turboshaft engine, synthetic signal, inaccurate sensors.

A08-016 TITLE: High Performance Computing for Rotorcraft Structural Dynamics

TECHNOLOGY AREAS: Air Platform, Information Systems, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop methodology and software to adapt scalable, parallel processing methods for high performance computing of rotorcraft structural dynamics problems and demonstrate the achievable benefits via application to a rotorcraft comprehensive analysis code.

DESCRIPTION: Rotorcraft computational predictive capabilities are critical for all phases of rotorcraft research, development, and engineering. Accurate and computationally efficient research and design tools are essential for the development of future rotorcraft having mission performance, life cycle costs, and reliability needed to meet tomorrow's challenging requirements. Over the past few years, Computational Fluid Dynamics (CFD) codes have been linked to computational structural dynamics (CSD) capabilities of rotorcraft comprehensive codes using CFD/CSD coupling techniques (Ref. 1) to provide fundamental new capabilities that will change the way the technical community - and most importantly, the rotorcraft industry – conducts the rotorcraft design process. Current DoD programs are aggressively pursuing further developments in this arena, e.g., the DoD High Performance Computing Modernization Office is sponsoring an HPC Institute for Advanced Rotorcraft Modeling and Simulation (HI-ARMS) with emphasis on advanced CFD development. The key to accurate and practical CFD applications is the use parallel processing on a massive scale to distribute the computations between hundreds and eventually thousands of CPU processors. The effectiveness of this approach depends on scalability, that is, can computation time for large problems be substantially reduced by increasing the number of processors without degrading the run time benefit due to the data communication overhead between processors. Since CFD computations are generally scalable, parallel processing offers considerable promise for improving rotorcraft CFD throughput. Although the CFD analysis comprises most of the rotorcraft computational requirement, structural dynamics analysis of a complex rotorcraft may not be insignificant for large models and may conceivably constitute a bottleneck in computational performance for future rotorcraft applications. To date, structural dynamics computations for rotorcraft applications have not been shown to be as amenable to HPC parallel processing methods as CFD computations (Refs. 2-4).

Rotorcraft structures are typically modeled with multi-body finite element methods for rotor blades and fuselage structures. For typical anisotropic composite rotor blades, current analysis methods divide the 3-D structural problem into a nonlinear 1-D beam problem and a linear 2-D cross section problem to greatly reduce the computational burden compared to full 3-D approach. Fuselage models are based on either simple beam element stick models or reduced order models obtained from elaborate finite element models based on NASTRAN or similar codes. The purpose of this topic is to explore possible approaches for applying scalable, parallel processing HPC methods to the rotorcraft structural dynamics (CSD) problems. This is to include the development of algorithms and computer software architecture to enable accurate, efficient, computations to be performed for full CFD/CSD coupled rotorcraft applications. If possible, it is desired that these methods should be adaptable to existing rotorcraft comprehensive analysis codes, e.g., Ref 5. Such methods should be sufficiently flexible to address different types of rotorcraft structural components such as rotor blades, auxiliary lifting surfaces, and fuselages, and rotor hubs, and drive train components as well. It is also desired that the methods to be developed for this topic be applicable and efficient for such 1-D nonlinear beam finite elements.

PHASE I: Identify candidate approaches to apply scalable, parallel processing HPC methods to rotorcraft structural dynamics analysis. Develop the relevant theoretical basis. Identify and estimate the expected computational performance benefits. Define and develop candidate computer software architectures including an assessment of the feasibility of integrating such approaches into typical existing rotorcraft comprehensive analyses. Perform pilot studies to demonstrate applicability and benefits of proposed approaches.

PHASE II: Provide top-level software design approach for scalable parallel processing approach developed in Phase I. Based on the top-level system design, complete the detailed design for the software of the coupled CFD/CSD system. Following the detailed design, implement the associated software modules. Integrate the software modules in the comprehensive analysis. Test the integrated software and generate representative results for comparison with baseline comprehensive analysis. Generate timing results to measure improved runtime efficiency and throughput for representative problems of relevant size and complexity. Prepare appropriate test reports and software documentation for the developed code. Prepare user and application documentation.

PHASE III: The advanced comprehensive analysis software system will be used by DoD R&D organizations such as U.S. Army RDEC and equivalent Navy organizations for application to ongoing research investigations and engineering analysis support of fielded rotorcraft. The integrated software will be provided to rotorcraft industry for application to the rotorcraft design process. Here, advanced design methodology will be equally applicable to military and civilian vehicles, increasing design cycle effectiveness and ultimately reducing development and operating costs and improving vehicle mission effectiveness. Particularly relevant for future rotorcraft design applications will be unique requirements of DoD joint heavy lift rotorcraft where multi-disciplinary effects of aeroelastics, flight controls, and engine drive train dynamics on aerodynamic performance and structural design loads in all flight regimes will be particularly critical owing to the amplified aeroelastic interactions associated with very large flexible vehicles.

REFERENCES:

1. Mahendra J. Bhagwat , Robert A. Ormiston, Hossein A. Saberi, and Hong Xin, “Application of CFD/CSD Coupling for Analysis of Rotorcraft Airloads and Blade Loads in Maneuvering Flight,” Presented at the American Helicopter Society 63rd Annual Forum, Virginia Beach, VA, May 1-3, 2007.

2. Giuseppe Quaranta, Pierangelo Masarati, and Paolo Mantegazza, “Multibody Analysis of Controlled Aeroelastic Systems on Parallel Computers,” Multibody System Dynamics 8: 71–102, 2002.

3. Coulon, D.; Gerardin, M.; Farhat, C., “Adaptation of a Finite Element Solver for the Analysis of Flexible Mechanisms to Parallel Processing Systems,” Second International Conference on Computational Structures Technology, Athens, Greece, 30 Aug – 1 Sept. 1994.

4. Farhat, C, Pierson, K. and Lesoinne, M., "The Second Generation FETI Methods and Their Application to the Parallel Solution of Large-Scale Linear and Geometrically Non-linear Structural Analysis Problems," Computer Methods and Applied Mechanics and Engineering, Vol. 184, (2-4), April 2000, pp.333-374.

5. Saberi, H, Khoslahjeh, M, Ormiston, R. A., and Rutkowski, M. J., ‘Overview of RCAS and Application to Advanced Rotorcraft Problems,’American Helicopter Society 4th Decennial Specialists, Conference on Aeromechanics, San Francisco, CA, January 2004.

KEYWORDS: CFD, computational structural dynamics, scalable parallel processing, rotorcraft aeromechanics, comprehensive analysis, joint heavy lift.

A08-017 TITLE: Advanced Rotorcraft Comprehensive Analysis

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop advanced technology modeling and simulation software components to significantly improve accuracy, efficiency, functionality, and ease of use of multi-disciplinary rotorcraft comprehensive analysis. Integrate the software into an existing rotorcraft comprehensive code to enable researchers and industry designers to develop future Army rotorcraft with substantially improved mission effectiveness at lower cost and reduced development risk.

DESCRIPTION: Rotorcraft computational modeling and simulation capabilities are critical for all phases of rotorcraft research, development, and engineering. Fast, accurate, easy-to-use computational tools for research and design are the foundation for developing future rotorcraft having mission performance, life cycle cost, and reliability needed to meet tomorrow's requirements.

Over the past 10 years, a new generation of multidisciplinary, comprehensive rotorcraft analysis codes has begun to change the way the technical community – and most importantly, the rotorcraft industry, conducts the rotorcraft design process. The most prominent is RCAS, the Army-developed Rotorcraft Comprehensive Analysis System (Ref. 1) a modular, multi-disciplinary code based on rigorous physics-based modeling that replaced earlier empirical, inaccurate, and inefficient codes. RCAS is now used in virtually all areas of the rotorcraft technical community.

In recent years, Computational Fluid Dynamics (CFD) codes have been linked to the computational structural dynamics (CSD) capabilities of rotorcraft comprehensive codes, e.g., Ref. 2, to provide major new capabilities. Current DoD programs are aggressively pursuing further development of rotorcraft CFD/CSD technology. It is increasingly important that new comprehensive analysis software technology be developed to leverage advances in CFD/CSD and to significantly improve stand-alone applications as well. For many years to come, the stand-alone comprehensive code will continue to fulfill a critical role in the industry design process. Therefore, the present SBIR topic is focused on developing new comprehensive analysis technology and the topic is not aimed at rotorcraft CFD or CFD/CSD coupling methods.

Advanced computer software technology and new rotorcraft research offer opportunities to significantly improve rotorcraft comprehensive codes. The key problem is that today's comprehensive analyses are not sufficiently accurate, robust, or computationally efficient to meet today's critical modeling and simulation needs. They do not have sufficient functionality or the ability to interface automated tools in the industrial design environment. The topic is aimed at solving these problems by developing new technology for rotorcraft software that may be integrated into an existing comprehensive analysis, e.g., Ref 1. The topic is not intended to develop a new comprehensive analysis system.

New software technology is needed specifically for: 1) tools to rapidly input physical property data, perform error checking of input data, and automatically interpolate airfoil and structural property tables; 2) software to automate development of arbitrarily complex structures and aerodynamics models and graphically display the physical and topological models; 3) graphical animation of outputs such as structural deformation response, rotor wake vortices, and eigenvectors and mode shapes; 4) specialized models of complex rotorcraft components, e.g., transmissions, drive train components, swashplates, and easy-to-use "super-elements;" 5) aerodynamic and dynamic models for on-blade and active controls of arbitrary geometry; 6) improved methods for airloads, induced velocity, and interference aerodynamics; and 7) fast, robust trim methods and case management tools.

The intended product is software code providing capabilities in the areas described above that surpasses the current state-of-the-art in accuracy, efficiency, and effectiveness. The intended software product will be reliable, trustworthy, fully tested and fully integrated into an existing rotorcraft comprehensive analysis system and will be fully documented.

PHASE I: Provide new technology software that will address the objectives of the topic. Provide the top-level preliminary design of the proposed software including the interfaces for integration into the candidate rotorcraft comprehensive analysis, e.g., Ref 1. Develop the mathematical basis and algorithms needed to address the problems defined in the topic. Outline the technology approaches and tools for the software modules to be implemented in Phase II. In key areas, design and implement prototype software modules, including integration in the candidate comprehensive analysis to demonstrate viability and benefits relative to existing technology.

PHASE II: Based on the top-level system design and prototypes demonstrations in Phase I, complete the detailed design for the full software system including detailed integration plans for the candidate target comprehensive analysis system. Following the detailed design, complete all math basis and algorithm development, and implement all software modules. Integrate the software modules in the candidate comprehensive analysis. Test the integrated software and generate representative results. Generate timing results to measure improved runtime efficiency and throughput where applicable. For software components having increased functionality and accuracy, demonstrate the new capabilities and compare predictions with existing codes and experimental data to quantify improvements. Prepare test reports, software documentation, user manuals and example application descriptions.

PHASE III: The advanced comprehensive analysis software system will be transitioned to and used by DoD R&D organizations such as U.S. Army AMRDEC and equivalent Navy organizations for ongoing research investigations and engineering analysis support of fielded rotorcraft. The integrated software will be transitioned to the rotorcraft industry for application to the rotorcraft design process to increase design cycle effectiveness and ultimately reduce development and operating costs and improve vehicle mission effectiveness. Advanced design methodology will be equally applicable to both military and civilian vehicles. Particularly relevant for DoD rotorcraft will be the new joint heavy lift rotorcraft where capabilities developed in this topic will be essential in dealing with multi-disciplinary effects of aeroelastics, flight controls, and engine drive train dynamics on such rotorcraft - owing to the anticipated magnitude of the aeroelastic interactions associated with very large flexible vehicles.

REFERENCES:
1. Saberi, H, Khoslahjeh, M, Ormiston, R. A., and Rutkowski, M. J., ‘Overview of RCAS and Application to Advanced Rotorcraft Problems,’American Helicopter Society 4th Decennial Specialists, Conference on Aeromechanics, San Francisco, CA, January 2004.

2. Potsdam, M., Yeo, H. and Johnson, W., ‘Rotor Airloads Predictions Using Loose Aerodynamic/Structural Coupling’, American Helicopter Society 60th Annual Forum, Baltimore MD, June 2004.

KEYWORDS: Comprehensive analysis, rotorcraft, modeling and simulation, aeromechanics, software, design methodology.

A08-018 TITLE: <u>Light Weight Collective Pitch Control Systems for Swashplateless Rotors</u>

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Innovative collective pitch control systems are needed for use with future swashplateless helicopter rotors. The control system will include the actuators and mechanisms, and will be small, light weight, simple, reliable, maintainable, and robust.

DESCRIPTION: Swashplateless rotors are being developed for three reasons: 1) for reduced weight, 2) for reduced maintenance, and 3) in support of active rotors, which enable the elimination of the swashplate, for reduced hub vibration, rotor power, and rotor noise. A swashplateless rotor uses on-blade controls, such as trailing-edge flaps, for primary flight control. For optimum performance at off-design conditions, the pitch angle of the blade root must be adjusted in flight. Consequently, a light weight collective pitch control system is needed. Innovative design concepts are needed.

Although a blade root pitch control system can be envisioned to include higher harmonics, such added bandwidth and control authority is not allowed during Phase I of this topic. Instead, the Phase I work must focus on collective control, for minimum weight. Furthermore, this approach will allow a direct comparison with conventional rotor controls.

Control systems are sought which are small, light weight, simple, reliable, maintainable, and robust, as expanded here. The small size is desired mainly for low aerodynamic drag, but also for reduced ballistic vulnerability and radar cross-section. The light weight will reduce the weight of swashplateless rotors. The use of a simple design will reduce manufacturing costs and failure mechanisms. The incorporation of a reliable design will reduce the maintenance required by conventional swashplates, which use the hydraulic system. A maintainable design will keep operation and support costs low. Finally, a robust design will satisfy the harsh military specifications, including the operating environment and ballistic damage.

A wide range of design concepts – actuators and mechanisms – are solicited. If hydraulic systems are proposed, concepts should be included for reduced maintenance and vulnerability. Concepts which are amenable to non-collective motion – including blade tracking, cyclic pitch, higher harmonics, and individual blade control – are conditionally permitted: 1) at least 80% of the technical proposal must pertain to collective control, and 2) the Phase I work must be completely focused on collective control.

Two broad approaches are allowed: 1) accommodate an existing shaft, mast, hub/rotor design, or 2) include a new hub/rotor design. The proposal should clearly communicate which configurations will be considered, to include the shaft, mast, and hub/rotor design. For proposals to modify the hub/rotor design, the benefits of this approach should be described. The phrase "hub/rotor", herein, describes the design features of the hub and/or rotor that are used to define the interface and to provide the desired kinematics and/or flexibility, to accommodate flap, lag, and pitch motions, and lag damping. It is conceivable that some designs would affect the rotor hub design, possibly including some aspect of the blade design.

The needed collective pitch travel, speed, and duty cycle are dependent upon the particular hub/rotor configuration under consideration.

PHASE I: Perform a feasibility study. Clarify and expand the design requirements. Develop conceptual designs. Develop at least one preliminary design. Detail the key functions of the preliminary design(s). Provide a physical description of the preliminary design(s), including size, weight, range of travel, and strength.

PHASE II: Perform a major research and development effort, culminating in a well defined, deliverable prototype. Continue the development of the design(s), and continue to refine and expand the design requirements. Evaluate the significance of military specifications, including the operating environment and ballistic damage. Consider additional conceptual designs, if needed. If appropriate, estimate the design ramifications of non-collective control. Fabricate prototype hardware for collective control. Perform bench tests to verify design function and strength. Perform simplified, but representative, component life tests.

PHASE III: Develop final system requirements and a detailed design, based on lessons learned in Phase II, specific to a particular aircraft. Build pre-production hardware. Perform extensive strength and system life testing. If this project is successful, the resulting collective pitch control system would be useful for the design of a variety of future military and civilian rotorcraft. Improved rotorcraft performance reduces operating costs and increases mission effectiveness.

REFERENCES:
1. Sonneborn, W., 2003, "Vision 2025 for Rotorcraft," Paper No. AIAA-2003-2852, AIAA/ICAS International Air and Space Symposium and Exposition, Dayton, Ohio, July.

2. Aiken, E.W., Ormiston, R.A., and Young, L.A., 2000, "Future Directions in Rotorcraft Technology at Ames Research Center," Proceedings of the 56th Annual Forum of the American Helicopter Society, Virginia Beach, Virginia, May.

3. Giansante, N., 1995, "Advanced Rotor Actuation Methods (ARAM)," Final Report, USAATCOM TR 95-D-10, June.

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KEYWORDS: Helicopter, rotorcraft, swashplate, swashplateless, rotor, collective, pitch, control, blade, root, indexing, performance, reliability, safety, fail-safe.

A08-019 TITLE: Sensor Guided Flight for Unmanned Air Vehicles

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: Develop software that guides platform flight to deliver robust, reliable sensor performance from UAVs.

DESCRIPTION: Sensor guided flight is an essential capability for utilizing UAVs more effectively in reconnaissance, surveillance and target acquisition (RSTA) missions. Sensor guided flight is envisioned as the ability for a UAV’s sensing system, primarily imaging system, to automatically request platform position and attitude that maximizes its performance. It is the ability to monitor viewing conditions for a given RSTA task, assess whether the sensor system parameters and platform position and attitude are the most optimum for those viewing conditions, and if not, compute and recommend preferred parameters and platform state for best quality imagery for those viewing conditions.

This effort will develop the software and architecture that can deliver robust, reliable RSTA from UAVs. The technical approach should include but is not limited to considerations of sensor system settings such as pan/tilt/zoom as well as camera type, and preferred platform position and orientation. Considerations of external environmental conditions such as visibility, sunlight angles, precipitation, terrain type, shadows, and such are not required, but would be a plus. It may be assumed that a flight mission begins with a known type of object or threat being targeted over a given terrain type.

It is intended for now to focus the effort to gimbal-mounted EO/IR sensor systems on fixed wing aircraft. For the initial effort, especially during Phase I of this topic, offerors may use any set of representative data for gimbal azimuth and elevation limits as well as aircraft attitude constraints. Constant velocity flight may be assumed with altitude variations allowed within a restricted range. For effort that progresses into Phase II and possibly beyond, quantitative data representative of platforms of interest to the Army such as the Shadow or planned Warrior unmanned air vehicle will be provided, if needed.

At a minimum the system needs to: develop a set of sensor system configuration parameters that can be adjusted automatically during flight; develop simple techniques to initialize sensor system parameters to an optimum default configuration based on immediate mission and recommend preferred, safe, altitude, azimuth and elevation angles for best imagery to the operator; develop a method to automatically monitor platform state and check if landing gear, skids, wings, antennas or any such ownship viewing obstacles as well as known terrain occlusions and elevation variations during flight interfere with the line of sight (LOS) to ground; and in response automatically alter sensor system configuration parameters to regain LOS or alert operator and recommend preferred platform orientation to regain LOS. The system also needs to be able to adapt to time of day and light conditions with at a minimum a change between EO and IR camera types for best imagery. The ability to adapt to known, externally provided data on visibility (rain, cloud cover, etc), terrain type (color, texture, foliage, desert), and features (roads, buildings, hills) or a subset of these would be viewed as advantageous. It is expected that the system will be able to transition from operator-managed flight planning to fully autonomous flight seamlessly.

PHASE I: Identify feasible system architecture design and key software elements that can be used/developed and integrated. Conduct proof of concept assessment of critical elements with representative data. Develop and describe initial prototype for integration and test.

PHASE II: Establish preliminary performance estimates and identify key technical issues using simulation testing. Identify changes and refinements needed based on test results. Design and develop a complete system and install it on a small UAV or surrogate and conduct testing to characterize system performance. Define requirements and goals for follow-on system development efforts based on the results of this research.

PHASE III: This technology addresses an essential capability in autonomous UAVs for the Army's FCS goals and similar related DoD systems. Utilization of UAVs for reconnaissance and surveillance missions is still a highly labor intensive operation within the military with today's state-of-art. The number of UAVs that will be operated by the US Army, other DOD agencies as well as other Federal and State agencies for such mission is on an exponential growth path. The technology that will be developed by this topic will reduce the difficulties, shortcomings and labor burden involved in such operations. It will allow for much more effective and easier use of UAVs for monitoring ground activity whether in a military context or in relatively benign stateside border security, disaster response, traffic monitoring, geological mapping and commercial survey and monitoring applications. The transition to these applications will be paced by the extent to which the technology establishes reliability and conforms to interoperability standards and airspace management needs consistent with the wider aviation community practices.

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3. Intelligent Unmanned Air Vehicle Flight Systems, J. Miller, P. Minear, and A. Niessner, Pennsylvania State University, State College, PA; A. DeLullo, B. Geiger, L. Long, and J. Horn, Pennsylvania State University, University Park, PA AIAA-2005-7081.

KEYWORDS: Autonomous, Navigation, UAV, Reconnaissance, Surveillance, Tracking, Environment, Visibility, Sensor.

A08-020 TITLE: Innovative Pitch Link Actuators for Individual Blade Control (IBC)

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: The objective of the topic is to perform the required research and development work towards a flight worthy, sustainable, pitch link actuator for a helicopter rotor individual blade control (IBC) system.

DESCRIPTION: Individual blade control involves the replacement of pitch links with a device that serves as both a pitch link and a blade root actuator. As clearly shown by recent NASA/ Army wind tunnel testing on a UH-60, and by the German flight testing of a CH53G, individual blade control has the potential to increase performance, reduce vibration and acoustics, and allow in-flight, automatic tracking of rotor blades. Any new concepts for IBC actuator design/systems require simplicity and appreciation of operational safety and air worthiness constraints. The ultimate solution will be one that insures a minimum impact of the retrofit process and high reliability. Innovations are required to develop a concept of future IBC systems that can be scaled and retrofitted to a range of helicopters. Example targets include the CH-47, and UH-60, as well as smaller helicopters and UAVs.

PHASE I: Phase I of the project begins with a state-of-the-art assessment of the large volume of work to date on IBC actuators and systems. This assessment should include benchtop demonstrations of hardware for direct comparison of various approaches to IBC. Using the lesson learned from previous work and this initial assessment, Phase I concludes with the development of a new concept and validates the technical feasibility. Phase I should conclude with a prototype demonstration under simulated loading, and demonstrate the necessary expertise and research quality to insure a successful Phase II effort.

PHASE II: Using the results from Phase I, the Phase II effort should continue the development of the new IBC actuator concept. This new concept should aim to achieve performance improvements in terms of increased range as a first priority with vibration reduction as a second priority, and acoustics alleviation as the third priority. The system is required to demonstrate the capability of automated blade tracking. There is no interest in reducing blade vortex interaction noise in descending flight, and so the acoustics aspects of the IBC system should address high speed impulsive noise as the target. Prototype hardware should be able to demonstrate fail safe operation under simulated loads and exceed performance of state-of-the-art IBC actuators. Deliverables of Phase II include detailed fatigue life analysis and testing, airworthiness requirements validation, maintenance and reliability assessments, and harsh environmental testing according to military standards. Phase II should also demonstrate the scalability of the solution from a medium lift helicopter to a light weight helicopter in order to maximize the value to the US Army. Supporting analysis using suitable comprehensive aeromechanics codes is desired but should not prevent the effort from focusing on hardware development. The final concept should address all of the practical issues associated with an IBC system such as slip ring requirements, power requirements, electrical interference, hub modifications, open and closed loop control, and the feasibility of retrofitting existing Army helicopters. Phase II should conclude with all of the required detail to support the Air Worthiness Release (AWR) process of Phase III.

PHASE III: Phase III begins with the Air Worthiness Release process for flight testing of the final IBC system. This phase of the project includes flight testing on two different scales of helicopters from medium lift to light weight. The Phase III process should begin with a fieldable and maintainable concept, and the final question of the payoff of IBC in terms of performance, vibration, and acoustics should be quantified through flight testing. Demonstration of automated blade tracking and its operational impact on vibration should also be part of the Phase III flight test program.

REFERENCES:
1. Jacklin, Stephen A., Blaas, Achim, Teves, Dietrich, Kube, Roland, "Reduction of Helicopter BVI Noise, Vibration, and Power Consumption Through Individual Blade Control", AHS 51st Annual Forum and Technology Display; Fort Worth, TX, 9-11 May 1995.

2. "Open Loop Flight Test Results and Closed Loop Status of the IBC System on the CH-53G Helicopter", Christoph Kessler, Daniel Fuerst, Uwe T.P. Arnold, American Helicopter Society International 59thAnnual Forum, Phoenix, Arizona, May 6-8, 2003.

KEYWORDS: Individual blade control, IBC, active rotors, vibration reduction, rotor performance, lift-to-drag ratio, increased range.

A08-021 TITLE: <u>Innovative Systems for Reduction of Rotorcraft Hub Drag</u>

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop technology to reduce aerodynamic drag due to helicopter rotor hub and blade shanks using active, passive or a combination of methodologies which can be applied to new or existing hub/blade designs.

DESCRIPTION: The aerodynamic drag of the hub and rotor blade shank is a substantial fraction of the total drag on a modern helicopter. Some current rotorcraft designs include traditional aerodynamic fairings on the hub and or fuselage to varying effect but many ignore this large drag source entirely because of its kinematics and dynamic complexity. In order to increase the speed, efficiency, and payload capacity of current and future rotorcraft designs to keep them relevant in future operational environments, the problem of hub drag will need to be addressed in innovative ways.

New technology concepts are sought to reduce drag produced by the helicopter rotor hub, shaft, control system and blade shanks. Concepts may include active or passive devices or involve a combination of methodologies. The goal of this work is to generate a wide range of concepts which may be implemented separately or in concert to address the problem. Both integrated technologies, which would require new hub design, and retrofittable technologies, which could be installed on currently fielded aircraft should be considered. Design goals should include small size, low weight, high reliability, ease of maintenance, and safe failure modes. Analysis of proposed designs should include static and dynamic loadings associated with rotorcraft hubs and blades and consider the operation of the systems in harsh environments and under all weather conditions.

PHASE I: Identify and define methodologies for hub drag reduction. Develop conceptual designs and analyze the feasibility of their implementation. Further develop feasible design(s) and model their effect on drag, as well as their physical attributes, power and control requirements and integration into the supporting systems.

PHASE II: Continue development and modeling of preliminary design(s). Build a proof of concept model of the system(s) and demonstrate their capability in a wind tunnel test or other appropriate laboratory experiment.

PHASE III: Develop complete implementations of the system or systems designed and tested in Phase I and II. The vision is a system or suite of systems which can be either retrofitted on currently fielded airframes or integrated into new or refreshed designs which will significantly reduce the drag associated with the rotor hub and blade shanks. The technology could be transferred through rotorcraft airframe producers, DoD Program Managers or through the small business as a retrofit service.

REFERENCES:
1. Keys, Charles., Wiesner, Robert. Guidelines for Reducing Helicopter Parasite Drag. Special Report to the 31st Annual National AHS Forum by the Ad Hoc Committee on Rotorcraft Drag, Washington, D.C., May 14-15, 1975.

2. Linville, James C. An Experimental Investigation of High-Speed Rotorcraft Drag. USAAMRDL Technical Report 71-46. 1972.

3. Sheehy, Thomas., Clark, David. A General Review of Helicopter Rotor Hub Drag Data. Special Report to the 31st Annual National AHS Forum by the Ad Hoc Committee on Rotorcraft Drag, Washington, D.C., May 14-15, 1975.

4. Williams, R. M., Montana, Peter. A Comprehensive Plan for Helicopter Drag Reduction. Special Report to the 31st Annual National AHS Forum by the Ad Hoc Committee on Rotorcraft Drag, Washington, D.C., May 14-15, 1975.

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KEYWORDS: Rotorcraft, helicopter, rotor, hub, pylon, parasite, drag.

A08-022 TITLE: Practical Composite Rotor Blade and Wing Structural Design Tool for Aeromechanical Assessments in Conceptual Design

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: The objective is to develop a means to rapidly assess aeromechanics issues for rotorcraft configurations with realistic rotor and wing structural properties during the conceptual design stage. Specifically, a design tool is needed that can provide realistic engineering beam properties for blades and wings given basic aircraft geometries, applied load distribution and design constraints. The realistic properties should satisfy structural design requirements such as static and fatigue stress, ballistic tolerance and dynamic stability guidelines. Variables should include material properties and cross-section topology.

DESCRIPTION: Rotor blade design is a specialized skill that is labor and computationally intensive which requires an iterative process between rotor design and comprehensive analysis. This inhibits efficient design and associated analysis of rotors for future rotorcraft systems. Currently, aeromechanics assessments for loads, vibration and stability are left out of conceptual design due to the difficulty of generating meaningful input to rotorcraft comprehensive analysis. Assumptions or technology projections made during configuration design may be unachievable or inadequate to meet system needs. Additionally, difficult aeromechanical problems are not discovered until the design space is significantly narrowed. Development of a high-fidelity, yet efficient and easy-to-use, composite rotor blade and wing cross-section design tool is critical to improve future rotorcraft systems. Once the tool is developed, the intent is to evolve the tool to include automation and optimization.

Current rotor blade aeromechanical analysis tools have beam analysis models with a capability to handle isotropic and, though limited, composite materials. Rotor blades are designed for given blade structural loads at critical flight conditions while meeting design and operational constraints. For the known loading conditions and constraints, the designer selects materials and cross sectional layout to meet required stress or strain failure criteria. The resulting blade structural and inertial properties are used to calculate the loads and stability of a rotorcraft using comprehensive analyses such as RCAS and CAMRAD II. A similar approach is used for the structural design of wing sections.

The blade design tool should allow flexibility for users to define/add/modify design variables such as section geometry (airfoil coordinates relative reference chord line, twist angle of chord line, quarter chord offsets including sweep and cone/droop), material properties, skin and spar thickness, web location, composite ply orientation, etc. The user should also be able to easily modify engineering constraints such as elastic axis location and center of gravity location within a defined range. Desired outputs are section properties include: a) stiffness (bending, torsion, extension; isotropic or anisotropic), neutral axis offsets, shear center offsets, principal axes pitch angle, modulus weighted radius of gyration, extension-twist coupling and b) inertia (mass, 2 moments of inertia), center of gravity offsets, principal axes pitch angle.

The end product of this SBIR is a high-fidelity, yet efficient and easy-to-use design tool. The tool would be used for an enhanced configuration design effort and lead to better transition during detailed design. Intent is to expand a viable analysis capability to apply engineering constraints and material inputs, generalize the resultant tool for both wings and rotors and then apply optimization and automation.

PHASE I: Develop or expand an existing rotor blade / wing cross-sectional structural analysis / design tool that can handle various design parameters for with user selection of structural materials and engineering constraints to meet critical design loading. The proposer will specify allowable material selection criteria and design requirements (constraints). A clear step by step guide should be provided to enable the user to add additional generic blade / wing section layouts.

PHASE II: Further develop tool and demonstrate its capability to design blades and wings with a defined set of engineering constraints which also meets loading conditions. Expand the tool with automation and optimization to significantly reduce blade and wing design time.

PHASE III: Prepare tool for distribution and transition to the technical community by creating libraries of structural materials properties, loading conditions and design requirements (constraints). These cases should be demonstrated for a range of rotorcraft configurations (single main rotor helicopter, tandem, tiltrotor and high speed compound) and compare with formal detailed design structural analysis.

Present results to rotorcraft prime manufacturers to obtain feedback about the adequacy of the design tool, and to receive suggestions for improvements. If this project is successful, and further development is also successful, the resulting design tool can be used in the design of a variety of future military and civilian rotorcraft. Transition path potential may include rotorcraft manufacturers, DoD configuration design activities, or other activities.

REFERENCES:
1. Johnson, W., Yamauchi, G. K., and Watts, "NASA Heavy Lift Rotorcraft Systems Investigation," NASA/TP-2005-213467, December 2005.

2. Zhang, J., and Smith, E., "Design Methodology and Analysis of Composite Blades for a Low Weight Rotor," Proceedings of the American Helicopter Society Vertical Design Conference, San Francisco, CA, January 18-20, 2006.

3. Hodges, D. H., Saberi, H., and Ormiston, R. A., "Development of Nonlinear Beam Elements for Rotorcraft Comprehensive Analyses," Journal of the American Helicopter Society, Vol. 52, No. 1, Jan. 2007.

4. Cesnik, C. E. S., and Hodges, D. H., "VABS: A New Concept for Composite Rotor Blade Cross-Sectional Modeling," Journal of the American Helicopter Society, Vol. 42, No. 1, Jan. 1997.

KEYWORDS: Rotor, blade, wing, structures, cross-section, conceptual design, structural design, structural analysis, composite, materials, airfoil, rotorcraft, helicopter, tiltrotor, aeromechanics, dynamics, aeroelasticity, stability, tandem helicopter, compound helicopter, comprehensive analysis, optimization, automation, beam, beam analysis.

A08-023 TITLE: Reinforced High Temperature Titanium Metal Matrix Composite Systems For Impeller Applications In Advanced Army Turboshaft Engines

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: To develop a reinforced high temperature titanium metal matrix composite material system for impeller applications in advanced Army turboshaft engines for increased performance.

DESCRIPTION: Ongoing operations in adverse and challenging theaters have created a need for increased performance from advanced turboshaft engines. It is anticipated that these advanced turboshaft engines will involve new centerline engines that are greater than 3,000 shaft-horsepower with a 20-35% reduction in specific fuel consumption (SFC), a 50-90% improvement in shaft horsepower to weight, and a 35-40% reduction in production and maintenance cost. These turboshaft engine goals are acknowledged to be highly aggressive. To achieve them will require technology leaps. New and innovative material systems are necessary to allow operation at higher cycle temperatures and pressure ratios to meet the necessary system level performance goals, while reducing the weight of the engine and providing an affordable solution.

The objective of this topic is to develop a reinforced high temperature titanium metal matrix composite (TiMMC) for impeller applications in turboshaft engines for Army rotorcraft. Titanium metal matrix composites (TiMMC) offer significant improvement in stiffness and strength over conventional monolithic alloys and allow significant component weight savings for advanced turbine engine applications. However; TiMMC used for impeller applications are prone to residual stress buildup that causes cracking within the impeller due to limited ductility. This topic will develop a reinforced TiMMC with improved ductility, strength, and stiffness to alleviate the cracking within the impeller. The reinforced high temperature TiMMC should be capable of operating at advanced turbine engine operating conditions, which include tip speeds of greater than 2000 ft/s and impeller exit temperatures of greater than 1100 degrees Fahrenheit while exhibiting 6,000 hrs / 15,000 low cycle fatigue (LCF) cycles of design life.

PHASE I: Phase I of the effort will develop and evaluate reinforced TiMMC systems (such as reinforced by nano sized dispersoids) for one or more creep resistant titanium alloy matrices (such as Ti-6-2-4-2+Si, Ti-834, Ti-1100) for turboshaft engine impeller applications. Phase I will evaluate manufacturability, feasibility, and basic mechanical properties of these systems, and may include coupon testing for evaluation of material properties. At the end of this phase, the optimal composite system should be selected to continue development in Phase II. The offeror should coordinate with an engine manufacturer to determine the operating temperatures and pressures that will be experienced in advanced turbine engines, and to determine the material properties necessary for operation in turboshaft engines for impeller applications. At the conclusion of Phase I, the composite system should prove to have the necessary properties, with the potential to be able to operate within the turboshaft engine environment for impeller applications.

PHASE II: This phase will develop and optimize the composite system selected in Phase I. A full scale component, representative of a turboshaft engine impeller, shall be produced and tested for mechanical properties including tensile, fatigue, creep, fracture toughness and crack growth. Material properties should be evaluated at room temperature and at equivalent elevated temperatures experienced in advanced turboshaft engines. Material structure and failure mechanisms should be examined. Manufacturability of the material and machinability, as well as the affordability should be evaluated.

PHASE III: Focus on the commercialization of the technology through integration into engine manufacturers' propulsion systems for use in future engine development programs.

Commercialize the technology through integrating the developed system into engine manufacturers' military engine development efforts to contribute to the reduction of specific fuel consumption by 20-35%, improve shaft horsepower to weight by 50-90% and reduce production and maintenance costs by 35-50% with increased operating temperatures and pressures on future advanced military or commercial engine development programs. This technology has a wide application to multiple Program Executive Office (PEO) Aviation current and future platforms in addition to multiple commercial platforms. For example, this technology is applicable to the development of an improved engine to support a growth CH-47 or Joint Heavy Lift (JHL).

DUAL USE APPLICATIONS: The resulting effort will be applicable to both military and commercial applications as both applications can gain improved performance and higher operating temperatures and pressures with this technology.

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KEYWORDS: Titanium Metal Matrix Composite, Gas Turbine Engines, Turboshaft Engines, Impeller, High Temperature, Reinforced.

A08-024 TITLE: Lightweight Metallics for Cargo Helicopter Main Rotor Shaft Applications

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: This topic seeks to identify and develop an affordable lightweight metallic material and manufacturing process that could replace the current material and provide a significant weight reduction (15-25%) for the main rotor shafts of the CH-47 cargo helicopter.

DESCRIPTION: The main rotor shaft(s) of a large cargo helicopter such as the Boeing CH-47 are one of the largest,heaviest, and highly loaded single components on the aircraft. The current rotor shafts of the CH-47 are manufactured from AMS 6352 (AISI 9310) steel alloy hardened to Rockwell C 35. The shafts are nearly 48 inches long with a maximum diameter of 6 inches. The total aircraft flight loads are transferred from the main rotors, through the main rotor shaft, and into the airframe. The rotor shafts experience a combination of cyclic axial, torsional, and bending loads. The CH-47 forward rotorshaft weighs 216 pounds. The unltimate bending moment is 792,000 in-lbs and the ultimate torsional load is 2,600,000 in-lbs. The shafts have several splines at various locations along its axial length. These splines, which interface with the rotor controls and provide attachment points for the main rotor hub, are case hardened to Rockwell C 60 to provide wear resistance. The lower portion of the shaft consists of an integral planetary carrier through which the driving torque load is applied to the shaft. Potential approaches include the use of advanced titanium alloys, advanced high strength cobalt based alloys such as Aermet 100, and the combination of several different metallic materials to obtain the optimum solution. The ability to create high strength wear resistant splined joints equal to that provided by case carburization will be a key to the potential use of any new material system for this application. The proposed approach should place a high level of emphasis on affordability with respect to material and manufacturing costs. Corrosion resistance of the proposed solution should be equal to or greater than the current shaft. Target weight reduction is 15-25%.

PHASE I: During the phase I effort, analysis of the technical approach proposed should be conducted in detail. This analysis should include discussions with rotorcraft airframe manufacturers to identify the specific requirements for the main rotor shaft. A preliminary analysis of the potential weight savings and projected cost of the proposed approach should be conducted. Target weight reduction is 15-25%. Small scale manufacturing trials and material characterization testing may be conducted to establish basic feasibility and guide the effort to be conducted in Phase II.

PHASE II: The results of the Phase I effort shall be further developed to scale-up the proposed approach and optimize materials and manufacturing methods. The specific approach to conducting this optimization and scale-up effort shall be closely coordinated with a rotorcraft airframe manufacturer. This development work shall be supported by necessary design and modeling effort. Manufacturing trials and material property development of increased complexity shall be conducted to evaluate the performance of the specific approach. Fabrication of a full-scale main rotor shaft shall be conducted. Static strain testing of the shaft shall be conducted and compared to predicted model results. Potential target applications shall be identified and plans for technology insertion and product development conducted.

PHASE III: Effort in this phase would involve further collaboration with the helicopter manufacturer regarding design and manufacture. Additional specimens would be fabricated incorporating any improvement resulting from the Phase II effort. Additional static testing and dynamic testing with full rotor loads applied should be conducted. Efforts to qualify the new design for flight test and introduction to service should be conducted. While the UAV ATO is the best which to link this technology at present, the potential transition path to current and future versions of the CH-47 cargo helicopter is clearly supported by the Cargo helicopter program manager.

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4. Frederick W. Brown, Jeffrey D. Hayes and G. Keith Roddis, Improved Tooth Load Distribution in an Involute Spline Joint Using Lead Modifications Based on Finite Element.

KEYWORDS: Helicopters, shafts, steel, titanium, splines.

A08-025 TITLE: On-Line Oil Condition and Metal Wear Analysis Sensor

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: The objective of this SBIR is to develop an on-line oil monitoring system that can detect metal debris content and the quality of the system lubricants. As health and usage monitoring systems (HUMS) are implemented in the military, it is imperative to incorporate as much as possible of the aircraft maintenance process. Currently, aircraft with HUMS are primarily monitored for vibration measurements. In order to develop a more complete HUMS, implementation of routine maintenance schedules such as oil changes based as actual measured oil quality parameters is required.

Currently, to ascertain an Aircraft's comprehensive operating oil condition, Army personnel must send a sample to an oil analysis laboratory. Depending on the distance the laboratory is from the aviation unit the process can take several days or longer. Conversely, this on-line oil monitoring system will produce results instantaneously, not days. Therefore, developing this on-line oil monitoring capability for HUMS will increase aircraft safety and operation and support (O&S) costs.

Aircraft lubricants are essential in maintaining the condition of flight critical components. Any degradation in the lubricant's properties impairs its ability to protect the aircrafts dynamic components. By having the ability to monitor oil condition real-time and on aircraft, the user can change the oil at the optimum schedule and when unexpected contaminants are detected. Contaminated oil can degrade and corrode dynamic rotorcraft components. Thus, oil changing timing becomes critical as left unchecked degraded oil can damage flight critical parts the longer it remains in the aircraft. Contamination of oil can also cause seals to expand and develop fire hazards.

DESCRIPTION: This effort will develop a plug sized sensor to determine oil quality on-line and in real-time. The goal is to replace existing chip detectors with this on-line oil quality and metal wear analysis sensor. The sensor will have the ability to detect critical parameters the Army Oil Analysis Program (AOAP) and Joint Oil Analysis Program (JOAP) laboratories currently monitor such as the total acid number (TAN), water content, thermo-oxidative degradation, fuel/coolant dilution, and anti-oxidant depletion. The plug sensor will also detect the metal ware particle content in the oil. This recognition will include the ability to distinguish the size of the particles and identify specifically what metals particles are present in the oil. This is an important feature as detailed wear metal analysis can help indicate which components being lubricated are becoming degraded or failing. Therefore, this effort will give the aircraft's maintainers the information presently available only at the AOAP and JOAP laboratories on the aircraft and in real-time.

PHASE I: Phase I of the effort will develop and validate the proposed technology. Phase I will develop the technology sufficiently to prove the viability and confirm the sensor can be made into a package small enough to replace existing chip detectors. The sensor design should be capable of operating in the intended environment.

PHASE II: Phase II will develop the Phase I technology into a fully functional prototype. The system will be tested to assess the accuracy and repeatability of the oil monitoring functions to include accurate readings of the critical parameters identified above and detailed metal analysis capability of debris present in the oil. Aircraft interface issues should be investigated and addressed.

PHASE III: Dual use applications. This technology is applicable to any aircraft. Both military and commercial operators could use the technology developed to better operate/manage aircraft lubricant systems to save O&S cost and enhance aircraft safety. This technology could be integrated into aircraft through existing chip detector locations which will make it a desirable product for the intended users. The information could also be implemented into HUMS if the aircraft is so equipped. Additionally, once validated and demonstrated , it is anticipated this technology will lessen the workloads of the AOAP and JOAP certified laboratories.

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2. Army Oil Analysis Program (AOAP) Guide for Leaders and Users, TB 43-0211, 1 Dec 2004.

3. On-Board Total Oil Monitoring System (TOMS) for Helicopter Transmissions and Engines, USAAMCOM TR-00-D-18, T. Digiuseppe, September 2001.

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KEYWORDS: Maintainability, maintenance management, sensors,miniature electronic equipment, miniaturization, user need.

A08-026 TITLE: Advanced Manufacturing methods for Composite Gearbox Housings for Rotorcraft Applications

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PEO Aviation

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

OBJECTIVE: This topic seeks to develop lightweight, cost effective solutions for the integration of fluid passages into the walls of the composite gearbox housings for use on helicopters.

DESCRIPTION: Composite gearbox housings offer the potential for reducing the weight of future rotorcraft. Widespread use of composites in gearbox application has been limited by high manufacturing costs associated with several key technical challenges. This topic seeks to develop lightweight, cost effective solutions for the integration of fluid passages into the walls of the composite gearbox housings. These passages are currently integrated in to the metallic housing during the casting process. Gearbox housings used in current production rotorcraft applications are typically fabricated from either cast magnesium or aluminum alloys. Each of these materials has it’s own set of positive and negative attributes. Magnesium is lightweight and can be cast into complex shapes but is susceptible to corrosion. Careful design and the application of special coating systems has made magnesium acceptable in may applications. Aluminum, while denser than magnesium, is corrosion resistant and can also be cast into complex shapes. The increased density increases weight and reduces the overall performance of the rotorcraft. Various forms of composite housings may be applicable to the various gearbox housings on the rotorcraft. The accessory gearbox housing of the turboshaft engine is typically a higher temperature, lightly loaded structure. Compression molding of chopped carbon fiber with a high temperature resin has been utilized in the past. Main rotor gearboxes typically transmit all flight loads through the gearbox upper cover and thus utilize a more complex fabric type lay-up and resin transfer molding (RTM). Past efforts to integrate fluid lines into compression molded parts has been limited by variability in wall thickness, and the high cost associated with removal of wash out, or melt out cores. Past efforts at integrating fluid lines into RTM housings has been limited to post fabrication drilling, and external plumbing.

PHASE I: During the phase I effort, analysis of the technical approach proposed should be conducted in detail. This analysis should include discussions with rotorcraft airframe and engine manufacturers to identify their specific needs. Effort should be conducted to evaluate the various applications and manufacturing methods currently in use and anticipated in the future. The results of this effort should be utilized to determine the most effective method of integrating fluid passages into a rotorcraft composite gearbox housing. Given the potential that different manufacturing methods may be applicable to the various gearbox housings on the rotorcraft, it is possible that more than one approach may be required. Upon selection of the specific approach(s), small scale manufacturing trial should be conducted to establish basic feasibility and guide the effort to be conducted in Phase II.

PHASE II: The results of the Phase I effort shall be further developed to scale-up the proposed approach and optimize materials and manufacturing methods. The specific approach to conducting this optimization and scale-up effort shall be closely coordinated with a rotorcraft airframe or engine manufacturer. This development work shall be supported by necessary design and modeling effort. Manufacturing trials of increased complexity shall be conducted to evaluate the performance of the specific approach(s). Potential target applications shall be identified and plans for technology insertion and product development conducted.

PHASE III: Effort in this phase would involve further collaboration with the helicopter or engine manufacturer regarding design and manufacturing issues. Additional specimens would be fabricated incorporating any improvement resulting from the Phase II effort. Additional static testing and dynamic testing should be conducted. Efforts to qualify the new design for flight test and introduction to service should be conducted. the most likely transition paths are to the T-700 turboshaft engine and/or the UH-60, AH-64, and CH-47 helicopters.

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KEYWORDS: Composites, Gearbox Housings, Fabrication, Helicopters, Turboshaft Engines, Fuels, Lubricants.

A08-027 TITLE: Effects of High Temperature on Solid Propellants: Insights Into Their Effects on Slow and Fast Cookoff Responses Toward Insensitive Munitions

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The first objective of this project is to develop a model to predict physical and chemical changes in solid propellants as they increase in temperature during Slow and Fast Cook-Off (SCO and FCO) Insensitive

Munitions (IM) testing. The second objective is to develop a subscale, inexpensive test that predicts the results of full scale SCO and FCO IM tests.

DESCRIPTION: Several incidents that resulted in significant loss of life and property, including the one on the Forrestal during the Viet Nam conflict, demonstrated that bombs and missiles are susceptible to bullet and fragment impact, slow and fast cook-off, sympathetic detonation, and shape charge jet threats. MIL-STD-2105C outlines the Insensitive Munitions program that requires all warheads, explosives, and propulsion systems to comply with its requirements or get waivers while they work toward meeting their requirements.

Many propellants have difficulty passing the SCO and FCO threats because the hazardous processes are occurring within the propellant itself and mechanical mitigations have not been as effective as desired. Propellant chemical, physical, and performance properties have been well studied for temperature less than 70°C, but very little work has been done between 70°C and the auto-ignition temperature.

This project has two primary tasks. The first task is to characterize the chemical, physical and performance properties at temperatures approaching auto-ignition. Hypotheses for physical and chemical changes that occur during cook-off tests will be developed based upon the experimental test results. The second task is to develop a small scale, inexpensive test that successfully predicts the results of expensive full scale SCO and FCO tests. This task also includes developing a model that predicts physical and chemical changes that occur during these two IM tests.

PHASE I: The goal of Phase 1 is to establish hypotheses for changes in physical characteristics, decomposition, and/or reactions that occur in solid propellants as they approach their autoignition temperature. Knowledge of physical and chemical changes that occur to solid propellants as the temperature increases will be of great importance to those who are formulating solid propellants to pass SCO and FCO IM requirements. The effect of increasing temperature on chemical and physical properties will be determined for smoky, reduced smoke, and minimum smoke solid propellants (three classes) using conventional instrumental techniques. The composition of off-gassing and decomposition products that are given off during heating will be determined in order to infer what chemical changes are occurring. Tests will be performed to determine the temperatures at which physical and chemical changes occur, including the auto-ignition temperature. The changes in density as temperature increases will be determined. Microscopic techniques will be used to determine changes such as migration, dewetting, and bulk propellant damage. Other tests that determine chemical and physical changes at increasing temperature will also add to the data base. At a minimum, these tests will be performed at 20°C, 40°C, and 60°C below the auto-ignition temperature for that propellant as determined by previous testing. The results of the experimental testing will be analyzed to determine trends and correlations and one or more hypotheses will be proposed that predict the physical and chemical changes that occur to the three classes of solid propellants.

PHASE II: Small scale motor tests will be performed to determine the effect of increasing temperature on the burning rate, combustion pressure, and thrust. These results will be combined with the hypotheses from Phase I to develop a model for the changes within solid propellants as the temperature approaches auto-ignition. Other tests may be necessary to confirm the model. Two solid propellant formulations will be made based on the model and tested to validate the model. A small scale, inexpensive test will be developed to predict SCO and FCO tests based on the model's prediction of scaling from subscale to full scale engine tests. This test will be used to characterize all three classes of propellants. Two of the formulations tested will be selected for full scale SCO and FCO tests. One of the formulations will expect a violent response and the other a mild response. The model will be revised, if necessary, after the subscale and full scale testing.

PHASE III: The results of this program can be applied to all Army warheads and propulsion systems currently deployed missiles including TOW, Javelin, Hellfire, MLRS, ATACMS, and PAC2 and PAC3. Other developing systems such as ADKEM and NLOS-LS will also be interested. The Air Force, Navy, Coast Guard, and NASA will also be interested in applying this technique to their solid propellant, warhead, bomb, and other energetic formulations. This program would also be of interest to Home Land Security and the Fire Safety Council.

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4. Department of Defense Test method Standard, “HAZARD ASSESMENT TESTS FROM NON-NUCLEAR MUNITIONS,” MIL-STD-2105C, 14 July 200.

KEYWORDS: Insensitive Munitions, solid propellants, burning rate, auto-ignition temperature.

A08-028 TITLE: <u>Complementary Non-Destructive Evaluation (NDE)/Testing (NDT) Techniques for Stockpile Reliability Programs (SRP) of U.S. Army Tactical Missile Systems</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Develop and demonstrate non-invasive radiography testing techniques that are complementary to current Army NDE/NDT methods than can determine dimensions, flaws (voids, inclusions, and cracks), proper assembly of components, corrosion, and other performance limiting defects within U.S. Army tactical missile systems that consist of heterogeneous materials (i.e. explosives, adhesives, electronic components, composites, plastics, etc.).

DESCRIPTION: Current state-of-the-art (SOTA) NDE/NDT technology has not been demonstrated on U.S. Army missile systems and new methods need to be developed, particularly in an effort to keep pace with the development of new materials (i.e. composites) and applications. Advances in the use of lasers and imaging technology (including video, holography and thermography) have made non contact NDE/NDT more viable in many situations. Computer advances have allowed signal processing techniques and expert systems to be used which enhances the quality of the information obtained using traditional and new NDE/NDT methods.

Explosives (including initiators, warheads, and propulsion units), electronic systems, and mechanical systems degrade over time based on the temperatures and vibration environments to which they are exposed. Other environments (humidity, chemical) also degrade these and other systems in various ways (e.g. corrosion, adhesive degradation, tin whisker growth greater than 20 mils, etc.). It is critical to long-term system reliability that components be monitored within the systems on a continual basis through the SRP. As part of the SRP, traditional X-ray NDE/NDT methods are employed to inspect missile systems prior to component/flight testing to determine the levels of degradation the missile components have received during field handling/storage environments. However, high resolution views of these systems using traditional X-ray NDE/NDT techniques are often obscured due to storage/shipping containers, peripheral components and different material types. These traditional X-ray NDE/NDT techniques cannot see corrosion, adhesive degradation, or other shelf life and performance limiting anomalies that currently go undetected (e.g. cracks smaller than 0.1 mm in thickness in explosives/propulsion units, air gaps around bridgewires within explosive initiators, polymer rich spherical voids on the order of 0.375 mm-0.625 mm in diameter within the propulsion unit). Other characteristics of defects and flaws (i.e. size, shape, and location) are dependent on the missile system and the types of materials generally utilized in development of each component.

Radiographic quality is defined by two terms, sensitivity and resolution. Sensitivity is that change in material thickness that may be detected on the radiograph. Resolution is the size of discontinuity (void, inclusion, delamination, etc) that may be detected on the radiograph. A radiograph quality level is typically represented by a two digit term, i.e.2-2T. The first digit (2) represents the sensitivity in percent of the total thickness of material of interest penetrated. The second (2T) represents the resolution in percent of total thickness. A quality level of 2-2T is generally considered the standard.

Currently, the U.S. Army has demonstrated on larger items a quality level exceeding 1/4-1/4T. In other words, a thickness change of 0.25% and a discontinuity within the part of .25% of the parts thickness could be detected on primarily carbon-based materials. A further example of the capabilities of current U.S. Army X-ray radiography (in terms of spatial resolution and minimum resolved spacing) can be found in reference 6.

PHASE I: Perform a feasibility study to identify SOTA NDE/NDT techniques/technologies that can safely be performed on current tactical missile systems for the U.S. Army. The reseach for the feasibility study will determine the current capability of these SOTA techniques/technologies (see below references for a sampling of new techniques that could be considered) with respect to the types of defects/materials and sizes of U.S. Army tactical missile systems to achieve a minimum of current capabilities but for carbon and non-carbon based materials. A system design shall be developed that focuses on the design, fabrication and application of these techniques (either for one type of NDE/NDT technique or a hybrid technique that incorporates multiple technologies) that will provide better resolution of current imaging techniques and can determine performance limiting defects in tactical missile systems without “false positives”. The contractor should identify the safety and performance benefits along with associated costs. Results will be addressed in a final Phase I report with associated costs to further develop the recommended system in Phase II.

PHASE II: Develop and demonstrate a prototype system on realistic missile system components. Conduct testing to demonstrate certain key attributes of the system including safety, reliability, and performance improvements over current U.S. Army capabilities. Government furnished components with inherent flaws will be provided to demonstrate and evaluate the feasibility of the test equipment.

PHASE III: This system could be applied to a broad range of civilian and military applications, including the inspection of commercial shipping containers, vehicles, aircraft, and missiles. The system could be an integral part of new techniques for Homeland Security inspections.

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7. Dimensions for Army small tactical missile systems (i.e. Hellfire, Javelin, TOW, Stinger) can be found at: http://www.fas.org/programs/ssp/man/uswpns/usmissiles.html

8. The following website gives good details under the "Rockets for Rookies" link: http://www.fas.org/programs/ssp/man/uswpns/usmissiles.html.

KEYWORDS: Stockpile Reliability Program (SRP), Non-Destructive Evaluation (NDE), Non-Destructive Testing (NDT), tactical missiles, radiography, thermography.

A08-029 TITLE: Thermal Management in a Composite Skin Missile Airframe

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Develop a laminated carbon fiber and multi-functional polymer based composite that provides increased heat dissipation characteristics with minimal impact on the structure's weight, and without significantly increasing cost of manufacturing and materials or decreasing overall composite strength. Since the costs of traditional composites vary with respect to individual components, cost will not be based on a specific goal value. It will simply be comparative to other baseline options. Weight and strength will be assessed in a similar manner. While heat dissipation could be similarly compared as the other driving attributes, a goal of 50 W/m K (Watts per meter per degree Kelvin) is anticipated, which would be significantly better than traditional, baseline carbon based composite laminates.

DESCRIPTION: Modern tactical missile systems rely on polymer based composites due to their high-strength, low-weight characteristics. Traditional, laminated carbon fiber composites are capable of transferring heat within each carbon layer; however, the transfer from one layer to another is very low. By allowing more heat to transfer between layers, more heat would be dissipated throughout and distributed through the structure minimizing the local impact of the heat source. Enhanced heat dissipation in composite structures would enable mounted electronics within airframes, such as radar and CPUs (central processing units), to disperse excess heat prior to electronic component or composite structure failure. The challenge lies in the novel incorporation of fillers, coating, or other heat transfer mechanisms in a manner that can still be incorporated into a composite manufacturing process without significantly increasing cost or weight while also maintaining required strength levels.

PHASE I: Screening analyses will be performed to test various fillers, resin systems, chemical species, coatings, or other potential heat transfer improving materials for laminated composite manufacturing. Manufacturing methods such as filament winding and hand laid laminates are of greatest interest for the proposed research. Criteria for selection should include thermal properties, potential for incorporation into traditional airframe manufacturing methods, mechanical performance characteristics, weight, and cost. Through coupon/sub-scale testing, candidates shall be chosen. Baseline criteria and respective values for strength, cost, weight, and heat dissipation will be assessed for comparative purposes. A heat dissipation goal of 50 W/m K for the composite structure will be pursued through computer analysis and product testing. Considered success for Phase I will be small scale composite products and thermal models that illustrate significant advances in heat dissipation versus traditional methods as well as the associated trade-offs between cost, strength, and weight. Trade studies will be utilized.

PHASE II: Readiness for Phase II will be determined by assessing the progress within the Phase I effort. If the 50 W/m K goal has been obtained without significantly sacrificing strength, weight, or cost, the project would be considered ready for Phase II. If the goal heat conductivity has not yet been met, but significant advances have still been made from baseline thermal conductivities, the program may be considered ready for Phase II. Building from the information gained from Phase I, models will be generated using the data to determine the benefits of the selected candidates into, but not limited to, tube-shaped prototype airframes under representative thermal loads due to component heating. These prototype structures will then be manufactured to test the accuracy of the model and to verify the capabilities and processability of the candidates. Processing parameters will be documented for each structure manufactured and tested. Final processing parameters will be defined.

PHASE III: Enhanced heat dissipation in composite structures would enable mounted electronics within airframes, such as radar and CPUs (central processing units), to disperse excess heat prior to electronic component or composite structure failure. Representative systems that could utilize such technologies are the future Air-to-Ground Missile System (AGMS) and Precision Kill Weapon System (APKWS). Other defense applications include man portable combat systems, tube launch systems, Unmanned Aerial Vehicles, and various non-DOD applications.

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3. Kato, O. et.al., "R&D on Technology for Fabrication of Carbon Fiber of High Thermal Conductivity," Petroleum Energy Center, 2000.

4. Che, J. et. al., "Thermal Conductivity of Carbon Nanotubes," Nanotechnology, p65-69, March 2, 2000.

KEYWORDS: Thermal management, heat transfer, heat dissipation, composites, carbon fiber, composite structures.

A08-030 TITLE: Improved environmental protection for Zinc Sulfide

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The goal of this topic is to develop novel methods or techniques for improving the protection of Zinc Sulfide (ZnS)/multispectral ZnS domes and windows from environmental damage.

DESCRIPTION: Multimode seekers are of increasing interest to the Army and the Department of Defense. Such seekers typically use multiple bands within the infrared requiring the use of dome and window materials with a broad transmission spectrum. Multispectral Zinc Sulfide provides excellent broadband transmission but suffer from susceptibility to damage from handling, sand erosion, and rain impact. Some sort of environmental protection is required to prevent damage during normal operations. The purpose of this topic is to develop an advanced missile dome protection for ZnS/multispectral ZnS that surpasses the durability of the latest coatings. The protection can be a replacement for or a supplement to existing coatings. The combination of micro/nanostructures with existing coatings might be appropriate.

PHASE I: Develop techniques for improving the durability of ZnS/multispectral ZnS windows and domes using protective surface structures and/or coatings. The technique must address antireflection without degrading infrared transmission. A coated transmission of 65% at 1.06 micron wavelength and an average transmission of 85% for 8 to 12 microns is desired. The contractor will perform transmission measurements and provide data for each technique. Six Zinc Sulfide flats of approximately 1” in diameter will be prepared and delivered to the Government for rain and/or sand erosion testing. The flats will be provided by the Army. The goal is to make a convincing case that the contractor commands the processes necessary to make durable domes in Phase II.

PHASE II: Further refine the protection for ZnS/multispectral ZnS selected during Phase I. For success in this phase the contractor must: 1) provide transmission data that verifies that infrared transmission is maintained, and 2) perform whirling arm rain erosion testing to compare the developed protection with a state-of-the-art coating to be chosen by the Army. This test should demonstrate a minimum of 50% increase in transmission at 1.06 microns, after 10 minutes at 550 mph, over the chosen coating. Two 7” diameter domes processed with the techniques developed in this topic shall also be delivered to the Army for possible testing. The particular ZnS variant to be used for the domes will be determined during the course of the topic.

PHASE III: Demonstrate full production capability for processing Zinc Sulfide windows and domes using the protection technique(s) developed and refined in Phases I and II.

REFERENCES:
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2. "Materials for infrared windows and domes: Properties and performance", Daniel C. Harris, Society of Photo-optical Instrumentation Engineers, Bellingham, August 1999.

3. "Tri-mode seeker dome considerations", James C. Kirsch, William, R. Lindberg, Daniel C. Harris, Michael J. Adcock, Tom P. Li, Earle A. Welsh, Rick D. Akins, Proc. SPIE Vol. 5786, p. 33-40, Window and Dome Technologies and Materials IX; Randal W. Tustison; Ed., 18 May 2005.

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KEYWORDS: Infrared windows, long wave infrared, zinc sulfide, rain erosion protection.

A08-031 TITLE: <u>Advanced Adaptive Maneuvering Air Vehicle</u>

TECHNOLOGY AREAS: Air Platform, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To provide innovative design variants for an intercept against threats possessing intentional maneuver capability while addressing large handover uncertainty associated with early detection and launch of an interceptor for extended range intercept.

DESCRIPTION: Current interceptor designs have limited range and maneuverability. To address extended range intercepts, more handover error must be removed during the flight. This in turn drives the stored divert requirements and ultimately the entire missile stack-up. To add further complexity, newer threats are anticipated to have intentional aerodynamic maneuver capability from mid (50km) to low (20km) altitude. For long times of flight a very small threat maneuver G capability leads to significant interceptor divert requirements. Practical interceptor designs to include the entire missile stack are sought that can address these advanced threats.

Long duration flight times within the atmosphere require significant speed to maintain sufficient maneuverability to address the threat maneuvers. Flying outside the atmosphere puts a severe burden on the amount of stored propellant required driving the overall mass to potentially unacceptable levels. Options to achieve the necessary maneuvers include propulsive or aerodynamic. Each of these options have there advantage and disadvantage. In addition, typical cylindrical interceptor body geometries do not lend themselves to very efficient lifting body geometries (i.e. poor maneuverability). Usually, L/D range from less than 1 to an achievable maximum of 1.5. To address the energy loss that will be realized within the atmosphere designs are sought that provide greater L/D performance. Traditional lift generating devices, such as wings, lifting body, or blended wing-body may offer sufficient improvement to allow a viable interceptor concept. Unfortunately, the introduction of lifting surfaces also drives the aero-heating. A simple extension of the axisymmetric, geometry to an elliptical configuration appears to be a feasible starting point to increase lift while minimizing drag, but more intelligent and innovative alternatives need to be explored.

Methods have been proposed to address these advanced maneuvering threats, but only for short range. Adaptive maneuverability techniques need to be developed to address the more complex maneuver capability possessed by these advanced threats. Blended aero-propulsive controls have been shown to work well for short range threat scenarios. An extension of the state-of-the-art is sought to address more robust threat maneuverability and extended range operation. Hence, intelligent and innovative alternatives are sought to defeat a highly maneuverable extended range threat.

PHASE I: Phase I proposals must demonstrate (1) a thorough understanding of the Topic area, (2) technical comprehension of key interceptor performance problem areas, (3) technical comprehension of high speed flight control and maneuverability to include methods of operation from launch to intercept, and (4) previous experience in designing non-axisymmetric/flight vehicle concepts that address structural, thermal, and aerodynamic performance predictions using state-of-the-art methods to verify the performance data used to perform system level performance evaluations.

Technical approaches will be formulated in Phase I to address each of the key problem areas. System level performance for the candidate concepts will then be characterized through a trade study evaluation (missile stack and interceptor to include body geometry and subcomponents necessary to support the overall interceptor concept) to demonstrate the most efficient means to address the maneuvering threat (ballistic, atmospheric flight, or combination). The study will include evaluation of propulsive, aerodynamic, and/or blended methods to achieve the desired interceptor maneuverability with a flight duration up to 400 s with a range up to 1,500 km. The performance study will include performance objectives and methods from launch to the intended intercept utilizing 3 or 6-degree-of-freedom simulation modeling as required. To support the system simulation efforts, aerodynamics, mass properties, component design and operational performance limits will be addressed. However, Phase I will focus primarily on the kinematic performance. It is understood that the lowest risk (possibly lowest cost) approach may be the least efficient, but the information may prove very useful in the down select process envisioned for Phase II where more detailed analysis of the system performance will be pursued on a selected concept(s).

PHASE II: For Phase II, a down selection from the Phase I trade study will focus further analysis on those concepts that show the most promise to address intercept of the maneuvering threat. During the Phase II process, a system engineering effort will continue to study operational performance of the interceptor, but emphasis will shift as to define component performance (airframe geometry, control surfaces, IMU, GPS, Seeker, Propulsive Subsystem, GN&C software) influence on the overall performance.

PHASE III: If successful, the end result of this Phase-I/Phase-II research effort will be advanced interceptor missile designs.

The transition of this product, advanced design concepts, to an operational capability will require application for specific threat scenarios along with design maturation detail development for component placement (packaging), materials selection (for thermal protection and strength), and fabrication of a prototype. Additional refinements may be required specifically in the way of component performance studies and guidance/control studies.

For military applications, this technology is directly applicable to all missile systems. The most likely customer and source of Government funding for Phase-III will be those service project offices responsible for the development of current intercept missile systems - THAAD, PAC-3, and NMD programs - and advanced hypersonic missile systems - HyFly, X-51, and Facet.

For commercial applications, this technology is directly applicable to advanced avionics techniques for commercial applications such as high speed supersonic transports and to orbital launch systems.

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KEYWORDS: Air vehicle, intercept, adaptive maneuver techniques, aerodynamics.

A08-032 TITLE: Advanced Scramjet Engine/Vehicle Design

TECHNOLOGY AREAS: Air Platform, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To provide innovative design variants to axisymmetric, annular flow, scramjet engine and flight vehicle configurations which can resolve vehicle lift and engine startup limitations.

DESCRIPTION: Current computational fluid dynamics (CFD) model calculations predict reasonable performance for hydrogen fueled, axisymmetric, annular flow, scramjet engine and flight vehicle configurations in the high speed Mach 10-12 flight regime. This basic engine/vehicle configuration offers many advantages for future Army tactical weapons development in terms of packaging, storage, launch technique, and as a structurally efficient flight vehicle. These same theoretical calculations, however, also reveal practical limitations to the basic geometry because (1) engine performance degrades rapidly with angle-of-attack greater than about one degree and (2) engine start at design flight Mach number requires that either some captured air be diverted or that the flowpath area be increased during the startup transient.

Any extended constant-altitude flight trajectory with the basic axisymmetric, annular flow, scramjet engine and flight vehicle configuration, for which the scramjet excels, will require lift to maintain altitude. As stated above, flight at angle-of-attack to produce lift degrades engine performance as an undesirable consequence; yet, traditional lift generating devices, such as wings, are largely precluded in the Mach 10-12 flight regime because of drag and aeroheating. A simple extension of the axisymmetric, annular flow geometry to an elliptical configuration appears as a feasible alternative to increase lift at low angle-of-attack but more intelligent and innovative alternatives need to be explored.

Methods have been proposed to solve the startup problem for the basic axisymmetric, annular flow, scramjet engine and flight vehicle configuration using a variable geometry flowpath. Even more exotic alternatives, e.g. an eroding inlet cowl, have been offered, but incorporation of a truly practical, workable solution remains illusive. Hence, intelligent and innovative alternatives are also required to insure startup for either the basic or any alternate scramjet engine/vehicle geometries.

PHASE I: Phase I proposals must demonstrate (1) a thorough understanding of the Topic area, (2) technical comprehension of key lift, drag, and engine performance interaction problem areas, (3) technical comprehension of high speed scramjet startup phenomena, and (4) previous experience in modeling integral scramjet engine/flight vehicle performance using state-of-the-art computational fluid dynamics models for nonequilibrium, chemically reacting flows.

Technical approaches will be formulated in Phase I to address each of the key problem areas. At least one innovative, meaningful demonstration will be proposed and a flowfield solution produced with the computational model during Phase I to assess the potential for Phase II success. The goal for Phase I is a Mach 10-to-15 scramjet powered hypersonic flight vehicle of elliptical, or possibly kidney shaped, plan form providing a lift-to-drag ratio of 3-4 in an outward turning annular flow configuration.

PHASE II: Additional design alternatives formulated in Phase I will be developed and refined using computational fluid dynamics to evaluate engine performance and flight characteristics over a broad range of tactical scenarios of interest. The ultimate objective of Phase II will be an optimization of the Phase I design which can, in addition to the Phase I goals, achieve engine start from booster separation at Mach 8 to provide for acceleration to cruise at Mach 10-to-15 and flight times from 100 to 400 seconds with an inlet kinetic energy efficiency of at least 97%, a combustion efficiency of at least 80%, and a nozzle efficiency of at least 97%.

PHASE III: If successful, the end result of this Phase-I/Phase-II research effort will be advanced scramjet engine powered flight vehicle design concepts. The transition of this product, advanced design concepts, to an operational capability will require application for specific mission requirements.

For military applications, this technology is directly applicable to all airbreathing missile propulsion systems. The most likely customer and source of Government funding for Phase-III will be those service project offices responsible for the development of advanced hypersonic missile systems such as the Navy/DARPA HyFly, Air Force X-51, and DARPA Facet programs.

For commercial applications, this technology is directly applicable to advanced propulsion techniques for commercial applications such as high speed supersonic transports and to orbital launch systems. such as high speed supersonic transports and to orbital launch systems.

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KEYWORDS: Scramjet, flight vehicle, computational fluid dynamics, hydrogen fuel, lift, startup.

A08-033 TITLE: <u>Transpiration Cooling Computational Fluid Dynamics Submodel</u>

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To develop advanced submodels for transpiration cooling which can account for the physics of the process in either Reynolds Averaged Navier Stokes (RANS) or Large Eddy Simulation (LES) computational fluid dynamics formulations.

DESCRIPTION: Transpiration cooling is a process whereby a cooling media is introduced in low quantities in the vicinity of a wall of a missile/rocket component such as a combustor, nozzle, control surface, or inlet. The resulting film absorbs heat from the wall and simultaneously reduces the drag of the flow over the wall. Cooling and drag reduction are simultaneously achieved with the transpiration cooling concept; yet this two-fold advantage has rarely been utilized.

The goal or technical objective of this effort is to (1) quantify the advantages of the use of a transpiration cooling technique, (2) to accurately simulate the transpiration cooling concept, and (3) to determine the advantages of various cooling media. State-of-the-art computational fluid dynamics models for multi-phase, chemically reacting flows incorporating transpiration submodels would serve as the foundation to accomplish these goals.

Innovative concepts for the application of this technology are desired to be applied to any of a number of aero-propulsion applications, combustor applications being the item of highest interest and the nozzle of least interest. This requires both innovative applications of the technology and accurate physical simulations of the process.

PHASE I: Phase I proposals must demonstrate (1) a thorough understanding of the Topic area, (2) technical comprehension of key transpiration problem areas such as boundary conditions and particle/mixing/combustion interactions, and (3) previous computational fluid dynamics experience in modeling multi phase, nonequilibrium gas particle, chemically reacting flows with a computational fluid dynamics code possessing those capabilities.

Technical approaches will be formulated in Phase I to address the key problem areas for inclusion into computational fluid dynamic models. At least one innovative, meaningful demonstration of transpiration cooling will be executed and a flowfield solution produced with the computational model during Phase I to assess the potential for Phase II success. Such a demonstration could, for example, model helium transpiration into a Mach 3 air cross flow at 1 atmosphere static pressure and 1800 K static temperature since this methodology would feed directly into the Phase II prototype demonstration.

PHASE II: Additional model improvements formulated in Phase I will be incorporated as prototype computational fluid dynamics submodels for inclusion into an existing Government or commercially available computational fluid dynamics model. This advanced computational fluid dynamics model will be run blind for a a hypersonic scramjet test case for which detailed flowfield data will be available to demonstrate the advanced capabilities for analyzing and modeling transpiration cooling.

PHASE III: If successful, the end result of this Phase-I/Phase-II research effort will be validated submodels for the design and analysis of transpiration cooling concepts.

The transition of this product, a set of validated research tools, to an operational capability will require additional upgrades of the software tool set for a user-friendly environment along with the concurrent development of application specific data bases to include the required input parameters such as combustor geometries, aerodynamic properties, and performance parameters.

For military applications, this technology is directly applicable to all combustion driven missile propulsion systems. The most likely customer and source of Government funding for Phase-III will be those service project offices responsible for the development of advanced hypersonic vehicles such as the Navy/DARPA HyFly, Air Force X-51, and DARAPA Facet programs.

For commercial applications, this technology is directly applicable to commercial and industrial combustion processes - power plants, kilns, foundries - as well as commercial aircraft and rocket propulsion systems.

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KEYWORDS: Transpiration, computational fluid dynamics, two phase, gas particle flow, finite rate chemistry, combustion, propulsion.

A08-034 TITLE: Low Power Electronics and Energy Harvesting for Anti-tamper Applications

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Contractor shall develop low power electronics with energy harvesting suitable for use in active (powered) anti-tamper (AT) applications. Contractor can propose adding energy harvesting to a current low power AT technology, or develop a new AT technology based on low power electronics and energy harvesting.

DESCRIPTION: As AT is a relatively new area of concern, the development of AT techniques is in a somewhat immature state and new ideas are always needed. One area needing protection is in the electronics of weapon systems, where there are many critical technologies that can be compromised. Techniques are now emerging to begin to try to combat this loss of the U.S. technological advantage, but further advances are necessary. The goal of low power electronics and energy harvesting is to extend the operational lifetime to 20 years for powered (active) anti-tamper techniques.

We are interested in low power electronics and energy harvesting systems capable of achieving 20 years of powered operational time for active AT electronics. Contractor shall propose a design for a low power active anti-tamper system with energy harvesting to extend the operational life for active AT electronics. Contractors may submit proposals for current AT techniques implemented with low power electronics and energy harvesting, or new techniques implemented with low power electronics and energy harvesting. Low power electronics and energy harvesting will be approximately equally weighted. Contractor shall estimate operational lifespan of the proposed system. Proposals will be judged based on the proposed anti-tamper system and the estimated operational lifetime for the low power electronics with energy harvesting.

For the low power electronics and energy harvesting for anti-tamper applications, the nominal operating temperature range is -20 degrees Celsius to 40 degrees Celsius. Operation over the industrial temperature range of -40 to +85 degrees Celsius is desired. Reduced performance at the ends of the industrial temperature range is acceptable. Operation over a wider temperature range, up to full military temperature range of -55 Celsius to + 125 Celsius, will be considered a plus.

The available energy for energy harvesting will depend on environment. In storage, there may be very little or no energy available for energy harvesting. During transportation, there will be a significant amount of motion for energy harvesting. Current literature reports energy harvesting over the power range of 0.5 to 150 microwatt level [1] and 50 microwatt [2]. Energy harvesting techniques have a limit on the peak power available [3]. Current research indicates that a battery/energy harvesting system can be optimized to operate energy neutral, where the average power consumption does not discharge the battery (ignoring self discharge) [3].

It should also be noted that the use of off-the-shelf components in a system can seriously compromise an AT design due to the ready availability of open-source documentation. The effort should therefore focus on denying an adversary access to enough information to begin such a data search. The technologies/techniques developed should inhibit an adversary's exploitation and/or reverse engineering effort to a point where it will require a significant resource investment to compromise, allowing the U.S. time to advance its own technology or otherwise mitigate the loss. As a result, the U.S. Army can continue to maintain a technological edge in support of its warfighters.

PHASE I: Contractor shall research and determine the feasibility of extending the operational life of a low powered, active anti-tamper system with energy harvesting. The contractor may develop simulations, and/or prototype hardware to demonstrate proposed concepts for low power active anti-tamper with energy harvesting technologies. The contractor shall provide a report on low power active anti-tamper system with energy harvesting concept.

PHASE II: Contractor shall develop proposed low power active anti-tamper system with energy harvesting into a working prototype. The nominal operating temperature range is -20 degrees Celsius to 40 degrees Celsius. Operation over the industrial temperature range of -40 to +85 degrees Celsius is desired. Reduced performance at the ends of the industrial temperature range is acceptable. Operation over a wider temperature range, up to full military temperature range of -55 Celsius to + 125 Celsius, will be considered a plus.

Contractor shall perform accelerated aging test to determine the operation life time for the low power active anti-tamper system with energy harvesting over the industrial temperature range of -40 to +85 degrees Celsius, or a wider temperature range if applicable. Contractor shall select an independent evaluator to test the anti-tamper features of the prototype. Contractor shall deliver a prototype low-power electronics with energy harvesting, anti-tamper system and a report describing all activities in the project and technical specifications of the prototype system.

PHASE III: Department of Defense Directive (DOD) 5000.2R provides instructions on identifying critical technologies and on defining methods to protect them. Commercialization opportunities exist throughout the Defense Department. Commercialization potential exists with other agencies like the Department of Homeland Security. Commercial civilian markets include: secure internet commerce, electronic funds transfer, banking industries, electronic automatic teller machines (ATM), and Federal Information Processing Standards Publication (FIPS) 140-2 [17] applications.

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15. A. J. Hotchkliss, et al: "Measurement of Engine Speed By the Analysis of Vibration," SAE Document # 960714, Feb. 1996.

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17. NIST: "Security Requirements for Cryptographic Modules," Federal Information Processing Standards Publication 140-2, December 2002. (http://csrc.nist.gov/publications/fips/fips140-2/fips1402.pdf).

KEYWORDS: Low power, energy harvesting, volume protection, sensors, anti-tamper, AT, micro-electromechanical systems, MEMS.

A08-035 TITLE: High Aspect Ratio EMI Grid Application Technique

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To develop high aspect ratio grid lines application technique utilizing a stamping process.

DESCRIPTION: There is a need to significantly reduce the cost of applying an electro-magnetic interference (EMI) grid to a deep concave surface of a missile dome. One recent effort in this area was a soft lithography technique but this technique had a problem of achieving a line thickness that would meet the ohms per square requirement. Another approach utilized direct laser writing which did not appear to be able to provide the desired cost savings. This effort is to develop methods of applying a high enough aspect ratio thin fine grid line (a 1 mil line width with a 15 mil rectangular pattern) to deep concave surfaces that will achieve 1 ohm per square resistivity.

PHASE I: Develop and demonstrate a low cost method of applying a thick grid to a 150o, 7 inch diameter hemispherical dome. Initial demonstration of the proposed grid application method should be done on a flat surface in a manner that will allow the measurement / evaluation of the grid resistance.

PHASE II: Refine the developed method so that it is becomes cost effective and is capable of consistently replicating the grid. Demonstrate the process, through the production of 20 samples that will be provided to the Government for evaluation for consistency. Target production rate is 10,000 domes per year.

PHASE III: A number of new missile sensor systems desire/require EMI protection. Additionally this type of grid application can be used for EMI shielding optically-based security systems (e.g. security cameras near airport ATR installations). Other application could include the reduction of radar cross sections, anti-icing for windows and/or surveillance domes as well as other types of optical diffusion grids. The development of an affordable electro-magnetic interference (EMI) grid application process will greatly improve the affordability for future grid/pattern application requirements.

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KEYWORDS: EMI grid, optical ceramics, aluminum oxynitirde, spinel, process improvement, manufacturing technology.

A08-036 TITLE: Novel Energetic Polymers

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To explore new polymers based on environmentally friendly elements namely carbon, hydrogen, nitrogen and oxygen, that incorporate known and new energetic functional groups. These new polymers will exhibit desirable physical properties of flexibility, non crystallinity, yet be robust to air, water, and mechanical stresses, and be insensitive to mechanical stimuli such as impact, friction and electrostatic discharge.

DESCRIPTION: The Army is spending considerable efforts in developing insensitive missiles and munitions which are also environmentally friendly. Many systems are based on poly unsaturated hydrocarbon systems which are end capped with functional groups which are further chemically reacted with known cross linkers such as isocyanates to form large, tough yet flexible networks. These systems are physically and chemically robust, yet flexible and strong, and age well. However, they are energy poor and suffer from low densities and often are not chemically compatible with certain chemical compounds. It would be highly desirable to find new polymerizable oligomers having desirable energetic functionalities which incorporate known and/or novel endothermic and/or oxidizing groups which improve the energy content anf density (p >1.25 g/cm3) of the final polymer, yet make a robust, tough, flexible and safe polymer. The purpose of this topic is to find new energy rich and robust oligomers which may be polymerized for several DoD and industrial applications.

PHASE I: Identify, synthesize, and characterize gram quantities of reasonable pure oligomers with desirable energetic functional groups that increase density (p > 1.25 g/cm3) and/or endothermicity and/or oxygen balance. These polymers can be generated using known or novel polymerization routes to products having average MW > 3000 a.w.u. based only on carbon, hydrogen, nitrogen and oxygen. These polmers will be end terminated with chemical functionalities that can be further cross-linked with known or novel chemical agents to form larger polmeric products which demonstrate viable polymeric end products. Supply 10 gram quantity of promising polymer to appropriate US Government Laboratory.

PHASE II: Develop environmentally friendly and cost effective routes to produce pound quantities of promising polymers having desirable narrow molecular weight regimes. These polymers shall exhibit thermal and chemical stabilities to air and water, and have purities that are relatively free of low molecular weight polymers having M.W. <1000 a.w.u. Investigate the chemical and physical properties of selected promising polymers which are further crosslinked using known or novel chemistries to build large robust polymeric networks. Deliver 1 pound quantities of selected promising polymers to appropriate US Government laboratory.

PHASE III: Develop environmentally friendly and cost effective routes to produce pound quantities of promising polymers having desirable narrow molecular weight regimes. These polymers shall exhibit thermal and chemical stabilities to air and water, and have purities that are relatively free of low molecular weight polymers having M.W. <1000 a.w.u. Investigate the chemical and physical properties of selected promising polymers which are further crosslinked using known or novel chemistries to build large robust polymeric networks. Deliver 1 pound quantities of selected promising polymers to appropriate US Government laboratory.

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KEYWORDS: Energetic Materials, Novel Polymers, functional groups, environmentally friendly manufacturing process.

A08-037 TITLE: Low Cost Production of Domes Using Freeze Casting or Similar Technology

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To develop a low cost, high purity, process for the fabrication of green bodies for domes and windows using freeze casting or similar technology.

DESCRIPTION: The most common methods of fabricating spinel and aluminum oxynitride (ALON) dome green bodies consist of preparing the ceramic powder using conventional powder preparation technologies, and forming the green body by filling a mold with powder and using cold isostatic pressing (CIP) to make it into a green ceramic body. This method is time consuming due to the handling of the powder and mold filling, and expensive due to the cost of CIP equipment, touch labor handling time and total cycle time. Some recent developments in the manufacturing of highly transparent spinel parts, based on the use of low cost freeze casting technology, have shown that high purity near-net-shape green body preforms may be a viable alternative. This casting technology appears to offer some advantages over the standard ceramic powder approach. This effort will evaluate the requirements for moving the freeze casting or similar technology from the laboratory to manufacturing. The approach must be capable of consistently making a full hemispherical sintered domes of at least 7” in diameter that will exhibit, at a minimum, 84% transmission at 4.5 microns, 80% transmission at 0.7 microns, have a thickness of 0.180 inches and a refractive index homogeneity better than 100-ppm over a 160 degree aperture.

PHASE I: Develop and demonstrate low cost freeze casting or similar approach to make a spinel or ALON sintered body 7” dome (7” diameter hemisphere, 160 degree aperture) that will exhibit, at a minimum, 84% transmission at 4.5 microns, 80% transmission at 0.7 microns, have a thickness of 0.180 inches. The developed technique will then be the foundation used to demonstrate this fabrication technology. At a minimum 5 2 inch diameter 1/8 inch thick samples of material made by the proposed process shall be provided to the Government for evaluation.

PHASE II: Refine the developed process and scale it up to consistently produce spinel or ALON domes that meet the above requirements. The refined process will be used to make at least 10 prototype transparent spinel domes, to be provided to the Army for evaluation, to demonstrate the consistency of the process. A complete optimized process flow from precursor materials to deliverable sintered domes will be completed during Phase II. Production cost estimates will also be developed. The demonstrated process should be capable of making 10,000 per year when capitalized.

PHASE III: There is an ever increasing need for low cost domes that have the characteristics of the spinel and ALON domes. Full scale manufacturing demonstration of manufacturing process documented during the Phase II effort will be applied during Phase III. Process steps which apply to monolithic domes will be identified. Spinel is a leading candidate dome material for both the Army Joint Air to Ground Missile and the Air Force Small Diameter Bomb II. In addition, spinel is a material used for lenses and windows in reconnaissance and targeting pods.

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KEYWORDS: Freeze casting, spinel, optical ceramics, process improvement, manufacturing technology.

A08-038 TITLE: Vision Based Adjunct Navigation Technologies

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Develop a design for a vision based navigation (VBN) system that combines day/night imagery of terrain with a geospatial database. The VBN will provide an independent day or night navigation solution to Army missile and aviation platforms if global positioning system (GPS) data is denied. A prototype of the imaging system will be built. This prototype will be tested with appropriate geospatial databases in the AMRDEC image signal processing laboratory.

DESCRIPTION: Develop a vision based navigation (VBN) system. The design developed will provide imagery from multiple camera heads that can be correlated with appropriate optic flow algorithms and a terrain image database to develop an independent navigation solution. The capability is proposed to enhance or serve as a backup to the flight vehicles motion estimation devices, i.e. the inertial measurement unit (IMU) and Global Positioning System (GPS). The VBN would provide crucial geo-location data when GPS navigation data is not available. Loss of GPS could occur due to being jammed or to operation in terrain or urban environments that obstruct the signal.

The VBN system will operate under either day or night conditions. The overarching design goals are that the VBN must fit into a missile body and operate at velocities up to 200 m/s and at altitudes from 100 to 500 meters. The design should consider technologies that would support these goals and are tactically viable in a missile flight environment. This technology can also be useful to commercial automotive, robotics and aircraft industries.

PHASE I: Conduct trade studies to delineate the system requirements that will achieve the design goals. Develop a VBN design that meets the system requirements. Identify technology status and timelines for development. Develop a detailed design to build a prototype VBN system. Develop a detailed plan for testing and integrating the system to include future captive flight testing on a helicopter platform. Develop a test configuration design that enables correlation and comparison of the VBN images with a geospatial database and correlate to determine GPS location.

PHASE II: Fabricate the VBN imaging system prototype. Measure the system performance under laboratory conditions. Collect data over Government approved terrain site. Support the integration and test of the hardware and collected data within the AMRDEC image signal processing laboratory either on a test platform or in the image signal processor laboratory. Document the subsystem performance and potential to achieve system goals.

PHASE III: Develop, in coordination with the Government, a captive flight test plan. The plan would include helicopter captive flight testing. The plan should also include aircraft flying trajectories that would emulate a missile environment. Market the prototype to commercial industry for cars, personal robotics, and aircraft industry.

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1. Image-based navigation in real environments using panoramas, Bradley, D.;Brunton, A.; Fiala, M.; Roth, G.; Haptic Audio Visual Environments and their Applications, 2005. IEEE International Workshop on 1-2 Oct. 2005 Page(s):3 pp.

2. High Altitude Navigation with Passive Imaging Sensors, Ching-Fang Lin, Tasso Politopoulos, AIAA-94-3677-CP 3. Robot navigation using panoramic tracking, Pattern Recognition, Volume 37, Issue 11, November 2004, Pages 2195-2215, Mark Fiala and Anup Basu.

KEYWORDS: Vision based navigation, geospatial, terrain databases, night vision, missile environment.

A08-039 TITLE: Prognostics for the Full, Net-Centric, Plug and Fight Integration of Army Air and Missile Defense Systems (AMD)

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The objective of this SBIR topic is to develop a prognostics capability to a System of Systems that provides for the full, net centric, “Plug and Fight” integration of Army Air and Missile Defense (AMD) weapons. This prognostics capability will continuously evaluate the condition of, and predict impending faults and failures of electronic and mechanical components thus improving the availability, reliability, and supportability of the systems in which these components are used.

DESCRIPTION: The Army is in the process of developing a full, net centric, “Plug and Fight” integration of its Air and Missile Defense (AMD) systems. This proposed System of System (SoS) is comprised of Common Command and Control (C2), the common interface modules on elements (sensors and shooters), and the battle management network to integrate across common C2 and system elements. The existing AMD Command and Control (C2) command posts, operations centers and communications will become part of the proposed SoS common C2 configuration. The proposed SoS common C2 will provide organic communications assets to support voice and data link requirements to subordinate, lateral, and higher C2 nodes. The proposed project is currently titled the Integrated Air and Missile Defense System of Systems (IAMD SoS). A single IAMD SoS consists of command post, a network, and two “plug and fight” components and is referred to as ASoSC2. The ASoSC2 defines the boundaries for the minimum Engagement Package, with a higher level Task Force potentially consisting of several of these Engagement Packages integrated together. Current planning calls for the ASoSC2 to incorporate a continuous prognostics capability that evaluates the condition of, and predict impending faults and failures of electronic and mechanical components. The ASoSC2 shall provide prognostic state and system data on demand and unsolicited system impending failure alert indication. Preliminary ASoSC2 embedded prognostics requirements are to detect and report 30% of all potential mission critical aborts six hours or greater before occurrence.

The SBIR program will develop a capability to predict ASoSC2 failures prior to occurrence so the hardware may be repaired or replaced at a time and place of the user's choosing. Typical components to be included in the ASoSC2 are the following: GPFU (Gas Particulate Filtration Unit); ECU (Environmental Control Unit); Storage LAN(Local Area Network) Switch; CAU (Cab Access Unit); Displays (Work Station); Keyboard (Work Station); Processors (Work Stations); NAS (Network Accessible Storage); Processor LAN (Local Area Network) Switch; VME (Virtual Memory Extension); MCSU (Micro Central Switching Unit) Voice Switch; UPS (Uninterruptible Power Supply); DTS (Digital Transmission System); KG 40 (COMSEC Radio)-HF; KG 40X (Radio)-HF; Mckay 8090 (Thales HF Transceivers); EPLRS (Enhanced Position Location Reporting System); FBCB2 (Force Battle Command Brigade and Below); BC (Battle Command) Server; Router/Switch; JTT (Joint Tactical Terminal) Receiver/Transmitter; RF Patch; DNVT (Digital Non-secure Voice Terminal); DAGR (Defense Advanced GPS Receiver); L-Band BFT (Blue Force Tracking); SINCGARS Radios; KG-175 (TACLANE); Mark XII ADI (Mode 5A)- IFF (Identify Friend or Foe); WIN-T (Warfighter information network-Tactical Communication); MIDS (Multifunctional Information Distribution System) Radio.

An embedded ASoSC2 prognostics capability shall provide state and system data on demand and unsolicited system impending failure alert indications. An embedded ASoSC2 prognostics capability will improve mission reliability, allow for replacement in a more conducive environment, thus improving time to repair. Finally, An embedded ASoSC2 prognostics capability will allow for advance ordering and placement of repair resources (spare parts, tools, maintainers, etc) to reduce overall down time.

PHASE I: In phase I, the offeror shall identify specific research approaches for an embedded ASoSC2 prognostics capability utilizing notional predominant failure modes as determined by the offeror for ASoSC2 radar sensors components, particularly networking and communications.

Next, the offeror shall design an experiment that will provide the failure data, with statistical confidence, to fully characterize the notional failure mode(s) identified. This shall include a determination of the failure frequency's dependency on environmental conditions, including but not limited to: temperature, temperature cycling, and vibration.

Finally, the offeror shall outline the expected prognostics method:
- cumulative damage: predict a failure based upon the physics of failure and the accumulated stress (damage) induced by the environments.
- precursor to failure: predict a failure based upon a precursor to failure event; an event or measurable signal that is well correlated to an impending failure.
- canary: predict a failure using a canary method, which is the use of a similar HW items that will fail prior to the system of interest.

PHASE II: In phase II, the offeror will:
- Execute the designed experiment from phase I.
- Perform root cause analysis on the failures precipitated by the testing.
- Analyze the data for trend and regression via statistical means (of their choosing).
- Develop the mathematical failure model or algorithm to enable prognostics.
- Embed the failure model into a prototype system.
- Demonstrate the failure prediction capability via accelerated environmental testing.

The deliverables will include a full report of the characterization failure data, the statistical analysis, the failure model/algorithm for evaluation, and the verification data proving the system's accuracy and precision.

Additionally, any additional "training" required of the algorithms that would be required for transition shall be provided in the form of a design/test guide.

PHASE III: Phase III will include transition of embedded ASoSC2 prognostics technologies into the IAMD SoS Acquisition Strategy that will employ a “Best of Breed” product line through the key DOD Project lifecycle phases of development, fielding and sustainment. The end-state of this technology will include a stand alone embeded prognostics capability for the ASoSC2 portfolio of products. In many commercial sectors of the US economy such as transportation, communications, and manufacturing; prognostics technology promises optimization of lifecycle management through increased readiness, increased user confidence, as well as smaller logistics footprint and lower operation and support costs. The products of this SBIR have direct application for large sectors of US commercial/civil economy in addition to the military sector, and can provide these stated optimization benefits during Phase III technology transitions.

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2. G. Vachtsevanos, “Performance metrics for fault prognosis of complex systems,” in Proc. IEEE Aerospace Conf, 2003.

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KEYWORDS: Prognostics.

A08-040 TITLE: Accurate and Reliable Rocket Thruster Technology

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The objective of this topic is to develop and demonstrate the technology required to produce a highly accurate, repeatable, and reliable thruster for divert and attitude control applications that also meets Insensitive Munitions Requirements.

DESCRIPTION: The Army develops rocket thrusters for a variety of applications including radial thrust, divert, and attitude control. The latter two applications require rocket thrusters that are very accurate, repeatable, and reliable. The purpose of this topic is to develop the technology needed for a small thruster to have the accuracy, repeatability, and reliability for a generic but very demanding application. This generic thruster has a nominal thrust of 6000 N with a total impulse of 90 N•s. In addition to this generic thruster performance level, growth to larger thruster values by a factor of four is desirable. The three sigma impulse repeatability will be 1%. The ignition delay, which is defined as the time between the ignition signal and first thrust, should be no greater than 2.5 ms and have a 3 sigma repeatability within 5%. The action time, defined as the pulse length of the thruster, should nominally be 15 ms and have a 3 sigma repeatability of 15% for the generic thruster. The combustion chamber operating pressure should not exceed 70 MPa. The thruster volume including all thruster components can not exceed 90 cm3 and preferably is not constrained to only a cylindrical motor case configurtion. One thruster dimension can not exceed 2.54 cm. The nozzle will be at one end and perpendicular to the curved outer surface of the thruster. The Army is looking for creative and innovative approaches to the problem and is open to all potential solutions. Although performance is the key criteria, low cost is of secondary but significant importance.

PHASE I: A detailed preliminary design of the thruster will be developed in sufficient detail to establish the thruster predicted performance of thrust, total impulse, and delivered specific impulse, as well as system weight and volume. The design scope should fall into the parameter for flight-weight thrusters and will consider the strength of materials at expected temperatures and pressures. Data will be provided that supports the repeatability, accuracy, and reliability requirements described in the Description section above. There is a predicted estimate for 5,000 units a year. The preliminary design will include an evaluation of the thruster system for bullet and fragment impact, slow

and fast cook-off of the propellant, sympathetic detonation, and shaped charge jet Insensitive Munitions (IM) threats to predict which are of most concern.

PHASE II: A final design will be developed that includes consideration of IM threats. Sufficient thrusters will be built and tested to demonstrate the repeatability and reliability of the design. IM tests for the threats considered to be most important in Phase I will be performed (a minimum of two) to determine the thruster system response to these threats.

PHASE III: This technology will have large appeal with a variety of applications, especially when there is a requirement for a thruster to have precision, repeatability, and reliability to perform the required task. All Army's missile platforms will benefit with improved accurate and reliable thrusters, even MDA will be interested for Divert and Attitude Control Systems (DACS) in their kill vehicles. Besides the DoD missile inventory requiring more and more accurate and reliable rocket thrusters, commercial markets will also be interested in this technology including automobile air bags, Homeland Security Coast Guard rescue rockets, and the new market for ballistic parachute deployment from aircraft.

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1. George P. Sutton, "Rocked Propulsion Elements: an introduction to the engineering of rockets." 7th Edition, John Wiley & Sons, 2001.

2. Stanley F. Sarner, "Propellant Chemistry" Reinhold Publishing Corporation, New York, 1966.

3. Gabriel D. Roy (editor), "Advances in Chemical Propulsion," CRC Press, New York, 2002.

4. DOD MIL-STD-2105C, "Hazard Assessment Tests for Non-nuclear Munitions," 14 July 2003. (Insensitive Munitions Test Method Standard).

KEYWORDS: rocket thrusters, reliability, precision, repeatability, propulsion systems, Insensitive Mutions testing, thruster testing

A08-041 TITLE: Improved Field of Regard for Strap Down Semi Active Laser Seekers

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The goal of this topic is to investigate non-traditional methods for increasing the field of regard for a semi-active laser seeker while maintaining the same instantaneous field of view.

DESCRIPTION: Strap down seekers offer improved reliability, reduced weight, and lower cost over traditional gimbaled seekers. The disadvantage of the strap down seeker is its limited field of regard (FOR). The goal of this topic is to investigate non-traditional methods for increasing the field of regard while maintaining the same instantaneous field of view (IFOV). Optical scanning methods, such as rotating prisms or programmable diffraction gratings, are two of the possible solutions to this issue. This topic seeks innovative approaches to solving this problem that would provide the advantages of a strap down seeker listed above, while improving the field of regard. The benefit to the warfighter would be the enabling of a lighter weight, lower cost munition for both manned and unmanned platforms. The light weight munition would offer increased stowed kill capability or the same number of stowed kills with a reduced impact on time on station.

PHASE I: Phase I is intended to be a feasibility study that investigates various methods for increasing the field of regard of a strap down semi-active laser seeker (SAL). The study should include an analysis of possible options, their advantages and disadvantages and the relative costs and performance when compared to traditional gimbaled systems. Recommendations for the path to follow in Phase II should also be provided.

PHASE II: Phase II will focus on refining the design, developing a proof of principle demonstration, and building a prototype. The goal should be a seeker with approximately a 6-8 degree instantaneous field of view and a 40 degree field of regard. The Phase II should result in a prototype capable of side by side testing with a traditional gimbaled seeker.

PHASE III: Phase III would focus on optimizing the design for production and transitioning the technology to the Joint Attack Munitions Systems Progam Office. Transition opportunities would include future lightweight precision strike munitions such as those fired from Unmanned Aerial Systems and as well as potential future guided rockets. Cost and weight will be driving factors for these transition opportunities. Commercial applications will depend on the techniques used to achieve the increased field of regard. Some approaches would find applications within the commercial camera and camcorder markets. Scanning approaches could find applications in a variety of situations such as point of sale scanners and image projectors.

REFERENCES:
1. J. Barth, A. Fendt, R. Florian, et al., "Dual-mode seeker with imaging sensor and semi-active laser detector," Proceedings of the SPIE Volume 6542 (2007).

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3. Additional Information
3.1.Definition of terms:
Semi Active Laser Seekers refers to a class of missile seekers that track the returned energy from a target illuminated with a laser designator. The designator is not part of the missile itself.

Field of View, for this application, refers to the instantaneous field of view of the optics in the seeker.
Field of Regard refers to the total area which could be scanned by the seeker.
Using the human eye as an example, the field of view is what you can see without moving your eye. Field of Regard is the total area you can scan by moving your eye around.
3.2. The original topic statement specified a narrow instantaneous field of view with a wide field of regard. Applications have now been identified which could accept a wide instantaneous field of view. Proposed approaches that address this application will also be considered under this SBIR.
3.3. A field of regard larger than 40 degrees is acceptable.
3.4. Laser designator pulse modulation schemes are used to ensure the seeker tracks the correct target. Proposed approaches should be compatible with existing laser pulse coding schemes.
3.5. The desired package size for the detector, optics, and electronics (excluding the dome area) is 70 mm in diameter and 2.5" in length.

KEYWORDS: Semi-active laser, strap down seeker, optical scanning, manufacturing cost.

A08-042 TITLE: Novel Structural Reactive Materials

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Design new formulations for novel structural reactive materials, demonstrate the process to produce them, and demonstrate their effectiveness in multipurpose Army warheads. The multifunctional material should combine good mechanical properties to carry load with highly reactive properties to enhance the Army’s munitions lethality upon target impact.

DESCRIPTION: Most of the mass and volume of current munitions is not directly related to the energy released at the targets, but to other functions such as load-bearing (structural members, payload casing) or fragment formation (bomb casing). If some of these other functions can be performed by a reactive material, the total energy delivered by a given munition could be increased, and/or the munition size could be reduced. Exothermic reactions between a metal and a metal oxide (thermite) and between metallic elements (intermetallic), as well as the combustion of metals (metal oxidation reactions) are extremely useful sources of energy production. Numerous energetic formulations exist. These formulations can be ignited via a thermal impulse as well as by laser impingement, mechanical methods or shock initiation. The challenge is to design a formulation that can be consolidated into a fully dense composite with good mechanical properties for load bearing capacity while it is still energetic and able to generate an exothermic reaction and release significant energy upon target impact. The technology will be judged successful if a fully dense composite has density greater than 7 grams/cc, with a reaction temperature greater than 2000K and chemical energy release greater than 2000 cal/g, and having a tensile and compresive strength in excess of 300MPa.

Therefore, Phase I will be judged successful by making a fully dense composite which meets the requirements for density, and reactive and mechanical properties stated above. The process should allow for tailoring of the reactive and mechanical properties by adjustment in the powder blend formulation. In Phase II, optimization will be aimed at adjusting the powder formulation and process to meet the reactive and mechanical properties for selected applications to the Army. For example, an increase in the amount of binder may reduce the strength, but increase the ductility of the composite. In addition, blending may be selected in Phase I to prove the feasibility of the concept. Energetic milling may be selected in Phase II to achieve improvements in microstructure uniformity and, thus, in mechanical properties and potentially in reaction initiation. Additionally, it is believed that a nano-scale microstructure will enhance the reliability of the reaction initiation and its sustainment to completion. As such, techniques that use nano or nano-grained powders and consolidation techniques that can be used to preserve the microstructure of the starting powder and achieve a nano-structured reactive composite, are of special interest. Warhead cases fabricated from reactive composites can throw fragments that can ignite upon target impact and release enormous energy and cause catastrophic damage, unlike conventional metal warhead fragments that can only penetrate the target.

PHASE I: Design a formulation for a reactive structural material and develop the process to produce a fully dense composite. Fabricate small specimens, and characterize the mechanical and reactive properties of the composite to demonstrate process feasibility.

PHASE II: Optimize product formulation, and demonstrate the process for nano-structured composites. Develop and demonstrate a prototype capability for production of components for sub-scale prototype weapon effects and lethality tests at ARDEC. Conduct prototype tests to characterize the initiation and energy release processes, and measure the reaction initiation thresholds and energy release rates.

PHASE III: The material developed under this effort will have dual use applications in military as well as commercial applications. The material can be inserted/transitioned into several Army hardware programs for weapon development efforts. Commercial potential is possible in petroleum exploration and oil well stimulation, mining, commercial blasting, high temperature synthesis of new materials and law enforcement applications.

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2. Fedoroff, B. T. and Sheffield, O. E., Encyclopedia of Explosives and Related Items, Picatinny Arsenal, Dover, NJ, Report No. PATR-2700, Vol. III, p. C611-C621, 1966, CPIA Abstract No. 68-0238, AD 653 029.

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KEYWORDS: Reactive materials, structural materials, powder consolidation, nano-structured composite, thermite, intermetallic.

A08-043 TITLE: <u>High Voltage, High Current, Solid State Switches</u>

TECHNOLOGY AREAS: Electronics, Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: To develop a compact, solid state switch capable of switching high voltages (20-200kV) and currents (I>5kA), with short transient times and low internal resistance. Switch shall survive high frequency cycling (>100kHz)for brief periods and function after gun launch.

DESCRIPTION: This topic is designed to examine the current state-of-the-art in solid state switches and develop a design that goes beyond today's capabilities. Vacuum based technology that is currently available, such as spark gaps, is large and requires extensive peripheral equipment such as gas handling equipment, pumps and extensive electronics and/or triggering circuits. Reliable, compact, solid state, pulsed power switches can offer a significant improvement to vacuum based technology. These switches can be an enabling technology for defense applications that use power modulators for high peak power electrical systems. Compact, high speed opening and closing switches could reduce the size and weight and improve the reliability of pulse power modulators and pulse forming networks. The objective size is to occupy 2 cubic inches volume. In addition the switch design shall be capable of operating within an extended industrial temperature range (-50 deg C to +125 deg C), withstanding long term storage (greater than 5 years)and withstanding a greater than 15,000G force environment. This effort should address technical challenges in materials development to improve performance, as well as, device design for compact size and weight, long lifetime, fast turn on or turn off time, high-efficiency triggering, and packaging.

PHASE I: Evaluate candidate materials, processes, and designs for novel/enhanced solid state switches. Produce a conceptual design and bread board it with representative hardware. Test intial switch design for feasibility.

PHASE II: Characterize the breadboard switch performance. Develop, fabricate and demonstrate a prototype which is robust, scaled, and meets criteria as specified herein.

PHASE III: Military applications may include modulators for high peak electrical systems such as directed energy systems and pulsed power systems. Commercial applications may include
solid state pulsed power systems for food and wastewater processing.

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KEYWORDS: Solid state switch, pulse power switch, pulse power modulator, pulsed power.

A08-044 TITLE: Innovative Tantalum Machining for Weapon Applications

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: The Weapons Systems & Technology (WS&T) Directorate of the U.S. Army Armament Research, Development and Engineering Center (ARDEC) is seeking to identify, develop, and demonstrate innovative machining processes for the rifling of explosively bonded Ta-10W (Tantalum-10% Tungsten) liners on medium caliber gun barrels.

DESCRIPTION: Explosive bonding is a cold welding process that has proved to be a viable alternative for depositing refractory metal liners on the inside of medium caliber gun barrels. Specifically, the Army has successfully cladded a Ta-10W (Tantalum – 10% Tungsten) liner onto the inside of truncated of 25mm M242 Bushmaster barrels. This novel technology has demonstrated to produce an extremely strong bond, environmentally friendly coating with the potential to eliminate the generation of hazardous waste that results from the current chrome electrodeposition process. In addition, coatings like Ta-10W are very desirable due to their high melting temperature. The service life of the Bradley medium caliber barrel (25mm), firing first generation XM919 was only 229 rounds.

Medium caliber gun barrels are rifled and thus an explosively bonded liner must then be machined (rifled) after cladding. While the explosive cladding of Ta-10W liners onto medium caliber gun barrels has significant promise, there remains the challenge to machine the liner after the explosive cladding has taken place. Little information, in terms of tooling, broach configuration, cutter design, speed and feed rates, lubricants, etc… exist on Ta-10W. Work under this research shall evaluate and determine viable machining processes for the cost-effective rifling of explosively bonded Ta-10W liners. Efforts under this initiative should also evaluate the configuration of the pre-bonded substrate and demonstrate a technically sound and cost effective rifling process that would maintain the necessary configuration of both 25mm and 30mm medium caliber gun barrels. Specifically, machining parameters such as proper broach tooling configuration, tool coating, lubricant, speed and feed rates shall be determined.

PHASE I: To identify and evaluate technically sound and cost effective alternatives for the machining of explosively bonded Ta-10W on a 12 inch truncated 25mm barrel section. The proper broach tooling configuration, tool coating, lubricant, speed and feed rates shall be determined. At least four separate 12 inch truncated barrels cladded with Ta-10W shall be successfully rifled with a rifling profile to match the 25mm Bushmaster barrel. From these tests – the correct tooling design, tool coating, lubricant to use, speed and feed rates of the broach shall all be determined to successfully rifle a 12 inch truncated 25mm Bushmaster barrel.

PHASE II: After the successful rifling of 12inch truncated 25mm Bushmaster barrels – Phase II shall rifle two full-length 25mm Bushmaster barrels. The rifling profile shall match the 25mm Bushmaster barrel progressive twist rifling profile. From these tests - correct tooling design, tool coating, lubricant to use, speed and feed rates of the broach shall all be determined to successfully rifle a full-length 25mm Bushmaster gun barrel. The barrel will be test fired to see how the Ta-10W liner , with rifling, stood up. The results will be compared to a chromium-plated 25mm Bushmaster barrel.

PHASE III: After successful rifling of a full-length 25mm Bushmaster barrel, the work will be continued on a full-length 30 mm MK44 barrel (Infantry Combat Vehicle). Phase III shall rifle a full-length 30mm MK44 barrel. The rifling profile shall match the 30mm MK44 barrel. From these tests, correct tooling design, tool coating, lubricant to use, speed and feed rates of the broach shall all be determined to successfully rifle a full-length 30mm Mk44 gun barrel. The barrel will be test fired to see how the Ta-10W liner, with rifling, stood up.

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KEYWORDS: Explosive Bonding, Tantalum, Tungsten, Ta-10W, cladding, medium caliber.

A08-045 TITLE: Reusable and Adaptable Cognitive Decision Aids Components For Remote Weapon Stations

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop real time cognitive decision aiding, visualization and natural Man Machine Interface (MMI) technologies to enhance the operator performance, survivability and sustainability of next generation remote weapon stations and armed robotic systems that will be integral to the network centric Future Force. Demonstrate capability to fully integrate muti-source platform sensor/intelligence data and provide mission focused view of battlespace with predictive course-of-action and mission rehearsal capability.

DESCRIPTION: Advances in artificial intelligence, cognitive science, information processing, intelligent controls, distributed processing and software engineering technologies now make possible the automation and intelligent aiding of many labor and time intensive tasks associated with remote weapon station and armed robotics system control and coordination required for time critical targeting and network centric effects based operations. Current controller technology has limited networking, visualization, decision aiding or map based collaboration capabilities, are not extensible and do not conform to open system standards. Futher research is required to provide highly modular, muti-functional and scalable architectures and a baseline component repository of cognitive decision aiding and remote weapon station/Unmanned System (UMS) components that can be rapidly configured to meet a broad range of armed, muti-platform robotic control and remote weapon station control requirements to include rapid mission plan generation across multiple platforms, real time plan monitoring and synchronization, automated battle drill and tactical behaviors and provide appropriate alerts and alarms based on multi-source sensor/intelligence data to enhance platform self awareness and self protection capability. Implementation architectures must conform to emerging weapon system Technical Architecture and distributed object computing standards. Proposals may address development of one or more reusable decision aid application components with the goal of achieving a 50% reduction in cognitive work load and operator response time compared to an unaided mode of operation.

PHASE I: Develop algorithm approach and architecture design concept and formulate preliminary development and implementation approach. Develop top level hardware/software (hw/sw) architecture specification and demo concept feasibility.

PHASE II: Development and demonstrate a functional prototype decision aid component(s) and operator interface in a realistic simulation scenario. Demonstrate component adaptability and reusability by addressing a minimum of two application scenarios, e.g. small unmanned areial vehicle/small unmanned ground vehicle (SUAV/SUGV)collaborative search & target engagement, SUAV/SUAV collaborative search & target engagement, SUGV/SUGV collaborative search and target engagement.

PHASE III: The end state of this effort will be reusable/reconfigurable controller/platform component technology that can be readily customized to meet varying mission requirements and inserted into user experiments. Expected transition path will be enhancements to Future Force Warrior Small Unit Lethality and Manned/unmanned teaming capabilities and follow-on transition to PEO Soldier and FCS.

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KEYWORDS: Mission planning, decision aids, multi-agent control, open architecture, software reuse.

A08-046 TITLE: Novel Efficient and Compact Diode-pumped Rod Gain Modules for Ultra Short Pulsed (USP) Lasers

TECHNOLOGY AREAS: Electronics, Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a diode-pumped rod amplifier head for Ultra-Short Pulse (USP) Yb: YAG lasers that is compatible with a chirped pulse amplifier (CPA) chain.

DESCRIPTION: Lasers based upon rod architectures offer a simple and rugged method for amplifying an Ultra-short duration laser pulse at moderate powers (250-500W average power output.) When paired with a chirped pulse amplifier chain, greater system flexibility and capabilities are realized. However, there is significant technical challenge when combining the two techniques in high rep rate operations. This effort will require the proposer to demonstrate intimate knowledge of the design and operation of diode-pumped rod amplifiers and of CPA systems, as well as innovative design and/or materials solutions to integrate the two.

Candidate solutions may include, but are not limited to, material solutions and the corresponding manufacturing methods. As the application for this technology is sensitive and constantly evolving, there should be little correlation between the gain media proposed and any intended application outside the USP laser itself. Should the effort progress to Phase II, further application information and/or system specifications will be provided to facilitate the construction of prototype gain modules.

PHASE I: Conceptually develop a diode-pumped rod amplifier head for Ultra-Short Pulse (USP) Yb: YAG lasers that is compatible with a chirped pulse amplifier chain.
Either of two approaches will be considered:
1. Design a module capable of taking an ultrashort pulse from an oscillator (external to the module) and performing the chirped pulse amplification via an incorporated diode-pumped rod amplifier, or
2. Design a diode pumped rod amplifier that is “plug and play” compatible with conventional CPA chains.

Specific technological challenges and associated metrics are:
1. Threshold for amplification efficiency is 25% with an objective of 35%.
2. Module will be able to produce USP output at a threshold rate of 20 Hz with an objective of 100 Hz (or more) with no statistically significant lose in output power.

Present candidate technologies/designs during Phase I and the expected performance characteristics obtained via modeling, simulation or mathematical methods to facilitate a decision for Phase II prototype construction.

PHASE II: Develop the Phase I resultant technology with systems integration input from ARDEC. Verify the proposed design in a bread-board demonstrator, validate results obtained from Phase I and early Phase II modeling, and ultimately construct sample amplifier module and integrate into a functional USP laser, and document experimental results.

Provide prototype hardware, technical data package and complete informational briefing to ARDEC.

PHASE III: In addition to serving the sensitive DoD and Army applications through ARDEC ATO-D.ARD.2008.03/Multimode HPM and Laser Induced Plasma Channel Technology, potential commercial applications include medical lasers, materials processing, or semiconductor processing. Such technology would increase the scope of these and other commercial applications by reducing the overall cost and size of the laser systems, as well as providing enhanced efficiencies and operational rates.

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2. http://www.lasermarking.trumpf.com/152.diodengepumpt.html.
3. http://www.llnl.gov/tid/lof/documents/pdf/236625.pdf.

KEYWORDS: Diode, pumped, solid, state, rod.

A08-047 TITLE: Edge-pumped Composites for Ultra-Short Pulse (USP) Lasers

TECHNOLOGY AREAS: Electronics, Weapons

OBJECTIVE: Develop edge pumped laser gain media that have uniform transverse pump absorption distributions while maintaining good optical beam quality and high laser efficiency at the kW average output power level.

DESCRIPTION: Current efforts utilizing solid state Ultra-Short Pulse (USP) Lasers have identified edge pumped lasers as a technology with the potential to greatly increase the performance of candidate systems. One of the critical components of edge pumped lasers is the gain media. In order to meet Army objectives, novel gain media design is required to ensure uniform absorption while maintaining beam quality and laser efficiency. This solicitation seeks “leap ahead” concepts for gain media materials, processing, geometry and/or finishing, pushing the leading edge of conventional gain media beyond the current capability. Please note, this solicitation refers to “slab” or “thin-disk” type bulk lasers, as opposed to rod lasers which are addressed in another solicitation. This solicitation is concerned with the edge pumping of this particular geometry, not face pumping.

Candidate solutions may include, but are not limited to, material solutions and the corresponding manufacturing methods. As the application for this technology is sensitive, there should be little correlation between the gain media proposed and any intended application outside the USP laser itself. Technologies that address multiple wavelengths of operation are desired, however, the scaling and/or modification of the proposed solution for application to other wavelengths should be discussed if selecting a candidate wavelength.

PHASE I: Design edge pumped laser gain media that have uniform transverse pump absorption distributions while maintaining good optical beam quality (within 5% of diffraction limit) and high laser efficiency (greater than 40%) at the kW average output power level.

In addition to the above mentioned key performance parameters, Phase I should also address the following challenges: thermal management and related thermal lensing, susceptibility to amplified spontaneous emission, and methods used to reduce and/or eliminate spatial hole burning.

Present candidate technologies during Phase I and the expected performance characteristics obtained via modeling, simulation or mathematical methods to facilitate a decision for Phase II prototype construction.

PHASE II: Develop the Phase I resultant technology with systems integration input from ARDEC. Validate Phase I performance characteristics by constructing sample gain material, integrate gain material into a functional edge pumped laser, and document experimental results. Iteratively continue the investigation until threshold values are satisfied. Experimentally determine the upper limits of operational capability.

Provide prototype hardware, technical data package and complete informational briefing to ARDEC.

PHASE III: In addition to serving the sensitive DoD and Army applications through ARDEC ATO-D.ARD.2008.03/Multimode HPM and Laser Induced Plasma Channel Technology, potential commercial applications include forensics, spectroscopy, laser ablation and molecular level materials processing. Other potential Phase III military interest includes Terahertz imaging and LIDAR detecting and ranging.

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1. http://www.dmphotonics.com/fs_filamentation.htm.

2. http://www.columbia.edu/cu/mechanical/mrl/ntm/level3/ch02/html/l3c02s05.html.

3. http://info.tuwien.ac.at/tubiomed/de/aktuell/Wintner_Laser_Lecture_5p153.pdf.

KEYWORDS: Ultra short pulse, laser, edge, pumped.

A08-048 TITLE: Biologically Inspired Processor

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: Develop, fabricate and demonstrate a computational processing network in which many fully programmable processing elements are interconnected in a fabric which dynamically, temporarily and automatically reconfigures itself based on the computational load and preprogrammed priorities.

DESCRIPTION: Considerable basic research has been ongoing in cognitive biological neural systems to determine how they function and attempt to simulate their functionality in integrated circuits and computer software. Such knowledge could be helpful to solve the problem of this solicitation. Practical applications have resulted in numerous artificial neural network (ANN) systems and inference engines that are both hardware (Application Specific Integrated Circuits (ASIC)) based and software based implemented on one or more processors operating in parallel network. This solicitation is not for the R&D of ANN circuitry or inference engines.

In the recent years massive single chip fabrics with embedded processors and embedded memory units have been built. Data flow in some fabrics is reconfigurable. The flow of data and the algorithm across the fabric ultimately limits the practical throughput of any algorithm operating in the fabric. This solicitation is for the research and development of a smart fabric in which the fabric itself, while the embedded processors and memory units are humming away, processing information, determines the optimal current inter-connectivity required to keep bottle necks from forming in the data flow. Examples: the fabric may need to move the processing algorithm within the chip to alternative processors or redistribute the algorithm across multiple processors or change the connectivity of the data flow or create alternative and duplicate sub networks. Basically the fabric will need to preclude data and path conflicts, assure that data is valid and available when and where needed, optimize the execution of algorithms and prevent crashes of an algorithm, etc. all on the fly. Ideas such as keying on the local temperature within the chip, activity within a processor, and the milliamps flowing into chip sectors, and distance of an argument from the executing processor, etc., might be used by the fabric to make its decisions. Power consumption within the fabric must be kept as low as possible.

PHASE I: The contractor shall create one or more innovative and practical designs for a fabric that operates as in the description above. The contractor’s design shall be developed to the level to clearly establish the manufacturability of the fabric using current manufacturing methods. The contractor shall simulate the fabric’s functionality in the presence of processors embedded in the fabric and executing an algorithm that involves numerous processors operating simultaneously in parallel or/and in series and that requires timely data flow between the processors. The designs for the fabric, the simulation description process, and simulation results shall be delivered to the government.

PHASE II: The contractor shall complete a prototype design which includes the fabric with processors embedded to the level ready for foundry fabrication as a full up prototype. The design should have at least ten processors and one million bytes of memory along with several input output ports into the fabric. The full up prototype design shall be thoroughly evaluated through computer simulation of all components and their integrated whole to provide the highest level of confidence that the prototype will function as in the description above. The simulations shall include execution of multiple types of mathematical and logic algorithms that fully test the smart aspects of the fabric and processors. The detailed design for the processor, the simulation plan, the simulation software, a description of the simulation and simulation results shall be delivered to the government.

PHASE III: The technology will support many applications where computational requirements are severe while power consumption must be at the lowest possible level, such as in the Software Defined Radio, HyperSpectral Imaging, Battlefield logistics, Battlefield management, battle space awareness, etc. This solicitation might be used in support of the ATO R.IS.2008.04 - Soldier Sensor Component & Image Processing. Commercial applications should exist in complex electronic networks and their implementation,in cell phone networks, and for smart autonomous robots.

REFERENCES:
1. Thoma, Yann; Sanchez, Eduardo; Hetherington, Carl; Roggen, Daniel; Arostegui ,Juan-Manuel Moreno, "Prototyping with a bio-inspired reconfigurable chip," Proceedings of the 15th IEEE International Workshop on Rapid System Prototyping, 2004.

2. Tempesti, G.; Mudry, P.A.; Hoffmann, R., "A Move processor for bio-inspired systems," 2005 NASA/DoD Conference on Evolvable Hardware, 29 June-1 July 2005, pp 262-271.

3. Pike, Rob; Dorward, Sean; Griesemer, Robert; Quinlan, Sean, "Interpreting the Data: Parallel Analysis with Sawzall," Google, Inc.; found at http://research.google.com/archive/sawzall-sciprog.pdf.

4. Lo, Samantha; Chang, Rocky K. C; Colitti, Lorenzo, "An Active Approach to Measuring Routing Dynamics Induced by Autonomous Systems," Workshop of Experimental Computer Science (ExpCS), 2007.

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KEYWORDS: Parallel processors, autonomous learning, networks, routing dynamics.

A08-049 TITLE: <u>Structurally Integrated Position and Orientation Sensor and Seeker Technologies</u>

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop innovative conformal onboard position and angular orientation sensors for munitions for line-of-site and non-line-of-site applications as alternatives to current systems that use GPS for low cost integration of real-time guidance and real-time terminal guidance into the next generation of precision guided munitions and smart munitions. Proposed research should not use inertia, magnetometer, optical technologies or signals from the Global Positioning System (GPS) as a reference and must be proposed for conformal integration into the munition structure such as fins or peripheral munition geometry.

DESCRIPTION: Innovative onboard full position and angular orientation sensor technologies are sought for munitions and other similar position and angular orientation measurement applications as alternatives to rate gyros, GPS, optical and other similar sensors. The primary goal is to develop full position and angular orientation sensors that could be used onboard munitions to provide full position and angular orientation information relative to a fixed or moving ground or airborne referencing system. It is highly desired that the sensors be geometrically conformal to the shape and size of munitions so that they could be embedded into the munitions structure and occupy minimal added volume. Such geometrical cavities can also be used as seekers in munitions to greatly enhance the performance and significantly reduce the cost of the system guidance and control components. Precision, direct and stable measurement of angular orientation is critical for guidance and control of smart munitions. The proposed sensors must provide angular orientation with accuracy of better than 0.1 milli-radians, must have negligible drift over several minutes of operation, must be capable of withstanding the harsh firing environment, such as temperatures of around 1200 deg. F and pressures of around 85,000 psi during firing, and very high accelerations of sometimes in excess of 100,000 Gs. The proposal should address the issues of position and angular orientation measurement accuracy, sensitivity, computational algorithms and the required calculations, susceptibility to environmental noise and methods of reducing their effects, optimal design of the proposed sensors through modeling and simulation, methods for conformal integration of the sensor into munitions. The primary trade-off parameters are conformability, size, cost, power consumption and accuracy.

PHASE I: Develop parametric analytical models to simulate the performance of the various geometrical shapes and sizes of the cavities to be used as either sensors or seekers. Develop algorithms for optimizing the geometrical shape and size of the sensor cavities to achieve maximum sensitivity and minimum sensor volume without compromising the structural integrity of the munitions. Develop methods for structural modeling and analysis of the structural integrity of the round with the integrated geometrical cavity during the firing. The designs must consider sensor cost and manufacturability issues.

PHASE II: Design a prototype of optimally designed geometrical cavities for polarized RF sensors as integrated in the structure of a selected gun-fired projectile or mortar. Fabricate prototype of the RF sensors as integrated in the projectile structure, perform structural integrity test, including air gun test, to illustrate survivability. Perform laboratory (anechoic chamber) tests and range tests to validate the performance of the optimally designed geometrical cavity sensors in measuring position and angular orientation.

PHASE III: The development of direct and absolute position and angular orientation sensors has a wide range of military, homeland security and commercial applications. In the military related areas, such sensors, particularly if they are low cost, are essential for guidance and control of all smart munitions, missiles and guided bombs. These sensors are also essential for the development of guidance and control systems of various weapon platforms, robotic systems, particularly those used for remote operation in hazardous environments, which may be encountered in homeland defense. Commercial applications include testing and validation systems such as those used in simulators.

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4. M. A. Karam, Northrop Grumman, " Multiple Scattering Contributions to the Radiometry of an Inhomogeneous Discrete Random Layer: A Radiative Transfer Approach.

5. J. Rastegar PhD, C. M. Pereira, "On the Geometry of 3D Orientation Measurement Using a New Class of Wireless Angular Position Sensors", ASME, Oct 2004.

6. Feinian Wang, Kamal Sarabandi, Radiation Laboratory, EECS Dep., The University of Michican, "Accurate Estimation of Electromagnetic Wave Extinction Through Foliage".

7. C. M. Pereira, MSEE thesis "Real-Time Referencing for Advanced Munitions Sensing Systems", State University of New York at Stony Brook, Dec 2004.

8. C. M. Pereira, J. Rastegar PhD., "Novel Conformal Sensor Technologies That Conform to Munitions Geometry", SPIE, Canada 2005.

9. C. M. Pereira, J. Rastegar PhD" On the Geometry of 3D Orientation Measurement Using a New Class of Wireless Angular Position Sensors", ASME, Oct 2004.

10. C. M. Pereira, J. Rastegar PhD "New Class of Onboard Absolute Orientation Measurement Sensor for Robotic Mobile Platforms", SPIE, Oct 2004.

KEYWORDS: Sensors, Angular Orientation Sensors, Position Sensors, Low-Cost Sensors for future Armaments, RF Cavity Geometry Optimization.

A08-050 TITLE: Novel Titanium Alloys for Improved Workability and Formability

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop new alpha-beta titanium alloys that offer lower cost and that will enable JPMO Lightweight Howitzer to further produce and field force-protect systems using lower cost titanium.

DESCRIPTION: The US Army's use of titanium alloys has risen dramatically for a variety of add-on armor and structural applications, as alloy contents improve the strength of the titanium composite. There exists opportunities to further improve titanium alloy performance and reduce costs through the addition of unique alloying elements.

While the use of titanium is increasing in Army systems, it is still a relatively new phenomenon when compared to steel. Because of this there are many existing alloys and possible alloys that have not been used in Army systems. Much of the titanium alloys in use are also made for aerospace applications. Aerospace grade titanium is not always suitable for many Army systems. The goal of this effort is to explore new ideas and technologies in developing non-aerospace grade titanium alloys for Army applications. By exploring new alloys that fit this need, the Army will be able to reduce the costs of titanium used in Army systems and expand it's overall use to new systems/areas. The overall life cycle costs for various systems will be decreased due to reduced weight and superior material properties, i.e., gas and transportation costs, improved corrosion resistance and wear resistance will reduce replacement/maintenance costs.

These new alloys must offer lightweight, high strength and high stiffness properties in order for the Army to create the high-performance components it requires in current and future weapons systems. The alloying production and compound manufacturing method chosen for the new alloys must ensure an adequate tensile strength and weight ratio.

Consideration should be given to titanium alloys that enable the production of weapons systems components by near-net shape casting, as this method eliminates or dramatically reduces the need for machining -- representing a significant cost savings. The need for a fully documented, repeatable and electronically transferable process must also be considered.

The following metrics are provided as a general guideline:
- 30% reduction in overall system weight when compared to conventional steel structures/systems.
- Yield strength in the range of 135-130 Ksi.
- Tensile strength at least 10% greater than yield strength.
- Decrease in cost 20% - 30% when compared to current market price for Ti-64 (non-aerospace grade).

PHASE I: A feasibility study will be undertaken to determine the viability of non-aerospace grade titanium alloying materials to create new titanium alloys with the optimal tensile strength, weight and low cost attributes. The alloys will be further analyzed to determine their viability to produce titanium components via near-net shape casting. Castable Ti-64 Grade 5 should be used as a baseline comparison for the alloy developed during Phase I. A successful effort will result in the development/selection of an alloy which can meet the majority of metrics contained in the Description.

PHASE II: Develop and demonstrate a compound specifically for use in the manufacture of armor and weapons systems components. Qualification testing will validate whether the titanium alloy composition can meet the strength and durability requirements for munitions manufacture. The end result is a strong yet lightweight alloy mixture, a near-net shape casting process and the needed equipment to make the titanium alloy rapidly producible and cost effective.

PHASE III: The "vision" for these alloys is that the Army will use them in the manufacture of key components of munitions to continue to reduce weight, improve performance and survivability. Both the recipes and the casting processes will be documented for future use and transferred to the industrial base. Commercially, the alloy composites and processes can be employed to reduce the cost to manufacture products for the automotive, medical device and cycling industries, as well as numerous other manufacturing sectors.

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1. Titanium and Titanium Alloys - Paper on the "Key to Metals" website. http://www.key-to-metals.com/Article20.htm.

2. Summary of Emerging Titanium Cost Reduction Technologies http://engine-materials.ornl.gov/Kraft-Titanium-2.pdf.

3. Low-Cost Titanium Armors for Combat Vehicles http://www.tms.org/pubs/journals/JOM/9705/Montgomery-9705.html.

4. Titanium and Its Alloys: Selection of Materials and Applications http://www.key-to-metals.com/Article125.htm.

KEYWORDS: Alpha-beta alloys, Titanium alloys, Munitions systems, Near-net shape casting.

A08-051 TITLE: High Resolution Multispectral X-ray Imaging

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design, develop and demonstrate a high resolution staring array detector module, to include readout electronics with control hardware and software, to be used in an digital X-ray inspection system for munitions.

DESCRIPTION: The Army and its ammunition plants are responsible for X-ray inspection of a wide variety of munitions in order to insure safety and proper functioning. Items inspected range from small fuze assemblies to 155 mm projectiles. X-ray energies to 460 KeV are routinely used. Energies in the MeV range are occasionally necessary to penetrate up to five inches of steel at the base of the larger munitions. (1,2,3) Although the medical community moved to digital X-ray imaging many years ago, the large energies required by the Army application and the non-availability of suitable detectors for use at those energies, has impeded a similar migration in the industrial radiographic community. (4) In an effort to move away from film-based radiography and towards digital radiography, ARDEC has sponsored several projects to develop technology for direct digital X-ray imaging and computed tomography.

Cadmium zinc telluride (CZT) is the X-ray sensor of choice for non-destructive industrial imaging applications because of its mechanical qualities, high X-ray absorption, and fast throughput.(5) It is capable of operating in single-photon mode in which the pulse output is proportional to the energy of the X-ray photon. This permits energy discrimination or energy band selection from a broad-band Brehmstralung source. Large pixelated monolithic CZT crystals for performing X-ray detection are now available and small detector arrays with modest resolution have been demonstrated.(6) Further innovation is required, however, to develop an imaging array capable of resolving flaws on the order of 0.005", e.g. HE-base separation gaps, as required by inspection criteria. Energy discrimination is necessary to reduce the effects of X-ray scatter which cause unacceptable artifacts in computed tomography and lost of contrast in images. Energy banding is necessary for dual energy computed tomography. The detector array must be modular, fully abuttable, have high spatial resolution, be spectrally sensitive with at least five selectable energy thresholds, and work at the high X-ray energies and flux rates encountered in industrial radiography.

This solicitation is for implementation of CZT arrays into a high resolution modular detection system capable of being scaled, or tiled together, to form a large area imager of arbitrary size. The module should be on the order of 1 cm x 1cm. A pixel pitch of 200 um is desired (50 x 50 array) although 250 um (40 x 40 array) will be acceptable. CZT thickness must be at least 3 mm in order to provide sufficient detection of 400 KeV X-rays. The electronics array must be capable of measuring, for each pixel, the energy of each absorbed photon to a resolution of at least 7% at 120 KeV at an average X-ray flux of 6 million photons per second per square mm. Comparator / discriminator circuits should provide parallel output at five user-selectable energy thresholds. Thus the system output should be a three-dimensional data array. That is for each pixel the number of photons exceeding each of the 5 energy thresholds should be reported.

PHASE I: Investigate the feasibility of developing a high resolution X-ray imaging module as described above. Rationale that the design will meet the requirements must be clearly presented and substantiated.

PHASE II: Develop, fabricate and test a complete X-ray detector system, as designed in Phase 1 above. The system shall consist of the detector module, all support electronics, and computer software required for operation.

PHASE III: Modular, high resolution, energy selective, sensitive and fast CZT X-ray detectors are required to properly inspect many Army end items. These items include projectiles, artillery shells, mortar rounds and small arms ammunition; such applications range from quality assurance inspections to malfunction investigations. As the technology matures, film-based radiography will be replaced with digital methods and new digital inspection techniques, such as three-dimensional CT imaging, will become practical. This will initiate commercial demand for digital systems. The same transition will occur in commercial/industrial radiography for NDE and process control. Homeland defense applications for these detectors, such as screeners for rapid detection and identification of illicit items, will become practical creating additional market opportunities. A successful Phase II program will prove feasibility and enable the successful contractor to find a partner to fund further development and develop commercial markets.

End Vision: Following successful development and validation, digital radiography protocols will be developed by ARDEC's radiographic laboratory under PEO-AMMO Life Cycle Pilot Process (LCPP) programs. The new protocols will become part of the NDE standards munitions plants will be required to adhere to in subsequent acquisitions which will initiate commercial market demand.

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KEYWORDS: Cadmium zinc telluride, X-ray imaging, X-ray detectors, pixelated arrays, X-ray, manufacturing quality, non-destructive evalutation, industrial radiography.

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A08-052 TITLE: Development of Nanothermite-Based Microthrusters

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

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

OBJECTIVE: Develop and demonstrate performance of nanothermite systems in propelling microthrusters.

DESCRIPTION: The principal applications of microthrusters are for primary propulsion, altitude control, and pointing capability of micro-spacecraft [1,2]. Some technologies currently being developed include: microgas generators for micro-actuators, airbags, and specialized military applications such as Low Cost Course Correction Technology (LCCCT). This latter technology employs microthrusters for in-flight trajectory correction of laser guided projectiles. The LCCCT provides enhanced accuracy and improved dispersion of a trajectory in-flight to compensate for system errors under all conditions. Overall, LCCCT is suitable against ground, air and naval targets and it can be applied to gun launched projectiles, mortars, and rockets. Although pyrotechnic microthrusters are known, the information on utilizing metastable intermolecular composite (MIC) materials for thruster application is not existent. It is anticipated that this project will focus on investigation of and application of MIC materials instead of conventional propellants for generating thrust impulses from 50 µN to 10 mN. Metastable intermolecular composites (MIC) belong to a class of nanoenergetic materials, where oxidizer and fuel are mixed at nanoscale leading to enhanced reactivity. MICs have improved performance in terms of energy release and ignition as compared to their micron-size reactants.

PHASE I: Design and test a microthruster chamber with micrometer size convergent-divergent nozzle in polycarbonate or metallic structures. Identify a suitable metastable intermolecular composite (MIC) based on pressure characteristics and load for generating thrust impulses from 50 µN to 10 mN in a microthruster chamber. Demonstrate ignition and performance characteristics of MIC material in a chamber with various sizes of convergent-divergent nozzles.

PHASE II: Develop correlation for thrust prediction generated by various MIC materials with respect to the size of microthruster chamber and size of nozzles. Demonstrate on-demand multiple ignition capability for multiple course correction. Develop and fabricate a prototype to meet the LCCCT munitions requirements as prescribed by the Department of Defense.

PHASE III: Construct and demonstrate a prototype of a microthruster for the LCCCT application and develop scale-up plans for microthruster production. It is expected that dual use application will be in DoD (LCCCT, space-based surveillance, nano and micro satellites, unmanned aerial vehicles) and commercial (remote sensing for climate and traffic, communication satellites, micro-gas generators for airbags and microactuators).

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KEYWORDS: Microthrusters, nanoenergetics, nanothemites, MIC, MEMS.

A08-053 TITLE: Thermal Sensing and Responsive Materials for Environmental Monitoring

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Identify, develop and refine thermally responsive materials to “record” and reveal environmental exposure history of ordnance components and other items whose performance can be affected by environmental extremes.

DESCRIPTION: Ordnance is designed to operate in a wide range of environments, however, at times, extreme conditions are encountered that can exceed the typical design ranges. It was documented in Desert Storm for example, that the temperatures inside shipping containers sometimes exceeded 190 degrees. This significantly exceeds the design limits of 145 – 165 F and can result in degraded ordnance performance, or worse. For example, propellant stabilizer is known to deplete at an accelerated rate as temperature rises and sustained exposure to high temperatures could ultimately lead to a potentially catastrophic event. High temperatures are also implicated in adhesive bond failures, circuitboard issues, and a reduction in the mechanical properties of engineering plastics common to many ordnance items. Despite these and many other consequences of elevated temperature exposure, there currently is no way to know what environmental extremes fielded items have experienced during their lifetime.

Having an indication of the environmental exposure history of an item will enable troops and munitions managers to readily identify ordnance that may have been compromised. As a result, compromised munitions can be culled from those that are fully serviceable – helping to ensure mission success and enhancing soldier safety.

Environmental exposure history can also support diagnostics and prognostics by QA and other personnel and support ultra-reliability over time as certain unanticipated vulnerabilities become apparent. In turn, the development community can address any vulnerabilities revealed.

Temperature indicators affixed to certain ordnance items (or propellant for example) could be optically read and provide an input to a fire control system potentially enabling improved delivery accuracy. Additionally this capability would support elevated soldier safety in the event an item is determined to be unsuitable for firing by the system as a result its thermal state.

Thermally responsive materials could also potentially be applied to weapon barrels to monitor the extreme temperatures that can be reached when undergoing high rates of fire. Breaching critical temperature regimes could indicate a safety hazard (e.g. "cook-off" risk) and/or the need for maintenance and/or barrel replacement since barrel wear can be correlated with high rates of fire and associated erosive temperature extremes.

The following characteristics/objectives are considered important for success:

- Very Low cost – In the approximate range of 25 cents to one or two dollars to monitor an item or group of items.
- Long life – as long as the life of the item - 10+ years. The indicators must be, and remain stable and compatible with a variety of substrates to which they might be applied. Ultraviolet light tolerance is highly important in some applications, but in some cases would not be critically important.
- Application of the indicators shall be easy and inexpensive and shall not degrade the performance of the item itself.
- The indicator/material shall be chemically compatible with a variety of metallic and organic material substrates.
- No external power supply shall be needed.
- The ability to irreversibly “trip” when certain threshold temperatures have been reached. Also, the ability to provide a current/reversible (“real time”) indication of temperature over the range of 0 to 200 F (for most applications) but also as high as approximately 1250 F for weapon barrel applications.
- The ability to indicate the approximate TOTAL number of exposure hours experienced over a variety of temperature ranges/bands up to approximately 200 F for most applications, and up to roughly 1250 F for weapon barrel applications.
- The indicators/materials ideally will be readily discernable by the human eye. That is – no specialized “reading” or decoding equipment shall be required to interpret the information. However, the ability to ALSO electronically/optically read/interpret the information for possible use and storage in information systems is a desirable capability.
- The total space consumption of the indicator shall be almost nil – in the vicinity of .025 cubic inches (for example – 1” X1” X .025”).

PHASE I: During Phase I the company shall explore materials and options to meet stated objectives. The approaches/solutions deemed most worthy of further work in Phase II shall be identified with a solid rationale provided as part of a Phase I report. Additionally at least limited demonstrations of the basic functionality of some candidate reversible and irreversible thermally responsive materials shall be conducted. Potential methodologies for using materials to “record” TOTAL exposure hours to a variety of temperature regimes shall also be explored. Temperature regimes of interest commonly would be in the range of 100-200 F, but for weapon barrel heating applications temperatures as high as 1250 F are of interest and shall also be explored. All work done in this phase shall be documented in the Phase I report. The company shall also lay out a plan for execution in Phase II that will address the approaches the company will take to meet the stated general performance objectives as well as LONG LIFE and stability of the materials, including UV energy tolerance.

PHASE II: During Phase II the company shall extensively develop and evaluate materials that address the stated objectives of the solicitation. The pros and cons of various approaches and candidate materials shall be addressed and those that offer the most promise will be the subject of extensive work. Extensive testing and demonstrations shall be conducted to assess/confirm their desired functional behavior as well as their suitability for long term use, and UV tolerance. Work shall also be conducted to assess the producibility of these materials and a credible projection of their cost shall be made. All work shall be thoroughly documented in a Phase II report.

PHASE III: The end state envisioned for this research is to have a “family” of customized, stable, and long lived materials that can respond to a wide range of temperature exposure histories (both reversibly and irreversibly) and reveal that history by simple observation. These materials could, for example, be used in conjunction with humidity indicator “windows” inside the packaging of sophisticated ordnance items. This would enable in-situ monitoring of the true temperature experienced by an item inside of its packaging. These materials could also be applied to very small components (e.g. electronics) to monitor environments. This could support engineering failure analyses and identification of vulnerable components and ultimately lead to improved designs and performance over time. As mentioned above, significant benefits could also potentially accrue in the weapon system safety and performance areas.

PM Excaliber and PM Mortars have provided written endorsements of this technolgy and others are expected. Transition to these organizations is anticipated pending a successful outcome of the research.

Note: This topic also addresses the Ammunition Stockpile Reliability Program (ASRP) called for in AR 702-6.

Commercial applications could encompass anything that is negatively affected by thermal extremes. These could include pharmaceuticals, blood plasma, food products, electronics, etc.

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KEYWORDS: Thermochromism, thermal materials, temperature sensing, thermochromic paint, phase change materials, polymers, liquid crystals.

A08-054 TITLE: <u>Spectrally and Spatially Foveated Multi/Hyperspectral Camera</u>

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: The objective is to develop an electronically controlled spectral- and spatial-foveated multi/hyperspectral sensor that is dynamically programmable to achieve variable spectral/spatial resolution and acuity in user defined regions of the image.

DESCRIPTION: The human eye is a foveating sensor. That is, the highest acuity or concentration of sensors is in the central portion of the sensor. The highest spatial resolution is in the center of the sensor and decreases towards the edge. Color is not seen on the edges of the Field of View (FOV) for the eye. This solicitation is for the development of a foveating visual multi/hyperspectral sensor in which regions of interest, (ROI's), have high spatial and spectral resolution as opposed to other regions of the image. Optimally, the resolution would change in a smooth fashion. Considerable Research and Development has been done to simulate the effects in images in order to decrease the data rates required, while maintaining the information of primary interest. The research has not been extended to more than three colors and mostly is done with monochrome images. This solicitation will extend the work to include changes in the spectral resolution as well as the spatial resolution. This solicitation is for developing the sensor to change the spectral and spatial resolution in user defined regions as opposed to performing the task in the post processing of the data. In addition to simply changing the spatial and spectral resolution the sensor should change the data acquisition and transmission rate in the ROI. That is, the ROI region should acquire and transmit its data to the outside processor/display faster than the surrounding region. The system should acquire and process the data to create an image of high quality, in which the ROI's have the highest acuity by a factor of two or more from the low acuity region in the spectral, spatial and temporal domains.

PHASE I: The contractor shall create one or more designs for a sensor which is foveated in both the spatial domain and the spectral domain and in acquisition rates as described in the description section of this solicitation. The contractor's design shall be developed to the level to clearly establish the manufacturability of the sensor using current manufacturing methods. The contractor shall simulate the sensors' functionality and the images expected of the sensor.

PHASE II: The contractor shall complete one of the sensor designs to the point where it can be sent to a foundry for fabrication as a full up prototype. The design should have at least two ROI's in the FOV as described in the description section above. The contractor shall either fabricate the high risk components of the prototype and test their functionality, or simulate the high risk components in gross detail. The full up prototype design shall be thoroughly evaluated through computer simulation of all components and their integration to provide the highest level of confidence that the prototype will function as in the description above.

PHASE III: The phase III shall result in a prototype sensor as per the design and be available for field testing as specified by ARDEC. The testing shall evaluate the foveated sensor for a wide range of military and commercial applications including Homeland Security operations such as the Border Patrol, airport security and FEMA in responding to urban security incidents or natural disasters. The new ATO, R.IS.2008.04. Soldier Sensor Component & Image Processing is one of the most likely paths for transition.

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KEYWORDS: Foveation,variable acuity, Region of Interest, hyperspectral, multispectral.

A08-055 TITLE: Compact Unit for Eye-safe Standoff Explosive Detection

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop a compact, man-portable explosive detection unit that offers real-time explosive detection from standoff approaching 30m, that does not rely on photoionizing radiation, and that can positively identify an exposed or concealed explosive substance.

DESCRIPTION: As a result of its role in the Global War on Terror, the Army faces threats from improvised explosive devices (IEDs) that cause soldier casualties and injuries in significant numbers, as well as extensive damage to Army equipment. The Army requires the ability to identify explosive threats before detonation. Many commercially-available explosive detection technologies involve the acquisition of a chemical sample of the suspect material and analysis of that sample's chemical composition. Such an approach presents dangers to the soldier resulting from the need to make close contact with the target, and is not suitable for certain applications such as wide-area surveillance. Standoff detection schemes have been investigated, and some technologies are commercially available, but many require bulky instrumentation, slow signal acquisition times, use of photoionizing radiation, limited standoff range, or several of these. Each of these drawbacks limits the potential applications in which a given technology could be expected to make a useful contribution. This solicitation seeks to develop an instrument that surmounts several of these obstacles. The emphasis of this solicitation is on bulk explosive detection, but trace detection approaches are welcome as well. The goal is an instrument that can detect and identify explosive threats that are exposed, or concealed by common dielectric materials such as clothing or plastics. The company shall develop a prototype detection device that is compact and man-portable and that can offer eye-safe operation and rapid explosive detection and automated identification at standoff.

The probability of successful detection of an explosive threat is increased when information from orthogonal sensor modalities can be synthesized to provide more comprehensive information about the target. While this call is not specifically for sensor fusion approaches, proposals that exhibit an awareness of the need for sensor fusion and that convincingly articulate a path by which their device could be extended or integrated with other orthogonal sensing approaches will be viewed most favorably.

PHASE I: Design a detection system that can detect and identify exposed bulk explosive threats at standoff approaching 10m. The device should offer eye-safe operation and should provide rapid operator-assisted identification of threats. The device should demonstrate ability to detect all common explosive materials (e.g. TNT, RDX, etc.).

PHASE II: Extend standoff range to approaching 30m. Demonstrate detection of concealed explosive threats. Automate threat recognition, with total time from initiation of signal acquisition to positive identification of explosive threat to occur within 1s or less. Quantify sensitivity and selectivity to known explosive materials as a function of standoff distance, mass/spatial characteristics of target, and presence of obscurants.

PHASE III: The system developed will have considerable potential for military and commercial security and antiterrorism applications. Commercial security applications include airport checkpoints, container screening, or border security. By extending the detector's list of recognized substances to include non-explosive threats such as narcotics or chemical or biological agents, the list of potential security applications increases considerably. Expanding the capabilities further to enable detection of homemade explosives or the constituents used to produce them would permit utilization of the detector in law enforcement or counter terrorism operations aimed at identifying bombers prior to device emplacement. Military applications could include installation security, suicide bomber detection, and route clearance operations.

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KEYWORDS: Improvised explosive devices (IEDs), Standoff Detection.

A08-056 TITLE: Bio-Inspired Battlefield Environmental Situation Awareness

TECHNOLOGY AREAS: Information Systems, Battlespace

OBJECTIVE: Develop a conceptual bioinspired navigation system for micro-air vehicle situation awareness in complex urban terrain. This system involves both the software and sensors, but the emphasis should be on the integration of information for safe navigation. The primary technical risk is in the development of algorithms which can exploit information available from very small and light sensors systems comparable in scale to those exploited by flying insects and birds. Exploitation of existing sensor concepts should provide adequate information, so the design should exploit such concepts rather than develop them.

DESCRIPTION: The world is populated with a seemingly countless number of tiny machines that exhibit very complicated adaptive behaviors in challenging environments – living creatures. Even very tiny and simple creatures manage to solve the problem of sensing their environment and control of motion and flight in a turbulent atmosphere. They do this with the aid of neural systems that are nearly microscopic.

There is more than one reason that this effectiveness is surprising. They perform their information processing with a neural system in which signal propagation speed (1m/s – 100 m/s) and switching times (~ 1 millisecond) are roughly one million times slower than the comparable numbers for a modern silicon based microprocessor. These processing elements are themselves living systems (neurons and associated cells) that need to ingest food, synthesize a variety of products they need for life and function) and cooperated with other similar systems. Moreover, they are exquisitely delicate – temperature and their biochemical environments need to be precisely controlled in order for them to function.

Human engineers, at least for the moment, are quite incapable of building something as small and complex in its behavior as a fly, despite the apparently very great advantages of our information processing technology.

The most plausible explanation for this unreasonable effectiveness is superior design. Despite many limitations of the underlying technology (living cells), biological systems are exquisitely adapted to solving the problems they face in survival.

That notion is the inspiration for biomimetic technologies. The goal is to understand and use these design principles to develop better mechanical systems for human technology.

In particular, we wish to adapt some of these design principles to the operation of Army autonomous and semi-autonomous systems, especially to the problem of how such systems are aware of and respond to environmental conditions likely to impact their operation, including, wind, obscurants, temperature, precipitation, and snow, as well as terrain and vegetative features.

PHASE 1: Develop a conceptual bioinspired navigation system for micro-air vehicle situation awareness in complex urban terrain. The Phase I report should discuss the environmental awareness challenges for such a system and detail a conceptual design for coping with those challenges. This plan should be informed by the design and operation of the sensor and control systems employed by small aerial bio-systems such as hummingbirds and dragonflies.

PHASE II: The primary Phase II products should be a detailed design, simulation and prototype for the bioinspired autonomous situation awareness and navigation system. The design and prototype should mitigate or solve the problems of the micro-aerial system operating autonomously in a complex domain. Those problems include avoidance of obstacles, maneuver in a crowded urban air space with complex atmospheric flows, and the ability to cope with other hazards of the urban battlefield environment.

PHASE III: The technologies developed in phases I and II are immediately applicable to small autonomous military systems, and should be readily commercializable for such applications. In addition, the same technologies are relevant to many or most of the other autonomous and semi-autonomous systems now under development for applications such as hazard inspection and disaster recovery, patrol of communication and transport routes, and surveillance, policing, and protection.

Autonomous military systems are near or at the point of the technological spear, but their use in almost every aspect of life is proliferating. While some sophisticated and expensive semi-autonomous robots explore distant planets other simpler and cheaper ones vacuum living room floors. Each of these systems faces the typical hazards of autonomous existence, and future progress in developing such systems depends on development of the mechanisms for environmental awareness necessary for their safe and effective operation.

Autonomous air and ground transport is projected to be an important technology in a decade or less. The most crucial requirement for bringing this technology to fruition is the ability to see and avoid obstacles and other vehicles. This will depend on a degree of environmental awareness beyond current systems. If the system developed in Phase II of this proposal is applicable to the problem, commercialization should have a huge payoff. Significant progress in such environmental awareness is likely to have broad applicability to both future military and civilian systems. An effective system should find a wide range of commercializable applications.

Other aspects of environmental awareness probably can't change a whole paradigm, but if they are applicable to military autonomous systems, there is a good chance that they would also have commercial potential.

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KEYWORDS: Biomimetic, environmental, autonomous, situation awareness , micro aerial system.

A08-057 TITLE: Urban Illumination for Soldier Simulations and Close-Combat Target Acquisition

TECHNOLOGY AREAS: Battlespace, Weapons

OBJECTIVE: Research and develop a model capable of calculating city light illumination levels for use with Gen III Night Vision Goggle (NVG) target detection models, first responder and law enforcement applications, and for implementation into the Target Acquisition Weapons Software (TAWS) and the Infantry Warrior Simulation (IWARS). As a first step in this direction a limited engineering model is desired.

DESCRIPTION: Quantification and prediction of detection, recognition and identification performance in an urban environment, where combat occurs at close range, requires innovative approaches to modeling close-combat target acquisition. Objects of interest may be just one element among many objects in a complex urban scene comprised of non-military buildings under artificial illumination. However, the most important objects of military interest, such as insurgent personnel, are often internal to buildings, buried in the scene content among other low to medium contrast objects. Illumination levels are a necessary piece of information in determination of target acquisition. In addition to the aforementioned, this model could lead to insights for close-combat target acquisition, resulting in a highly relevant impact for the Army.

In urban settings, target detection at nighttime using Gen III NVGs will be influenced by city-specific illumination levels. Further, at any specific location in an urban (city) location, the illumination levels at night are affected primarily by lunar phase and the number and location of street/area lighting. In urban settings, other factors that must be considered are the number, location, material type, and dimensions of buildings, and the aerosol content of the intervening atmosphere. In addition, the number of illuminated windows in a building will also affect local illumination levels and thus target acquisition. To predict target acquisition in such a nighttime urban environment, a model that includes the aforementioned effects needs to be developed and, for practical use in the modeling and simulation community, must run quickly. To accomplish this, a limited engineering level model needs to be developed with an eye towards employing realistic, fast-running approximations.

While radiosity and similar models suitable for use with global illumination [1] have been applied in the civilian community for photorealism effects, it has not been applied to Army scenarios concerned with urban light levels. Current illumination models do not account for these effects [2, 3]. Note however, a model that can predict nighttime illumination levels, given the limitations below, is desired; an imaging model is not a solution for this problem.

Results will apply to Gen III NVGs operating in the 0.6 – 0.9 um wavelength band [4]. This capability is required for the TAWS software [5] running on the Distributed Common Ground Station-Army (DCGS-A).

PHASE I: Develop a limited engineering model capable of determining nighttime urban illumination levels for an observer located arbitrarily within a city, as described in the scenario below, using Gen III NVGs. The model should consider direct and indirect light scattered off of buildings and their surroundings under degraded atmospheric conditions in a static urban setting. The model should be capable of predicting the illumination for variable observer-source geometries internal to the city and must be either fast running or amenable to producing lookup tables. Suggested parameters for this initial model are presented in the following scenario.

City Scenario:
Buildings: N (>= 4) rectangular windowless buildings, N/2 on each side of a roadway. The roadway should have a width of 7 meters; the mean building separation on each side of the roadway is 30 meters and the building dimensions are (LxWxH) 70x10x10 meters. The building albedo is 0.30 and the albedo of the surroundings is 0.25.

Lighting: The number and type of artificial lighting are L (>=2) 250 watt high pressure mercury lamps [6, 7] with a mean output of 40 lumens/watt each with a full-cutoff luminaire (no light is emitted above the horizontal plane) and an isotropic distribution pattern in the downward direction. The height above ground of the artificial light sources is 10 meters. Light positions are at user-selected locations along the roadway; non-artificial illumination sources, e.g. lunar illumination, may be accounted for by assuming a constant lunar flux = 1.

Atmosphere aerosol (all values are constant over the wavelength band): An extinction coefficient of 0.5 km^-1 and an albedo of 0.85. The scattering phase function can be represented by a Henyey-Greenstein phase function [8] with asymmetry factors (a relative measure of forward or backward scattering) of g = 0 (isotropic) and g = 0.65 (forward peaked). The optical depth is 1.0.

Provide validation that shows the model is providing reasonable results.

PHASE II: Generalize and extend the model to multi-story (>=2) buildings with variable albedoes, dimensions and separations. Add S (>=2) 250 watt low pressure sodium street lights [6, 7] with a mean output of 80 lumens/watt and other specifications as in Phase I lighting. Include W (>=4) windows/building with W/2 windows/floor facing the roadway. The windows may be devoid of covering and should be illuminated internally by an incandescent isotropic source of 100 watts. Locate the incandescent source such that only indirect light escapes through the window. Include scenarios where multiple scattering effects are noticeable, i.e. optical depths > 2, and allow for user-selected aerosol types [9]. Apply and demonstrate these extensions in TAWS [10]. TRL = 6.

PHASE III: Dual Use Applications. IWARS [11], a constructive, force-on-force model for assessing the combat worth of systems and sub-systems for both individuals and small unit dismounted warfighters in high-resolution combat operations, is being co-developed by the Natick Soldier Research, Development and Engineering Center (NSRDEC) and the Army Materiel Systems Analysis Activity (AMSAA), which are subordinate organizations to the U.S. Army Research, Development and Engineering Command (RDECOM). NSRDEC, AMSAA and RDECOM are the most likely sources for continued 6.2 funding. Since IWARS has an objective of providing a modeling capability for conducting integrated, multi-domain analyses that allow the complex relationships between soldiers, their equipment, and the battlefield environment to be explored, the addition of an urban illumination model to IWARS will improve the representation of the performance and behaviors of individual soldiers and their collaboration in small units for effects on C4ISR in realistic environments.

This capability can be commercialized into software modules for new or existing decision aids that can be used by/for civilian and military planners, first responders, the FAA, Homeland Security, ground emergency vehicles, sniper detection, law enforcement agencies and others impacted by reduced effectiveness of night vision sensors. The model would also have applications in simulators and gaming programs. The models and/or techniques should be detailed and published in one or more reports or journal articles.

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KEYWORDS: Night Vision; urban illumination levels, Target Acquisition Weather Software, (TAWS).

A08-058 TITLE: Situation Awareness Assessment Tools for Network Enabled Command and Control Field Evaluations

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop a situation awareness (SA) assessment tool that can be used in a variety of Army command and control (C2) system evaluations to measure both individual and team SA, so as to determine the utility of various technologies for supporting the tactical situation awareness and decision making process.

DESCRIPTION: To ensure tactical success, our military forces must "see first, understand first, act first, and finish decisively. To support these efforts, soldiers must possess high levels of situation awareness (SA), defined as "…the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (Endsley, 1995, p. 36). Level 1 SA involves perception of elements or cues in the environment (see first). Level 2 SA requires integration of these elements and comprehension and assessment of the current situation (understand first). Level 3 SA calls for projection of the future status of the elements in the environment and deciding upon an optimal course of action (act first). As such, to finish decisively, soldiers need to develop and maintain SA at all three levels. Additionally, a soldier's SA needs to be specifically focused around what is required for his role and position within the echelon. Furthermore, in network centric warfare, high levels of Team SA becomes an even more critical commodity providing a force multiplier effect that allows widely distributed forces to act in concert in a dynamically changing battlefield.

To ensure optimal performance in these complex operational environments, sensitive and validated measures of SA are needed to test and evaluate new technologies targeted at improving soldiers' SA. These measures need to be both sensitive and valid, and also function in demanding military evaluation environments, including stationary command posts and command and control on-the-move applications. Current methods of assessing performance in typical military operations rely on MOPs/MOEs (e.g., kills and losses, number of targets hit, number of missiles fired), which often lack information rich enough to diagnose cognitive performance with systems or determine needed improvements in decision aids and networked C2 collaborative technologies. Direct measurement of SA, through tools such as the Situation Awareness Global Assessment Technique (SAGAT) has been used successfully for this purpose (Endsley, 2000), however it is more suitable for simulation based studies than field based evaluation settings.

PHASE I: Design a SA measurement system to be used to evaluate both SA and Team SA in Army C2 testing environments. Design and develop an initial prototype of a SA assessment and analysis tool that can be used to measure individual and team SA (at all three levels of SA), to determine if soldiers are actually obtaining the SA they need to support the tactical situation awareness and decision making required for their specific role & position, and are achieving appropriate levels of shared SA within and between teams at different levels of the echelon.

PHASE II: Develop and demonstrate a functional prototype of the SA assessment and analysis tool designed in Phase I. Conduct validation studies of the tool showing its ability to measure individual and Team SA, and demonstrating the utility of the data for evaluating candidate technologies in terms of their support for soldiers' critical SA information requirements in both stationary command posts and on-the-move environments.

PHASE III: DUAL USE APPLICATIONS: As situation awareness is critical for a wide variety of DoD operations, the SA measures developed through this program will have widespread applicability to many Army and Air Force as well as Navy and Marine Corps operations including. Such a system can be used to support evaluation of new system technologies, new training approaches and systems, and evaluating effectiveness of training received. Potential applications include remote battlefield command, control, communications, and intelligence centers, air-defense systems, and ship-board combat information centers. It will also be directly transitioned into Network Enabled Command Capability system evaluation plan for SA. Outside of the DoD, a real-time SA assessment tool has direct applicability to Homeland Defense and disaster relief operations as well.

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KEYWORDS: Situation awareness, command and control, real-time performance assessment, NECC, Cognitive assessment, Information technology devices

A08-059 TITLE: A psychologically inspired object recognition system

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Electronics, Human Systems

OBJECTIVE: To create an object recognition system based on the newer psychological models of object recognition by using a series of different algorithms to identify a variety of objects in different orientations. Such a system would be extremely beneficial for robotic control/intelligence and would allow for an exponential expansion of robotic capabilities and intelligence

DESCRIPTION: Recognizing and identifying an object from a video input turns out to be a very difficult problem. The problem stems from the fact that a single object can be viewed from an infinite number of ways. By rotating, obscuring, or scaling a single object, one can create multiple representations of an object - which makes the problem of matching the object to a database of objects very difficult. The problem expands exponentially when objects that need to be identified have never been viewed before. Combine these limitations with the wide variety of objects which might be identified, and the problem becomes intractable.
One solution is to study and understand how human beings recognize objects in the real world and duplicate that functionality in a series of algorithms. Recent research (Tarr and Bulthoff, 1995) has indicated that humans use not one algorithm, but multiple algorithms for the task of object recognition - depending on the object being recognized and the situation at hand. Specifically, research has shown that people use template based algorithms (i.e. similar to the database matching algorithms described earlier) in addition to Geon based (Beiderman, 1995) algorithms and feature based algorithms. These three algorithms are used in conjunction with a fourth algorithm, a contextual cueing algorithm, which limits the overall search space. Finally, human spatial memory is able to mentally rotate objects in order to match the object to different representations (Shepard & Cooper).

Therefore, a rotation algorithm would complete the set of algorithms. Geon based algorithms use specific shapes represented as simple forms in a template matching schema. For example, a “cup” could be represented in memory as a circular tube with a tubular handle extending from its side. Or a “tree” could be represented as a triangle for the leaves and branches, and a single tube extending from the bottom of the triangle to represent the trunk. This is similar to a template based matching algorithm, but the representations are more abstract. The abstract nature of the representations allows for a more general matching algorithm to be used. In addition to this algorithm, feature based algorithms would be used in conjunction with the Geon based algorithms. Feature based algorithms use features as rules to determine the identity of an object. For example, a tiger has stripes and a leopard has spots. The advantage of feature based algorithms is that they are especially immune to problems of rotation, scaling and obscurance. In other words, the key features of a leopard are still visible irrespective of the orientation or scaling of the object.

In summary, new research suggests that a system based on the Geon models used in combination with template and feature based matching systems and context specific filtering algorithms which can rotate objects offer a better solution to the object recognition problem than the use of simple template based systems.

PHASE I: Implementations of the system should be specific to the theories mentioned in this call, with an emphasis on the latest cognitive psychological theories of object recognition. The Phase I output should demonstrate a conceptual integration of the different stated algorithms, with details of the integration expounded. The Phase I process should show that, with further implementation, the system could "scale-up" and be able to recognize a wide variety of objects from a wide variety of viewpoints. Phase I documentation should include all aspects of hardware as well as software integration as well as the theoretical aspects of integration. Training of the system needs to be addressed in detail. An ideal system should be able to be trained by someone of limited experience or expertise with the system; however, this is not a necessary requirement.

PHASE II: Phase II will include full implementation of a prototype. Recognition rates should be above 95 percent for trained objects and be rotationally and scale invariant. Additionally, the prototype should be able to recognize objects and symbolically label objects that the system has never been previously exposed to (i.e. objects outside the training set). The prototype should use video input (VGA) into the object recognition system. The prototype should be further trained on a wide variety of objects to show the system's scalability to a database of a large number of items. The objectives outlined in the Phase I of the program still apply.

PHASE III: Produce a fully integrated system that can serve as a stand-alone system and can be tested in experiments to confirm the object recognition capabilities of the system. Recognition rates around 98 percent would be the preferred target. The system should be designed to be modular enough to allow for hosting on a variety of hardware platforms.

DUAL USE: Commercial applications for an object recognition systems would include robotic security systems, autonomous factory systems and robotic health care systems. Security systems which need to recognize approaching vehicles, types of vehicles, or improvised explosive devises (IED) would be vastly improved by using a object recognition system. Factory robotics systems and health care robotics systems could be advanced beyond current capabilities by an object recognition system which would allow autonomous systems to recognize and manipulate objects in a variety of different settings. The application of this object recognition work could be transferred specifically to these commercial industries as well as to the general field of commercial robotics.

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KEYWORDS: Object recognition, computer vision, sensors, target recognition

A08-060 TITLE: <u>Hearing Protection Evaluation System</u>

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To develop a Hearing Protection Evaluation System (HPES) that emulates the human head and its interaction with directional and non-directional auditory fields created by continuous and impulsive acoustic signals. The HPES shall allow for characterizing both earmuff- and earplug-type Hearing Protection Devices (HPDs) in both impulse and continuous noise environments across the dynamic range of human hearing. The HPES shall also emulate the effects of bone conduction sound transmission on hearing protection provided by the HPDs.

DESCRIPTION: Hearing protection devices are critical to the audiological fitness and mission safety of military personnel. Protecting a Soldier's hearing from temporary and permanent hearing loss will save lives, increase the likelihood of mission success, and reduce long-term disability costs. Selecting appropriate HPDs for a particular Military Occupational Specialty (MOS) and specific mission objectives requires the knowledge of real-world HPD performance in various noisy environments, including sounds produced by the Soldier's own weapons.

There is a large selection of hearing protectors to choose from. An important factor in choosing an HPD is the understanding of what level of protection it gives the user in military relevant environments. There are many HPDs on the market and in development and they are becoming more sophisticated with advances in technology. Hearing protection generally takes the form of either earplugs or earmuffs. Both types could employ active and/or passive means of noise reduction, and could be linear or level-dependent (nonlinear). Some hearing protectors are independent of other equipment and can we worn on their own; some are part of a Soldier's communication headset.

One of the more promising hearing protectors for Soldiers is an in-the-ear nonlinear HPD for which protection level depends on the level of the arriving sound. It protects against louder sounds to a greater degree than against quieter sounds. This nonlinear aspect of the hearing protector allows the user to better hear his or her environment and converse when lower, non-damaging noise is present. An understanding of the performance of these HPDs in both continuous noise and impulse noise environments is essential in determining appropriate and effective hearing protection for Soldiers. It is also important to compare the effectiveness of these protectors against that of other protectors that differ in their concepts and actual design.

Thorough, reliable, and mission-appropriate evaluation of HPDs, such as the nonlinear devices, needs sophisticated objective methods. Current evaluation depends heavily on laborious laboratory testing procedures using humans, such as determining the device attenuation at human thresholds of hearing (ANSI S12.6), and assuming linear attenuation across the intensity range. This assumption of linearity is often not true for "linear" HPDs at high sound levels, and is intentionally not true for level-dependent (nonlinear) devices. Another human-based evaluation procedure is to place small microphones in ears and measuring underneath the HPD to determine attenuation at many sound levels (ANSI S12.42); however, this is possible only for earmuff-type HPDs. Both of these methods therefore have serious shortfalls in capability, in addition to being very time-consuming and dependent on the availability of human subjects.

Although some Acoustic Test Fixtures (ATFs) are available for HPD research, none of them can provide all of the capabilities required in this SBIR. Available ATFs are somewhat capable of characterizing earmuff-type HPDs but have very limited or no capability to characterize earplug-type HPDs. Existing fixtures do not accurately simulate human ear canals down to the eardrum and do not allow for objective control of device fitting (fitting repeatability), both for earmuffs and especially for earplugs. The rigid walls of the fixture's acoustic coupler do not accurately simulate the sound reflective/absorptive surface of the ear canal, resulting in poor emulation of the effects of the ear canal on sound propagation, and which can cause sound leakage around earplugs. Hollow artificial heads used in some of the fixtures can resonate at higher noise levels making it impossible to tell if the attenuation data are valid or are the result of sound leakage from the fixture itself. Further, the hard outer surface of the device can affect the fit of the earmuffs around the simulated ear. Finally, existing fixtures do not take into consideration the effect of bone conduction as a source of sound leakage for the HPDs, which can be a significant shortcoming at higher sound levels.

The development of an HPES with the features desired in the SBIR is not a low-risk task. Recent advances in electronics (microphones, in particular), materials (such as skin emulators), and acoustics, along with the advances in HPDs which drive the need for such a system, create the possibility that such an HPES might be feasible. The developer must approach the multiple, sometimes conflicting requirements (such as the ability to operate in both high- and low-level sound fields) in an innovative way.

The goal of this SBIR is to develop an HPES which at a minimum meets the following characteristics:

- Accepts both earmuff- and earplug-type hearing protection devices
- Permits HPD testing in both continuous noise from 30 dB SPL (free field) to 125 dB SPL (free field) and for impulse noise up to 185 dB SPL at the ear
- Accurately models an average human head, neck, and shoulder area.
- Is equipped with realistic and replaceable pinnae that match human pinnae geometrically and mechanically.
- Emulates realistic ear canals, including morphology, surface texture, stiffness, coefficient of friction, and temperature.

• Emulates the impedance of the human eardrum in the audible frequency range up to 10 kHz.
• Provides realistic “skin-like” material around the ear (with sufficient coverage for earmuff testing) and in the ear canal (for earplug testing).
• Accurately models the bone conduction pathways or with sufficient self-insertion loss so that the flanking mechanical pathways are negligible and can be included in a post-measurement correction.
• Is easily maintained by the user in the field including replacement of pinnae, ear canal couplers, and microphones.

PHASE I: Development or selection of the mannequin morphology, skin materials, pinnae and ear canal design, and transducers and other electronic components. Rationale behind the selections and a model or description of the functionality of the HPES concept shall be provided. Monthly reports on the work accomplished and a final report on all the design specifications and Phase II recommendations will be delivered to ARL.

PHASE II: Construct a complete HPES mannequin. Evaluate the measurements obtained from the mannequin against others available (e.g., KEMAR, Institute of Saint-Louis (ISL), the ANSI earmuff block for earmuffs) using both earmuffs and earplugs. Validate the performance of the system versus human measures as described the ANSI standards S12.42-1995 (R 2004), and S12.6-1997 (R 2002). Demonstrate the maintainability of the HPES under laboratory conditions. Deliver a prototype HPES to the US Army Research Laboratory at Aberdeen Proving Ground, MD with all documentation, measurement data, and manuals.

PHASE III: There is a large well-agreed-upon need within the auditory research and commercial HPD development communities for a HPES which will allow characterization of HPDs in impulse noise in addition to continuous noise, and which can be used with earplugs in addition to earmuffs. Additionally, hearing aid developers, consumer audio electronics companies, and other market segments involved in any way with human auditory perception would benefit from such a device.

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KEYWORDS: Acoustic test fixture, hearing protection, noise reduction measurement.

A08-061 TITLE: Eyesafe laser diode arrays for resonant pumping of Er-doped gain media optimized for cryogenically cooled operation

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop high power 1530-1535-nm eyesafe laser diode arrays efficiency-optimized for cryogenically cooled (~80oK) operation. To be used as a pump source for high-power eye-safe cryo-cooled Er-doped solid-state lasers (SSL). This program requires diodes specifically designed for cryo-cooled operation - not just the test and measurement of room temperature diodes cooled to cryogenic temperatures. The manufacturing process must be scalable enough to show promise for line of sight (LOS) Directed Energy Weapon (DEW) applications.

DESCRIPTION: High power lasers operating at so called "eye-safe" wavelengths present much lower ocular hazards to friendly and noncombatant personnel than lasers emitting at 1 micron (1 um). 1-um laser wavelength shifting via stimulated Raman scattering is possible, but at the sacrifice of the overall laser system efficiency and additional heat removal complications. Recently, Er-doped crystalline SSL has proven to be highly efficient eye-safe source with direct laser excitation around 1530 nm [1-3, 5]. Moreover, it was shown that by cryogenically cooling the gain medium one can achieve significant boost in optical-to-optical efficiency as well as easy power scaling with good beam quality while eliminating significant overall design complexity [4]. Key components for operating these lasers most efficiently (in a resonant, ultra-low-photon-defect, "pump-lase" scheme) will be pump diode arrays, most likely InGaAsP/InP-based, operating in the 1530-1535-nm spectral range [3, 5]. So far cryogenically cooled Er-doped SSL's were pumped by room-temperature operated InGaAsP/InP diodes. It is known that aggressive cooling is much more critical for InGaAsP/InP diodes than for GaAs/AlGaAs ones because longer-wavelength efficiency is significantly lower and drops more rapidly with increasing temperature. Thus, (i), InGaAsP/InP-based devices can greatly improve their efficiency with cryogenic cooling, and, (ii) cryo-cooling of diodes in the laser system designed with the cryo-components in place for cooling the SSL gain medium itself does not present additional logistic hurdle. The latter stands only if the diodes are optimized for the same temperature (77-80oK) as the gain medium. In this case the system would enjoy significant benefits in power and overall efficiency, as opposed to the case whereby each component is optimized for a particular temperature range of operation. In the latter case, systems benefits are compromised, a high degree of system efficiency is lost, and operating complexity is greatly increased. With diode pump lasers designed to operate at ~77oK, the pump diode source can be integrated into the solid-state laser cooling system. So it is important that diode designs be optimized for this temperature, and not for the intermediate temperatures, like 130-170oK, where the diodes designed for room temperature would likely to have their maximum electrical-to-optical efficiency. Technical solutions resulting in reduced diode output beam divergence and output spectral width will be given a preference.

PHASE I: Eye-safe 1530-1535-nm pump diode array designs are sought which are efficiency-optimized for cryogenically cooled (~80oK) operation. We expect an effort that includes rigorous or phenomenological modeling, fabrication of at least one test array designed to emit ~50W, and thorough characterization of that device in a wide temperature range down to ~70oK. The design, modeling and characterization must take into account the variables of interest in the diode laser such as doping, optical and electrical loss mechanisms, heterojunctions, and thermal coefficients of expansion of the materials. Full characterization must include output spectral bandwidth and beam divergence versus temperature effects. Indicate through analysis or characterization the expected limits in performance of operation at 77-80oK. Design approaches incorporating micro-optics for diode array divergence conditioning are strongly preferred. A 1-cm 1D array, a best-effort device with a performance goal of ~50 W CW at cryo-temperature and target PCE at least 60%, shall be provided to the Army Research Laboratory for evaluation in cryogenically cooled Er laser setups.

PHASE II: Develop the design and model of the Phase I leading to optimal performance at the operating temperature of 77-80oK. Fundamental limitations to the efficiency and lifetime of the diode lasers should be experimentally and analytically determined. Develop lensing schemes for the diodes designed for operation at 77-80oK. Contractor will also address manufacturing aspects, producibility, cost and yield issues associated with the eyesafe laser diode arrays for resonant pumping of Er-doped gain media optimized for cryogenically cooled operation. Develop substantial technological process scalability and produce a microlensed 2-D 1530-1535-nm pump diode array with the target power of ~300W CW. Target wallplug efficiency should be >75%. Developed 2-D diode array should be delivered to the Army Research Laboratory for further testing and evaluation in cryogenically-cooled Er laser setups.

PHASE III: Clear advantages of laser diode arrays for resonant, ultra-low-photon-defect, pumping of Er-doped gain media optimized for cryogenically-cooled operation will result in higher eye-safe SSL overall efficiency, reduction in weight/size, much higher design flexibility and improved ruggedness - highly desirable for both military and commercial applications. The military has a strong interest in incorporating advanced eye-safe HEL's based on the resonant, ultra-low-photon-defect, diode-pumped operation of Er^{3+}:YAG into directed energy weapon systems. Current specific tasks would include laser-based remote mine clearing and counter-RAM (rockets, artillery, mortars) applications. 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.

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KEYWORDS: Cryogenically-cooled solid-state laser, Er^{3+}-doped materials, diode pumping, long-wavelength laser diodes.

A08-062 TITLE: Fully Flexible Information Electronics with a Flexible Display

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a demonstrator level fully flexible Information Assistant that integrates a flexible display, flexible electronic boards, and a flexible package.

DESCRIPTION: The Army has developed 4-inch diagonal flexible displays with improved performance to include ultra-low power, sunlight readability, low-night signatures as compared to conventional glass based Liquid Crystal Displays. The flexible display demonstrators enable new capabilities for the Soldier such as; Commanders Digital Assistants with ultra-low-power, rugged, sunlight readable displays, and/or stand-alone flexible displays with remote processors and electronics. The Army is developing flexible displays through the Flexible Display Center (FDC) at

Arizona State University based on; electrophoretic and cholesteric liquid crystal based reflective displays, as well as organic light emitting diode based emissive displays. The FDC is developing the display and tab-bonded drivers. The anticipated substrates will allow the displays to conform in 1-dimension to a radius roughly equivalent to a credit-card, however, further improvements in flexibility may be achieved. The FDC 4” diagonal displays have been integrated into a PDA (“Flexible-Display Development for Army Applications” D Morton and E Forsythe, Information Displays, Vol 23 pg 18 OCT 2007). The next generation displays will be up to 7” diagonal. The FDC is not developing the electronic functionality for an appliance or packaging the appliance for a specific application. This shortcoming is an opportunity for a small business to develop a fully flexible Information Assistant (FFIA) demonstrator that incorporates a flexible display.

PHASE I: Proposals are sought for a novel Fully Flexible Information Assistant (FFIA) using flexible displays. The program will not fund flexible display development. The FFIA shall have functionality that includes, human interface(s) (small key-board, touch screen, buttons, scroll), wireless communication, GPS, wired connections such USB, and a processor with sufficient memory to store and run Army applications. The FFIA shall integrate a flexible displays with a 6" diagonal or larger and color. The Phase I proposals are sought for novel configurations, power management, system electronic functionality packaged into a flexible form-factor. The flexibility is to be slightly conformal, with the intent to improve ruggedness to withstand an impact and/or dropping. The system configuration and packaging may have the display and electronics in a single package or the flexible display module separate from the flexible electronics package. The capability for both should be included in the proposal. The proposals shall include sufficient detail on system architectures and packaging to determine feasibility of designing, assembling and delivering (2) systems to the Army at the end of a Phase II effort. The detailed system specifications shall be refined with the Army including PEO Soldier-PM SWAR during the Phase I effort, such as the specific wireless interface (for example zigbee IEEE 802.15.3), commercial GPS module, operating system (for example Linux), wired interfaces, such as high-speed USB, and human interfaces. The package shall be, at a minimum, adequate for Limited User Experiments.

PHASE II: During Phase II, the electronics layout design shall be finalized with the Army. Based on the final design specifications, the contractor shall purchase the necessary hardware and related licenses to assemble the Fully Flexible Information Assistant (FFIA) and deliver (2) units to the Army. The contractor shall test and confirm that the system functionality is operational. The packaging shall be adequate for Limited User Experiments by the Army. The Contractor shall receive feedback from the Army on system performance. The Phase II deliverable shall also include quarterly reports and a final report along with the (2) FFIA units.

PHASE III: The Information Technology Assistant using flexible displays offer significant possible commercialization for novel display applications and other electronic devices. The military has a strong interest in incorporating flexible substrate based displays and electronics into advanced military systems.

This SBIR topic will support the Army's Flexible Display Center as well as the associated ATO-R: R.ARL.2008.03 "Flexible Display Technology for Soldiers and Vehicles" PM Eric Forsythe ATO-M: MAL2004-04 ARL AL "Flexible Display Manufacturing" PM David Morton.

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KEYWORDS: Flexible displays, Information Assistant, electronics.

A08-063 TITLE: Bi-functional anode and High Temperature Electrolyte Membrane for Reforming Methanol Fuel Cell (RMFC).

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Synthesize and characterize proton conductive high temperature membrane for making a reforming methanol fuel cell (RMFC), which contains a bi-functional anode for methanol reforming and hydrogen oxidation. The membrane must be highly conductive; chemically, electrochemically and mechanically stable; and operable at the temperature between 250 and 300 oC. The objective also includes development of a bi-functional anode for such RMFC.

DESCRIPTION: Reforming methanol fuel cell (RMFC) is a type of indirect methanol fuel cell, which first converts methanol into hydrogen with a methanol reformer; and then the hydrogen rich gas is sent to a hydrogen/air fuel cell to generate electricity. The process of methanol reforming must be carried out at 250 – 300 oC in order to obtain about 90% fuel conversion efficiency and 50% hydrogen concentration [1]. However, the state of art hydrogen/air fuel cell in the RMFC can work only between 160 – 180 oC. There is a mismatch of the operating temperatures between the fuel cell and the reformer. In addition, there are two subsystems in a common RMFC, where the reformer and the fuel cell are located separately. Therefore, many auxiliary components are needed for each of the subsystems. If only one or two components have a problem, the whole RMFC will not work. Furthermore, these components not only consume additional power and energy, but also increase the total system weight. Only about 40-50% energy efficiency can be obtained by reforming methanol to hydrogen, and about 50-60% of this energy can be converted from the hydrogen rich gas to electricity in the fuel cell. Therefore, the final energy efficiency is less than 30% in a traditional RMFC.

In order to lower the problems in the traditional RMFC, we propose to develop a RMFC with a bi-functional anode electrode, which consists of two layers. One layer's function is to reform methanol, and the other layer's is to catalyze hydrogen oxidation. The advantages of the RMFC with a bi-functional anode are: lighter weight, simpler system configuration, less problem and higher power and energy efficiencies. There is no heat loss between the methanol reforming layer and the hydrogen oxidation layer. However, the key technology for the RMFC with bi-functional anode relies on a high temperature electrolyte membrane that is highly ionic conductive at 250-300 oC. Recently, T. Uda et al [2] reported that a CsH2PO4 based solid acid gave a satisfactory ionic conductivity at the temperature up to 260 oC, which is very near to the satisfactory 300 oC. Here, we solicit better electrolyte membranes than the present solid acid CsH2PO4 and the better methods of processing the electrolyte membrane for making a RMFC with bi-functional anode.

The goal of the proposed technology is to fill the gaps between the current power technologies and the soldier powers for future force warrior (FFW). It will address high energy and high power sources for long term operation (Li-batteries can only operate for hours), for wide environmental temperatures from -40 to + 60 oC (PEMFC and DMFC can only work between 0 to +50 oC), for operation by any orientation (DMFC can not work by changing orientation), for safe operation by soldiers (Li- batteries have safety problems), for low cost (DMFC has much higher cost than RMFC), for high system power (RMFC has much higher system power than DMFC).

PHASE I: Demonstrate the feasibility of the innovative concepts of a combination of high temperature electrolyte membrane and bi-functional anode that is operable at the temperature between 250 and 300 oC. Phase I work includes synthesis, processing, and electrochemical characterization of the electrolyte membrane in a fuel cell with a bi-functional anode. Products of electrolyte membrane and single fuel cell should be delivered to the army for evaluation.

PHASE II: Develop methods of membrane processing, fuel cell stack fabrication, and electrochemical characterization for high power and high energy RMFC with bi-functional anode. Phase II work also includes to build a prototype RMFC system using high temperature electrolyte membranes and bi-functional anode electrodes. Phase II deliverables will include progress reports, an interim report documenting the prototype system, a final report, and the prototype fuel cell system.

PHASE III: Demonstrate the potential benefit of the high temperature electrolyte membrane for application in a methanol reforming fuel cell system with bi-functional anode. The RMFC system is operable continuously at the environmental temperatures between -40 and +55 oC. The system energy density should be 800 Wh/Kg for 72 hours operation; and power density should be 30W/Kg.

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KEYWORDS: Fuel cell, PBI, CsH2PO4, Solid acid electrolyte, Intermediate temperature electrolyte membrane, Fuel reforming, Power density, Energy density.

A08-064 TITLE: Utilizing Computational Imaging for Laser Intensity Reduction at CCD Focal Planes

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: Enhance overall force protection, allowing the Future Force to conduct decisive actions without disruption, by developing computational imaging techniques that protect CCD sensor systems from damage caused by frequency-agile, pulsed lasers operating within the bandwidth of the CCD imaging system.

DESCRIPTION: Computational imaging techniques have been successfully utilized as a new paradigm for designing imaging systems with previously unobtainable performance. Two such examples include making an imaging system invariant to focus-related optical aberrations and extending the depth of focus of imaging systems. In some computational schemes, the point spread function at the focal plane is modified, usually spreading it out. In other words the energy is redistributed. A laser beam, incident from infinity, would focus to a small point, and the resulting high fluence could damage a CCD focal plane. The goal of the topic is to develop a computational imaging scheme, which would most likely involve the design of an appropriate optical wave-front modulator and signal processing routines and hardware. The resulting system should not adversely affect the standard optical performance, but in the face of an incident laser, would spread the energy out across the CCD focal plane such as to reduce the susceptibility of damage by at least two orders of magnitude. The performance of the computational imaging system for laser protection should work across the operating spectrum of the CCD, typically 400-700nm. The signal processing must occur at least as fast as the frame rate of the CCD.

PHASE I: Design one or more candidate optical wave-front modulation schemes and demonstrate through the use of appropriate simulation software, the laser protection performance as well as the optical imaging quality of the representative CCD imager system. Identify the critical technologies for realizing this concept. Conduct analysis on the design to determine fundamental limits of performance. Phase I deliverables will be progress reports and a final report.

PHASE II: Optimize the design from Phase I. Develop an appropriate wave-front modulator device or devices, develop the image processing algorithms and demonstrate those algorithms interfaced though a computer connected to a CCD as a proof-of-principle. Perform characterization of proof-of-principle demonstrator, including maximum laser fluence attenuation, overall system modulation transfer function (MTF) and image processing speed. Optimize this demonstrator and then develop a small form factor, signal processing electronics package, either for insertion between the CCD and the image system display, or integrated onto a CCD. Phase II deliverables will include progress reports, an interim report documenting the proof-of-principle demonstrator, final report, and final optical system, protected from pulsed laser damage from wavelength agile lasers utilizing computational imaging techniques.

PHASE III: Potential Phase III military applications for this technology include laser safety devices for Mounted Ground System optical sensors, as well as for CCD imaging systems on manned aircraft, unmanned aerial vehicles and unattended ground sensors. Potential commercial applications include laser protection of security cameras for use in Homeland Security applications (perimeter security at airports, coastal ports, nuclear power installations) or other remote viewing scenarios where a pulsed laser could be used by criminals/terrorists to defeat security at range.

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KEYWORDS: Optical, computational imaging, coding, CCD, laser, damage, imaging, laser protection.

A08-065 TITLE: Desulfurization of JP-8 Fuel by Adsorption of Oxidized Organic Sulfur Compounds

TECHNOLOGY AREAS: Materials/Processes

TITLE: Desulfurization of JP-8 Fuel by Adsorption of Oxidized Organic Sulfur Compounds.

OBJECTIVE: Develop a process based upon the oxidative desulfurization method to remove sulfur-containing compounds from Army's fuel (JP-8). The system will supply desulfurized JP-8 fuel at 10 gram/minute (g/min) with sulfur content no greater than 10 parts per millon (ppm), which is a sufficient rate and purity to support a JP-8 fuel processor coupled with a 2 kilo Watt solid oxide fuel cell (SOFC).

DESCRIPTION: A potential solution to a variety of Army power needs would be solid oxide fuel cell based power systems, ranging from tens of W to tens of kW. Because SOFCs operate at high temperature, they can be fueled with H2 rich streams containing significant amount of CO, which may be supplied by reformation of JP-8 fuel. Catalysts in reformation reactors and in SOFCs are, however, poisoned by sulfur within the fuel, which necessitates a sulfur-removal step prior to feeding JP-8 to the fuel processor. The common high-temperature and high-pressure hydrodesulfurization technology practiced at the refinery scale is not feasible for the power levels described above and alternative approaches to eliminate sulfur must be employed. Recently, innovative methods have been demonstrated (1-2) to catalytically convert common sulfur-containing molecules in hydrocarbon fuel (e.g., thiophenes, benzothiophenes, and dibenzothiophenes) to a sulfone and/or sulfoxide, which offers a better way to remove these oxidized organic sulfur molecules, with increased polarity, by stronger adsorption on sorbent materials. The hydrogen peroxide and molecular oxygen were used as oxidants in these processes. In the case of hydrogen peroxide, a sonoreactor was employed to facilitate the oxidation reaction of organic sulfur molecules and achieved an effective desulfurization. In the case of molecular oxygen, it was demonstrated that Fe(III) was able to convert benzothiophene and its derivatives to the corresponding sulfones or sulfoxides that were adsorbed on activated carbon. Both processes were carried out at ambient temperatures and they are both worthwhile further research and development. Due to the simplicity and ambient operating conditions, the oxidative process has the potential to form the basis of a desulfurization system in the power range described above; however, there remain questions and issues that must be addressed to gauge its potential to fill this need for the military. For example, is it possible to further increase the reactivity of dibenzothiophene oxidation to sulfone by molecular oxygen at room temperature? In the ultrasound assisted oxidation process, polyoxometalate homogeneous catalyst, surfactant, and phase-transfer agent must be separated from the desulfurized fuel and recycled. Can these processes be performed in simple and compact hardware? Can a heterogeneous catalytic fixed-bed process be employed and thereby eliminate the need for (homogeneous) catalyst removal and recycle? The sulfone adsorbent should have high capacity and be either regenerated or replaced: which, if either, is to be preferred? Can hydrogen peroxide be generated in-situ by, for example, ultrasound-induced decomposition of water, as demonstrated by Hua and Hoffman (3)? These and other issues must be considered if a practical and sustainable oxidative reaction based desulfurization process is to be fielded.

PHASE I: Demonstrate that the oxidative process can be used to desulfurize JP-8 to 10 ppm sulfur. Develop and evaluate at the bench scale approaches to enable a practical oxidative desulfurization process such as heterogeneous catalysts, minimization of oxidant reagent needed, innovative phase-separation and recycling methods, etc. Present and discuss a design of a complete oxidative desulfurization based system to desulfurize 10 g/min of JP-8 fuel to no greater than 10 ppm sulfur, with a focus on size and weight of each unit operation in the system.

PHASE II: Design, construct, and evaluate a complete oxidative desulfurization based system to desulfurize 10 g/min of JP-8 fuel to no greater than 10 ppm sulfur. At the minimum, the system should not require maintenance for 500 hours of runtime. The (dry) system must be self-contained and person-portable. Deliver one complete JP-8 desulfurization system to the Army for evaluation testing.

PHASE III: Developments in fuel processing systems for fuel cells will have impact on a wide range of military uses as well as commercial power sources such as emergency medical power supplies, recreational power, etc…

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KEYWORDS: JP-8, desulfurization, oxidation, adsorption, catalyst, fuel reformation, solid oxide fuel cell.

A08-067 TITLE: Metamaterial Antennas for Army Platforms

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: This SBIR will investigate metamaterial enhanced antennas realized from printed geometries. Such antennas are needed to mitigate loading effects on the bandwidth and radiation patterns of antennas that are integrated into Army platforms as conformal or embedded structures - that is, the loading effects of the platform should be mitigated by the metamaterials. Primary frequency ranges of interest include HF, VHF, and UHF, but the work should not preclude higher frequencies.

DESCRIPTION: A basic Army systems objective concerns integration of antenna apertures into the body of platforms so that the antennas themselves are not visible. This need for integrated antennas as conformal or embedded structures is made difficult by the loading effects of the platform, as there can be pronounced effects on both the bandwidth and radiation patterns of the antenna. Additionally, the Army is moving in a direction that develops antenna apertures with the capacity to support multiple functions operating over a wide frequency range. Recent advances in artificially constructed materials (metamaterials) have shown promise of mitigating platform loading effects making it possible to develop conformal and embedded apertures operating over a wide frequency range [1] - [4].

Metamaterials represent a new class of materials that can exhibit electromagnetic properties not normally observed in nature. Historically, the realization of such materials was through resonant structures (such as split-ring resonators) or using transmission line approaches (e.g., through Composite Right/Left-Handed (CRLH) transmission lines).

PHASE I: Using metamaterials (preferably planar realizations), simulate enhancement of planar antenna structures that would be suitable for conformal or embedded integration into an Army platform and will mitigate platform loading effects on the antenna's performance. Show (through simulations) the capacity to scale the design for different frequencies on a baseline Army platform such as a Humvee at HF, VHF, and UHF. Frequencies of legacy communication systems are of particular interest(e.g., SINGARS, EPLRS.) Decision metrics for transition to Phase II will include demonstration of improved performance for the standpoint of bandwidth enhancement and possible size reduction as compared to a comparable antenna without metamaterials. For example, should a metamaterial patch antenna be the realization of the research work, simulations of an embedded patch array (or single element) with and without metamaterial enhancements should demonstrate such improvements. However, the research is not limited to patch antennas and remains open to other candidate designs.

PHASE II: Build prototype antenna(s) conformal or embedded to a flat sheet (metal or composite material) to demonstrate baseline enhancement versus the same design without the metamaterial enhancements. For example, a patch antenna (with and without) metamaterials at the EPLRS band integrated into, or conformal to, a sheet of material having a high dielectric constant (relative dielectric constant on the order of 10.) Demonstrated performance should be comparable to or should exceed the existing design (of a legacy antenna) from the standpoint of bandwidth enhancement and possible size reduction. Phase II deliverables will include progress reports, an interim report documenting the prototype system, a final report, and the embedded prototype delivered to ARL for validation.

PHASE III: Metamaterial antenna enhancements could be used in a broad range of military and civilian security applications where embedded antenna structures are desirable for aesthetic reasons or for meeting the needs of covert operations such as border checkpoints or intelligence operations. Metamaterials have been shown to demonstrate "electromagnetic cloaking." This feature could be used to mitigate co-site interference by conformal integrating metamaterials (frequency band appropriate) onto platforms having multiple antennas.

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KEYWORDS: Metamaterials, conformal, embedded, antennas.

A08-068 TITLE: Cold Spray Nanostructured Powders

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The Army seeks to utilize engineered agglomerates of hard, nano dimensioned particles in cold spray deposition applications for the development of reactive materials and structural components. Nanopowders have increasingly gained attention because of their potential incorporation in explosive and propellant mixtures [5,6,7]Research has shown that there is greater mechanical insensitivities and greater energy release rates being achieved for explosive and propellant formulations designed with smaller particle sizes [5,6,7] The ignition of energetic materials is also increased by the use of nanoparticulates which react fastest compared with coarse particle mixtures, standard B/KNO3 and black powder [6].The demonstration of a method for the production of these powders that can be utilized in the cold spray process, with the potential for commercial production is desired. The cold spray process has been demonstrated to be able to consolidate reactive powders into structures that are of significant importance to the Army and DOD, such as Shaped Charge Liners and are in the process of being incorporated into other weapons systems as well. The use of nanopowders that can be utilized in the Cold Spray Process will increase the effectiveness of these weapon systems and allow the consolidation of nanopowders into structural bulk materials.

DESCRIPTION: There is a need by the Army and DOD to incorporate nanocrystalline materials into reactive material formulations and to subsequently be able to consolidate these materials to form structural reactive materials. The cold spray process can offer the means of consolidation with improved performance over conventional powder metallurgy techniques (this has been proven) , but cannot accomodate nanosize particles. The consolidation of powders by cold spray results in structures in which the original characteristics of the powder particles are not altered by melting. Hence, particles retain their characteristic dimensions and do not undergo phase transition as a consequence of consolidation into a structure. Unfortunately, nano-dimensioned individual particles cannot be aerodynamically impacted due to negligible momentum. This problem can be resolved through the use of agglomerates of nano-dimensioned individual particles of 5 micron diameter or greater. The individual particles then retain their characteristic nanometer scale dimensions within the deposited structure and can be utilizedin the cold spray process.

The agglomerated cluster of nano-scale particles must be robust enough to survive aerodynamic acceleration forces of the cold spray system intact. It has been found that nano dimensioned ceramics contained in a metal binder yield coatings of extreme hardness as predicted by the Hall-Petch Relationship. Ceramics such as WC, ZrO2, and VN have been used in this way. The Army seeks to utilize engineered agglomerates of hard, nano dimensioned particles in cold spray deposition applications for the development of structural components, reactive materials, hardened armor and the protection of wear surfaces. Successful deposition by cold spray requires a binder to be incorporated into the agglomerates.

PHASE I: Develop a scalable process for production of metal powders with controlled sizes (~0.020mm-0.200mm) and shapes (e.g. varying aspect ratio platelets, equi-axed, needle-like) with nanocrystalline and/or UFG microstructures with an adequate binder material that will serve to allow the powder to be utlized in the cold spray process and not significantly detract from the mechanical and physical properties.

Demonstrate and verify methods for production of metal powders of controlled morphology (size and shape), and with UFG/nanocrystalline microstructures in a variety of materials (e.g., Al and Al alloys, Ti and Ti alloys). The Phase I effort should result in the production of a laboratory batch of a nanocrystalline powder.

PHASE II: Construct a prototype system capable of producing nanocrystalline powder on a production scale based upon the results obtained in Phase I. Establish quality control protocols for high-volume powder production to include; raw material requirements, special handling and preprocessing, controlled morphology (size and shape)and rate of production. Test and evaluation of the nanocrystalline powders will be conducted and include; optical and electron microscopy, chemical analysis, density measurements and x-ray diffraction. Laboratory batches of powder will be supplied to ARL for consolidation by the cold spray process. This along with the aforementioned analytical techniques will be used as a means of evaluating the powders produced.

PHASE III: Transition technology to commercial applications with the fabrication of a large-scale production unit capable of producing nanocrystalline powders in quantities of at least 100lbs/day. The cold spray process can be used to consolidate nanocrystalline powders for a variety of very important Army, DOD and commercial applications with improved performance over conventional ingot metallurgy, powder metallurgy, thermal spray and other state-of-the-art consolidation techniques, which is the basis of this proposal. Researchers at ARL have been attempting to find a process that can produce a nanocrystalline particle with controlled sizes (~0.020mm-0.200mm) and shapes for use in the cold spray process, especially to produce very reactive structural energetic materials. Particles smaller than one micron are not conducive to the cold spray process.

The consolidation of nanocrystalline powders has been shown to improve the reactivity of energetic materials such as those that are being investigated by the Army as part of the 'Enhanced Lethality Program'. Specific applications of reactive materials are projectile bodies (these have been produced by cold spray at ARL in FY06 but without nanocrystalline materials). In addition, this technology can be used in the fabrication of special munitions that can be used to defeat land mines and improvised explosive devices (IED). These powders can also be used to produce erosion resistant coatings for rails and armatures in support of the EM Gun Program. Commercial applications are numerous, including wear resistant coatings for brake pads, compressor blades, turbine blades, leading edges of rotor blades, drill bits, cutting tools, lawn mower

The proposed topic is to produce metal powders with controlled sizes (~0.020mm-0.200mm) and shapes (e.g. varying aspect ratio platelets, equi-axed, needle-like) with nanocrystalline and/or UFG microstructures. These size particles will be able to be cold sprayed into reactive materials. Therefore, the concept is to have micron size particles that consist of nanograins so that they are able to be cold sprayed. The nanoparticles will be more highly reactive than micron size particles. In addition, these paticles can be incorporated into other applications. High performance coatings and bulk consolidates are integral for a variety of U.S. Army applications, including munitions, penetrators, armor, as well as ground and tactical systems, wherein materials are subject to severe operating environments. These powders can be used to produce high strength, wear-resistant/protective coatings and bulk consolidates with controlled morphology (size/shape) and UFG/nanocrystalline microstructure, using low-temperature spray and consolidation protocols, such as cold spray. It is well-established that metal alloys having UFG or nanocrystalline microstructures exhibit strength and hardness significantly greater (~2 times or more) than those of conventional materials. Furthermore, metal powders with tightly controlled morphologies offer unprecedented scope for realizing high-density coatings and bulk consolidates with superior structural integrity and bonding. A major barrier to realizing these applications is lack of large-volume production methods that can create powders with tightly controlled size and shape, while ensuring UFG/nanocrystalline microstructures in a variety of metals (e.g. Al and Al alloys, Ti and Ti alloys). This effort will advance the science and technology involved in commercial production of high performance powder metals, which is critical to transitioning the technology for army applications.

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KEYWORDS: Nanopowders, nano-structured materials.

A08-069 TITLE: Scalable & Adaptive Munitions Technologies

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To discover and develop innovative novel structural energetic materials for advanced munitions that will provide the weapons capability for scalable and adaptive lethal effects against platforms and personnel and to selectively destroy target function and/or neutralize attributes while limiting damage to surrounding structures/personnel.

DESCRIPTION: Ground forces conducting military operations in complex environments including urban, mountain, desert and wooded terrain currently do not possess the full flexibility and scalability of weapons that concurrently: (I) enables rapid overwhelming defeat and (II) minimizes collateral damage and noncombatant casualties. Radically new materials technologies are needed to develop new generations of weapons materials that allow a munition to adapt and scale its response to specific targets and desired effects.

Reactive materials represent an emerging technology of enormous importance to the DOD that can provide revolutionary enhancements to munitions lethality, effectiveness, safety, and survivability for broad applicability in weapons. However, new generations of materials are needed that have properties that greatly exceed what is currently available. Key to this endeavor will be the technical pursuit of innovative, leading-edge materials that may be used as dense, ultra-high strength Structural Reactive Material munitions cases (artillery projectile, mortar, bomb) that replace currently used inert steel. Conceptually, the reactive material case would become an integral part of the overall munitions structure that has the same strength as steel, but can also adds large amounts energy. These cases could be selectively fragmented to control the size, shape, and mass of the reactive fragments; selectively provide directional/mass focusing reactive fragments and effects that optimize precision, coupling, and scaling effects to the target; or selectively the reactive case is consumed in the explosive event producing no fragmentation, but adding tremendous energy as blast. The integration of structural reactive materials warheads will permit scalable and tailorable penetration, blast, and fragmentation when used in urban environments. These materials have the potential to double catastrophic kill radius in other applications such as self-defense applications and provide improvements in recognizable kill of surface targets.

The overarching technical challenge is to discover new types of reactive materials that have multi-functional properties such as carrying structural loads. The development of these new materials will include the understanding of (1) fundamental material, constitutive, and failure properties of selected formulations in the appropriate strain rate regimes and time/length scales, as a function of metal type and particle size; (2) the effects of intrinsic and constitutive properties to control phenomena such as shear banding, localized heating, diffusion, mixing, and onset of failure; (3) physics and chemistry leading to energy release; (4) how these and other phenomena control energy release rates and partition into thermal and mechanical energy; (5) methods to dynamically control fragment size; (6) new processes for forming the materials and understanding their manufacturing characteristics and producibility; and (7) numerical modeling to describe and predict properties.

It is envisioned that this new technology will not impose constraints on mission performance nor increase burden on supportability in operational, environmental, storage, maintenance and transportation. It is anticipated that the agility and multi-mission weapons capabilities developed under this program will lead to fewer and less munitions required. This new technology would provide: enhanced system performance and effectiveness in smaller envelop, capability to focus energy to target (mass focusing and directional fragmentation and blast) and reduce collateral damage, new kill mechanisms (multi-purpose munitions), and small weapons for MOUT and complex terrain.

PHASE I: Discover, define and design concepts for dense, high-strength reactive material cases and structures that can provide scalable and adaptive effects. It is desirable that these materials should have properties characteristics in terms of three primary metrics: compressive yield strengths 30+ ksi), density (7+ g/cc), and chemical reactivity (10+ kcal/cc). Desired materials shall have the aforementioned properties concurrent with the ability to scale energy release in time (up to 20 ms) with >75% complete energy release at kinetic energy impact velocities of 2 kft/s in order to address scalable effects from lower ordnance-speed applications.

PHASE II: Fabricate and test prototype materials to validate performance and applicability. Evaluation tests will be conducted at the contractor's facility as well as at an Army Research facility. Test samples will be accessed using various mechanical testing to evaluate material properties such as yield strength, hardness, and reactivity (dynamical testing using kinetic energy launch), and time and mass-dependent chemical energy release, including blast pressure and quasi-static pressure. Perform analysis addressing affordability, producibility and manufacturability plans for new materials.

PHASE III: The developed technology will be rapidly inserted into Army ATO program STAR – “Scalable Technology for Adaptive Response” and transitioned to PEO-AMMO, PM-MAS, PEO-Missiles & Space, DARPA, and acquisition programs of record (FCS, Excaliber). Technology will also be jointly integrated into Navy (Office of Naval Research), DTRA, and Air Force (Eglin Air Force Base Munitions Directorate) munitions programs, and also commercialized. Commercial products include the full spectrum of munitions from ordnance manufacturers.

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KEYWORDS: Scalable, adaptive, controlled fragmentation, reactive materials.

A08-070 TITLE: Full Field, Out-of-Plane Digital Image Correlation (DIC) from Ultra-High Speed Digital Cameras

TECHNOLOGY AREAS: Information Systems, Materials/Processes

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

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

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

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

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

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KEYWORDS: Digital image correlation, ballistic, high rate.

A08-071 TITLE: <u>Self-decontaminating materials using organocatalysts</u>

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

OBJECTIVE: Develop improved materials to detoxify chemical warfare agents (CWAs) by a catalytic reaction at ambient temperature.

DESCRIPTION: Current chemical decontamination protocols are labor intensive, impose a high logistical burden and make it difficult to maintain operational tempo. An ideal solution would be a coating or fabric that decontaminates chemical threat agents upon exposure without the need for additional reagents or energy input. The active component must be safe for personnel and environmentally benign, and must not alter the critical properties of the original coating or fabric.

Recent developments have demonstrated that catalytic reactions at ambient temperature can decontaminate the classical chemical warfare agents (CWAs). These catalysts are being incorporated into protective coatings and fabrics. However, current catalysts require metals in the active site, either in traditional metal/ligand structures or in enzymes such as organophosphorus hydrolase (OPH). Research has shown that some metal-free, all-organic molecular assemblies produce very active catalysts. The objective of this topic is to develop improved decon catalysts through this approach.

Of known catalytic materials with simple structures and low molecular weight, the amino acid proline has been identified as the simplest enzyme. This five-carbon molecule catalyzes aldol condensations and other reactions. A range of simple peptides, containing between two and ten amino acids, had been shown to catalyze a variety of organic reactions. These organocatalysts are generally robust, produced from readily available and inexpensive components, non-toxic, and tolerate a range of environmental conditions (e.g., heat) and materials (e.g., sulfur) that can deactivate traditional catalysts.

Among highly reactive decontaminants, hypohalite ion is noteworthy in catalyzing hydrolysis of the G-agents. Therefore, in pursuing "better, faster, cheaper" decon solutions, one tactic would be to target a stable catalyst with the same high activity, low formula weight, and low cost as hypohalite. As an alpha-effect nucleophile, the activity of hypohalite results from the combined electronic contributions of the adjacent halogen and oxygen. This example illustrates that the appropriate arrangement of electron-withdrawing or -donating groups essential to catalysis need not require a large and complex structure. Note that this topic focuses on stable catalysts; reactive materials such as hypochlorite are not responsive.

Research in this topic will therefore identify a small organic molecule, including but not limited to polypeptides, that can detoxify CWAs by a catalytic reaction at ambient conditions. This organocatalyst can then be incorporated into coatings or fabrics to produce self-decontaminating materials.

PHASE I: Develop one or more new non-metal-containing, low molecular weight organocatalysts that detoxify the classical CWAs under ambient conditions. Characterize the catalytic activity of the molecule in tests with CWA simulants.

PHASE II: Scale up production of the organocatalyst to the kilogram scale and demonstrate methods to incorporate it into coatings or fabrics without altering the critical properties of the original coating or fabric. Demonstrate the activity of the catalyst and test with live CWAs with a 10g/m2 challenge. Removal and destruction of 99.999% of the agent should be achieved. Test the durability and stability of the new catalytic coating or fabric under the expected environmental conditions. The catalyst must maintain activity in the presence of water and in a temperature range of -25 to 100?F.

PHASE III: The self-decontaminating material will have applications in the military, domestic preparedness (Homeland Security, emergency responders) and in the agricultural industry for decontamination of phosphonate pesticides.

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KEYWORDS: Organocatalysts, decontamination, chemical warfare agents

A08-072 TITLE: <u>A 250-W Solid Acid Electrolyte Fuel Cell Generator</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop a hydrocarbon-fed, solid acid electrolyte fuel cell generator that does not require water maintenance and operates between 200 and 400°C. The person-portable power system must produce 250 W (net) for use as a battery charger.

DESCRIPTION: The Army has need for compact electrical generators in the 200-500 W level for use as squad-level battery chargers. The energy requirements for battery charging will require a power supply fed with an energy-dense liquid hydrocarbon fuel. Reformed or direct-methanol proton exchange membrane fuel cells (PEM FCs) are candidates to fill these needs, but the polymer electrolyte membrane must be hydrated for proton conductivity, which adds the complexity of a water-management subsystem to the power generator and limits the cell operation temperature to approximately 80°C or lower. Additionally, because hydrocarbon reformers produce carbon monoxide as co-product with H2, a CO-removal subsystem is needed so as not to poison the fuel cell electrodes, which also adds additional weight and complexity to the generator. Higher temperatures (> 120°C) of the cell would be advantageous in that heat-transfer characteristics of the cell stack improve and CO poisoning of the electrodes is not a concern. Certain classes of solid acids (e.g., CsHSO4 or CsH2PO4) are proton conductors that have recently been demonstrated to function as effective electrolytes at temperatures 200°C and higher (1-4). These materials have been incorporated as combination electrolyte/separator in laboratory-scale, single-cell fuel cells fed by H2 or methanol (5). It is unknown, however, if a practical fuel cell generator can be built around this intermediate-temperature class of proton conducting electrolytes. The presence of liquid water in the cell (at start-up or shut-down) is problematic since the solid acids may dissolve, and the interfacial electrode-electrolyte impedance in the solid acid electrolyte cells is a challenge. The temperature of the solid acid cells, on the other hand, presents the intriguing possibility for direct electrochemical oxidation of simple hydrocarbons and/or in situ reforming. These and other issues must be addressed to determine if a power system can be built around a proton-conducting solid acid electrolyte and provide the power needs for a compact battery charger.

PHASE I: Design, construct, and evaluate a hydrocarbon-fed, intermediate temperature (200-400ºC) single-cell fuel cell that uses a solid acid electrolyte and evaluate a multi-cell stack (minimum four cells) based upon these results. Include at the bench-scale all control and ancillary subsystems required to produce power from the multi-cell stack. Polarization characteristics (voltage vs current and power density) of the cell and cell stack should be reported, as well as interfacial impedance trends of the electrolyte-electrode interface. Provide a detailed conceptual design of a 250-W (net) power system based upon the results generated in these efforts.

PHASE II: Design, construct, and evaluate a 250-W generator based upon the solid acid electrolyte and hydrocarbon fuel studied in Phase I. The power system must be person portable and as compact and lightweight as technologically feasible. Assess cost and manufacturability of demonstrated technology.

PHASE III: Developments in fuel cell power sources in the 250-W range will have immediate impact on a variety of commercial applications for auxiliary power units such as recreational or medical emergency equipment.

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KEYWORDS: Fuel cell, proton conductor, solid acid electrolyte, soldier power

A08-073 TITLE: <u>Hydroxyl Exchange Membrane Fuel Cell</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Design, construct, and evaluate a compact 20-W fuel cell power system for the dismounted warrior that uses a hydroxyl exchange membrane fuel cell and includes all balance- of-plant auxiliaries. The compact fuel cell power system must be energy dense (> 1 kWh/kg) and supply 1.4kWh of energy.

DESCRIPTION: Proton exchange membranes (PEM) are the proton-conducting electrolyte in low-temperature (<80ºC) fuel cells (FCs). PEM FCs are being examined for DoD applications spanning power demands from mW to kW and are a candidate compact power system for the dismounted warrior. The acid environment of the PEM requires noble metal electrocatalysts, which increases lifecycle costs and presently limits fuel choice to hydrogen or methanol. In addition, water-management issues arise because of electroosmotic pumping of water from anode to cathode; consequently, care must be taken in design and operation of the PEM FC to avoid dry-out conditions at the anode or flooding at the cathode. In principle, a hydroxyl exchange membrane (HEM) as a hydroxyl-conducting electrolyte would improve FC performance over state-of-art PEM FC technology and alleviate these problems (1, 2). The potential advantages and challenges of HEM FCs have been summarized recently (2). For example, non-noble (low-cost) electrocatalysts can be employed in both electrodes of an HEM FC, with an improved energy efficiency because of lower anode (fuel) and cathode (air) overvoltage; cathode flooding is less problematic; more complex fuels other than hydrogen or methanol may potentially be employed since C-C bond breakage is more facile in alkaline environment; etc … Challenges facing HEM FCs include the need to ensure carbon dioxide uptake into the HEM does not result in reduced ionic conductivity; chemical, electrochemical, and thermal stability of the HEM under FC operating conditions; etc…

Alkaline fuel cell technology has been described as a viable alternative to PEM FCs for transportation applications (3, 4), but it has not been systematically explored for portable power applications. A recent assessment based upon published information of ambient-air PEM and alkaline fuel cell technologies at the 7-kW level concludes that the two power technologies are of similar cost (1). It is undetermined, however, if HEM FC technology can be implemented in a compact low-power (20 W) system that has sufficient resilience to carbonate build-up inherent in an alkaline electrolyte exposed to carbon dioxide from air at the cathode or from deep oxidation of carbon-containing fuel at the anode.

The intent of this topic is to assess the viability of using a hydroxyl exchange membrane fuel cell as the power converter in a compact power system for the dismounted warrior. Because the balance-of-plant equipment that supports a HEM FC may differ from that required in a PEM FC power system, the choice and design of the balance of plant is an integral component of the topic.

PHASE I: Design, construct, and evaluate an air-fed, ambient pressure, multi-cell, hydroxyl exchange membrane fuel cell stack at nominal 5-W level using contractor's choice of fuel other than hydrogen (but selected within bounds of safety and cost considerations). Report stack polarization behavior (voltage and power density as a function of current density); measure and report fuel utilization; determine and correlate stack performance with relevant operational parameters; discuss stack scale-up issues to 20-W level, with attention given to balance-of-plant components.

PHASE II: Design, construct, and evaluate a 20-W (net) hydroxyl exchange membrane fuel cell system based upon the membrane type and fuel studied in Phase I. The system should be compact and energy dense (> 1 kWh/kg) and supply 20 W over a three-day mission. All balance-of-plant components must be contained in the system, including a cartridge-fed fuel subsystem to enable 24-h operation. Demonstrate sustained operation over 500 h including start-stop cycles.

PHASE III: Developments in fuel cells will have significant impact on a wide range of military uses as well as commercial power sources such as computer power, emergency medical power, recreational power, etc…

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KEYWORDS: Alkaline exchange membrane, fuel cell, compact power, soldier power.

A08-074 TITLE: Development of a Fieldable Brain Trauma Analyzer System

TECHNOLOGY AREAS: Biomedical

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

OBJECTIVE: To develop and field test a diagnostic system for quantitative assessment of cortical function which would be non-invasive, innocuous, rapid, portable, low-cost and easy to use. The instrument should be able to quantify sub-clinical traumatic brain injury (TBI) based on intracortical connectivity dynamics. The instrument could be used for pre-screening warfighters to establish baseline data, then post-screening blast exposed warfighters to assess TBI and for tracking of cortical connectivity to measure the effectiveness of medical treatment.

DESCRIPTION: The ability to assess closed skull brain function and dysfunction post exposure to blast is currently limited either to obvious anatomical changes visible on scans, severe derangement of electroencephalogram patterns or overt acutely observed behavioral changes. In many cases, the diagnosis is one of exclusion only, i.e. nothing else is wrong therefore the symptoms must be due to minimal traumatic brain injury (mTBI), especially since the behavioral changes may take weeks to develop, complicating return to duty decisions. Very recent advances in neurophysiology allow the use of non-invasive techniques to assess cortical functional connectivity. The published scientific literature suggests that neurological diseases including autism, schizophrenia, Alzheimer's, and ADHD are similar to altered cortical function resulting from mechanical trauma – such as that resulting from a non-penetrative blast – because these all are hypothesized to involve derangement or damage to the underlying cortical network, but without overt bruising or other visible changes. In particular, the fundamental building blocks of the cortex are changed in such a way as to limit the functional connectivity within and between these fundamental components of cortical circuitry (cortical columns). The ability to distinguish any sensory input as being from 2 separated sources rather than appearing to be merged as one depends on directly intact intra-cortical connectivity since this discrimination is a measure of the interaction between specific local stimuli within the cortex, and has been mapped directly to known brain structures at risk in mTBI. As an example, one of the more direct modalities to address the intactness of neural connectivity can be based on the somatosensory system, i.e. the discrimination of touch, and especially 2 point threshold discrimination. Other sensory modalities are also dependant on intracolumn connectivity, e.g. vernier hyperacuity in vision; however, touch is easy to process, available wherever there is intact innervated skin, is not limited to specific, possibly compromised special sense organ locations, and seems to have a preferential path to consciousness, as demonstrated by the haptic annunciator systems currently being considered for deployment. Since the disturbance in connectivity can be evaluated quantitatively and objectively via a sensory pathway that requires minimal cognitive effort, a fielded device based on somatosensation may provide critical data for mTBI diagnosis, although implementation in other modalities will be seriously considered. Dual use applications in civilian neurotherapy and neurophysiological research will open the technology to a wider market.

PHASE I: (Feasibility Study) Develop a diagnostic system that can be bench-tested and verified in a university hospital setting, quantitatively assess control vs. concussed and other minimally brain injured patients selected from the university sports community and other volunteers, and based on the results, submit a plan to optimize the interface, readouts and threshold criterion points for diagnosis of normal and abnormal brain function.

PHASE II: (Prototype Delivery) Year 1: The device will be refined based on the phase 1 results and implemented in hardware as an integrated portable unit. At least one such unit will be constructed and taken to an Army and/or VA hospital to be tested with actual mTBI patients for utility and evaluated for usefulness in diagnosis and management, including return to duty decisions by the military medical community.
Year 2: Based on the initial hardware implementation and further advanced testing, optimization, evaluation, and product design, at least one test unit will be prepared for possible deployment OCONUS to an active Army medical unit to determine its suitability as a fieldable device for the diagnosis of acute mTBI suspects.

PHASE III: (Transition) The finalized system will be ruggedized and optimized for manufacturing in quantity and transitioned to the field in conjunction with the Army Medical Research and Materiel Command. Simultaneous transition to civilian neurology clinics and university neurophysiological research departments will also be explored.

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KEYWORDS: Brain, injury, cortical processing, sensory processing, return to duty, two point discrimination, human, TBI.

A08-075 TITLE: <u>Terahertz Intracavity Spectrometer</u>

TECHNOLOGY AREAS: Chemical/Bio Defense

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

OBJECTIVE: To develop and demonstrate an intracavity terahertz (THz) laser spectrometer with an extremely sensitive molecular recognition capability and apply this technology towards the spectral sensing of very low-concentration chemical gases, biological aerosols and explosive vapors.

DESCRIPTION: Rich absorption spectra in THz frequency range caused by a combination of rotational, torsion and vibration transitions create unique spectral signatures for every material. This makes the terahertz part of electromagnetic spectrum ideal for molecular recognition applications [1-8].

Vapors are detectable if they provide noticeable absorbance on the path of the probe beam. Traditional THz spectroscopic methods utilize an effective path no longer than 1-20 meters, and thus, are unable to recognize vapors and gases with partial pressure of 10-2 Torr or lower (estimated for typical absorption cross-sections of vapors in terahertz frequency range). Hence, detection of the substances with low saturated vapor pressures, such as most of explosive compounds, becomes difficult or impossible in the frame of traditional spectroscopic methods.

A novel method of terahertz spectroscopic identification of explosive compounds, gases and vapors can be based on intracavity terahertz laser spectroscopy. Sensitivity of the intracavity laser method is many orders of magnitude higher than that of more traditional spectroscopic techniques and ideally may reach single molecule resolution. Therefore, development of this molecular recognition method will create new possibilities for identification of weak concentrations of vapors of explosives, harmful biological and chemical agents, and violate organic chemicals based on their THz spectral signatures.

Intracavity laser spectroscopy is well known for infrared and visible laser physics, but has not been previously applied for gas and vapors sensing in the terahertz frequency range (i.e., approximately 0.3 to 3 THz). Recently, the first application of the intracavity laser spectroscopy at terahertz frequencies for diagnostics on semiconductor samples was successfully demonstrated using the hot hole p-Ge terahertz laser [9,10]. Hence, this work motivates a full investigation of this sensitive technique for the spectral characterization of gases, aerosols and vapors, and an assessment of the effectiveness of this technology in defense and security threat detection applications.

PHASE I: In Phase I, intracavity laser designs and associated semiconductor laser structures and materials should be investigated. This phase of the work should produce modeling and simulation results that suggest the optimum engineering parameters and design approachs to a future hardware demonstration. It is also expected that this will be accompanied by preliminary experimental measurements that support the feasibility of proposed spectrometer design and that identify specific spectral ranges that will be used to sense a set of prescibed target agents.

PHASE II: In Phase II, a full prototype intercavity laser spectrometer should be implemented and demonstrated in a defense and security relevant sensing applications. Here, the instrument should be applied to collect THz-frequency spectral signatures from an array of low-concentration threat agent targets (i.e., from some subset of chemical gases, biological aerosols and explosive vapors). A prototype trace-gas sensors based on one or more THz laser designs with open cavity should be manufactured. For example, techniques employing terahertz quantum cascade lasers and p-Ge lasers might be utilized in this effort.

PHASE III: Developing and demonstrating of prototype THz intracavity sensor systems will allow for widespread applications in sensing and unambiguous identification of explosive compounds and hazardous chemicals (for DoD), and real time monitoring of violate organic compounds in human breath for medical diagnostic. This technology would support an array of chemical, biological and explosive sensor programs flowing out of the U.S. Army Edgewood Chemical Biological Center (ECBC), the U.S. Defense Threat Reduction Agency (DTRA), and the U.S. Navy Explosive Ordnance Disposal (EOD), just to name a few.

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KEYWORDS: Terahertz, laser, spectroscopy, chemical, biological, explosive, medical diagnostic, manufacturing materials and coatings

A08-076 TITLE: Nano-composite Semiconductor Lasers

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: Develop solid state lasers, operating at an eye-safe wavelength, based upon nano-composite, wide bandgap semiconductors for enhanced Army capabilities of infrared countermeasures, optical communications, and force protection.

DESCRIPTION: There is high interest in the development of eye-safe, high power laser systems for multiple DoD requirements. In particular, high power laser systems can provide speed-of-light engagement for missile defense leading to enhanced battlefield survivability and protection. The Army is the lead Service for developing solid state lasers for ground-based missile defense. In recent years, researchers in Japan have developed polycrystalline dielectric ceramics that for use as a new type of laser gain medium [1]. These materials have been shown to have superior performance compared to single crystals in prototype high power laser systems [2]. Since these ceramic materials can be processed at temperatures about several hundred degrees below their melting points, novel materials can now be synthesized into laser gain media. In addition a variety of shapes, in large area, and higher dopant concentrations higher than those in single crystals can be achieved. One of the major issues encountered with high power lasers is management of the heat generated during lasing. Whereas dielectrics have poor thermal conductivity, wide bandgap semiconductor materials, such as GaN or SiC, have values of 1-2 orders of magnitude higher. The semiconductor materials can provide enhanced thermal management to enable generation of high power laser systems required by DoD. Several research groups have already produced nano-scale GaN powders doped with different rare earth elements, including Er [3], that can lead to lasing.

PHASE I: Nano-scale powders of a wide bandgap semiconductor, doped with a suitable rare earth element, such as Er or Tm, are to be produced. Characterization is to verify sub- micron size of the powders, uniform particle distribution, and low levels of unwanted impurity concentrations. Efficient optical emission, at an eye-safe wavelength, from the powders is to be demonstrated. Technical pathways leading to the consolidation of the powders into bulk ceramic forms for lasing are to be specified.

PHASE II: Semiconductor nano-powders, doped with Er or Tm, are to be optimized and consolidated into bulk ceramic forms, such as disks or slabs. The ceramic forms must exhibit optical transparency, greater than 80%, at eye-safe wavelengths. Experiments are to demonstrate lasing in the ceramic media. Phase II proposals should specify methods for scaling up the production of the powders and consolidation into bulk forms at reasonable cost and with good reproducibility.

PHASE III: This effort will produce compact, eye-safe lasers, capable of high output powers with good beam quality and narrow-line continuous wave emission. Investigations are to demonstrate the power-scalability for military applications including infrared counter-measures, free space optical communications, and high-power laser defense. The same technology will find civilian applications in welding and telecommunications.

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KEYWORDS: Solid state lasers, an eye-safe, nano-composites, semiconductors

A08-077 TITLE: Large Area, High Power Ultraviolet Light Emitting Diodes

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop deep ultraviolet light emitting diodes having high quantum efficiency, long device lifetime, and large emission area to make usable for force protection objectives of bio-agent threat detection and manuever sustainment objectives of potable water.

DESCRIPTION: The III-V AlInGaN semiconductors have been shown to be ideal materials for generation of deep ultraviolet (UV) radiation, at wavelengths less than 280 nm, from a compact, environmentally stable source. Recent advancements in this material system have resulted in commercially viable light emitting diodes (LEDs) operating in the visible spectral region [1]. However, current UV LED performance is far below that needed for insertion into critical DoD applications, including bio-agent sensing and water purification [2-5]. In particular, the following characteristics of current UV light emitting diodes must be dramatically improved. The quantum efficiency of the UV LEDs must be increased by approximately one order of magnitude from their current value of 1-2% so that an acceptable amount of power is generated without restricting the input power budget. Operational lifetimes for presently available UV LEDs range from ~500 – 1000 hours with mean times to failure that are unacceptable for fielded systems. Statistical fluctuations in LED output power vs. time also severely hinder their usefulness. In addition, deep levels are found in current AlInGaN thin films which emit background radiation that limits the detection capability of fluorescence based sensors. Substantial improvements in material quality are needed.

This project aims to develop UV LEDs based on the AlInGaN material system that are suitable for DoD applications including bio-agent detection, identification and warning. Other protection mechanisms for the battlefield include water purification and NLOS (non-line-of-sight) communication for covert or emergency transponders. The LEDs are to emit at wavelengths of 280 nm or below, with a quantum efficiency in excess of 10%, with a minimum lifetime of at least 5000 hours, and with emission areas that can monolithically be scaled up to 0.5 mm x 0.5 mm. These metrics, which apply for a single die, are to be measured under CW operating conditions and should apply for a current density greater than 30 A/cm2. Other material systems such as II-VI oxide semiconductors may provide alternative solutions but must have strong justification for investment based upon comparison to state-of-the-art AlGaInN LEDs. Proposed efforts should be based on sound technical principles and involve novel concepts that will result in disruptive increases in LED performance.

PHASE I: Demonstrate the feasibility of developing and fabricating 280 nm UV LEDs having quantum efficiencies, lifetimes, and large emission areas significantly greater than current standards. Technical pathways leading to the realization of LEDs with such improved performance characteristics need to be specified.

The final report shall describe all activities in this project, including technical pathways leading to the realization of LEDs with such improved performance characteristics.

PHASE II: Design and fabricate LEDs that meet all of the technical objectives specified above. Prototype LEDs are to be demonstrated and provided to a DoD lab for independent testing and validation. Growth and processing equipment need to demonstrate capability to operate in a production environment. Affordability of LED manufacturing should be addressed for large area and high volume production by cost estimates and phase III production plans. Application spaces should be determined based upon output power, reliability and price for feasibility toward various protection and covert communications needs of the Army. This study will provide an estimate of technology readiness level (TRL).

Deliverables include a final technical report that describes all activities in this project.

PHASE III: This effort will produce compact, environmentally stable, deep UV LEDs, capable of high output power operation with excellent efficiencies and lifetimes. These LEDs are a critical component in fluorescence-based bio-agent sensors for military situations. The same technology will find civilian applications in water and air purification systems.

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KEYWORDS: Light emitting diodes, ultraviolet radiation, semiconductors, high performance

A08-078 TITLE: Detection and Location of Home Made Electro-Optical Booby Traps

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To develop a capability to detect, locate, and identify infrared (IR) commercial off-the-shelf (COTS) and other electro/optical devices that are used as triggering mechanisms (optical) for improvised explosive devices (IEDs).

DESCRIPTION: Commercial off-the-shelf (COTS) active and passive IR electro-optical systems can be readily used and modified as triggering mechanisms for bombs, booby-traps and optical trip wire devices. The goal of this program is to obtain novel, innovative, practical, and relatively inexpensive technologies that can detect, locate, identify and, if possible, mitigate these optical triggering mechanisms. Using methods proposed and selecting a viable countermeasure during Phase I, a proof-of-concept system will be constructed and then tested against selected COTS devices in Phase II.

PHASE I: The contractor will investigate and propose possible optical countermeasures in order to detect, locate, and identify infrared COTS devices. From the results of the investigation, the contractor will select the most promising countermeasures and propose a proof-of-concept system that can be constructed in Phase II and tested against selected COTS devices. A final report will be written describing the proposed countermeasure solution(s), the selection of the most promising solution, and propose an optical counter-measure system that can be used to implement a proof-of-concept system. The final report will describe optical beam characteristics of the optical threat (COTS device) in terms of emitted powers and pulse characteristics, fields of view, triggering distances between the transmitter and the receiver and electro-optical parameters and conceptual design of the proposed countermeasure system.

PHASE II: The contractor will design and build the proof-of-concept system proposed in Phase I for testing in the laboratory and in realistic field scenarios against COTS devices. In Phase II two deliverables will be delivered to the Government which are 1) the operational prototype that was built and 2) a comprehensive final report of the program and description of the design and optical, electrical and mechanical parameters of the operational system that was built and tested against selected optical threats.

PHASE III: The countermeasure system built during Phase II will be developed so that it can be integrated into ground and air platforms such as military and commercial vehicles, unmanned ground vehicles (UGVs), and unmanned aerial vehicles (UAVs). The system will be designed for optimum performance and tested extensively. It is expected that the system concepts and technology that are developed will also allow its use in the commercial environment, e.g., perimeter defense, inter- and intra-building defense and, possibly, to individual military and commercial personnel and for use in homeland security, local law enforcement, border patrol activities, and selected high value targets.

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KEYWORDS: Electro-optics, Infrared, Active COTS devices, Passive COTS devices, Optical triggers, Improvised explosive devices, Laser designators, Optical Detection, Optical signatures.

A08-079 TITLE: Precision Extraction and Characterization of Lines of Communication from Moving Target Indicator (MTI) Data

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: The objective of this effort is to develop and demonstrate algorithms to extract and continuously update high-accuracy maps of battlespace lines of communication from Moving Target Indicator (MTI) data streams.

DESCRIPTION: Knowledge of lines of communication (LOC) is critical for force maneuver and mission planning. These lines of communication may include foot trails, roads or waterways in rural, urban, mountainous or forested terrain. Many areas of the world have poor or no information on lines of communication. Either the information has gross geo-spatial errors or the LOCs are in regions which are difficult to map remotely. In the case of LOCs used by personnel and horses (and the like) almost no data exists. It is the objective of this effort to provide a means of deriving such mappings of LOCs from existing data collectors as a secondary product.
MTI sensors now have the accuracy necessary to track moving surface targets with high precision. They also have the ability to persistently surveil an area making it possible to build confidence through continued observation. As such this provides an accurate estimate of where lines of communication are and at a higher accuracy than currently available. Similarly, emerging MTI sensors can detect moving targets through foliage, and can characterize otherwise concealed lines of communication. Additionally, unlike road networks extracted from imagery, those extracted from MTI can also provide a characterization of road usage and road type, including clear delineation of foot trails.

The purpose of this effort is to develop algorithms to extract lines of communication from MTI data streams. These algorithms shall be capable of deriving products in real-time via live feeds or from existing data archives. Such data sets/feeds may include dismounts, vehicles and fauna. The sensors expected to provide data for this effort are Unmanned Aerial Vehicle (UAV) Ku-band sensors or UHF sensors, although the objective algorithms must be compatible with all existing MTI data collectors of reasonable suitability. Extraction algorithms may be assisted by Digital Terrain Elevation Data (DTED), Vector Map (VMAP) or other available standard terrain products and must produce VMAP and Shapefiles for compatibility with existing Geographic Information Systems (GIS) systems. Data input will be in standard STANAG 4607 format.

PHASE I: Investigate, analyze and document an innovative algorithmic approaches for the extraction of LOCs from MTI data. The feasibility of the concept shall be documented in the phase I report.

PHASE II: Develop, code, test and demonstrate a real-time algorithm, which implements the concept from Phase I. The baseline of this program will focus on the characterization of LOCs from Army UAV sensors. A report shall document and explain the final approach, implementation and results of the overall effort. The contractor will demonstrate the technology to the Government. Modeling and simulation shall be used where applicable. Real GMTI radar data will be made available in limited quantity during the first year of the effort, with full data sets available in the second year of the effort.

PHASE III: Successful technologies developed under this effort will be transitioned for military application. The algorithm shall be inserted into the Governments systems integration laboratory (SIL). Algorithms will be evaluated in the SIL and incrementally improved to facilitate more effective transition. Many acquisition programs would benefit immediately from this technology including Future Combat Systems (FCS) Unit of Action (UA), Aerial Common Sensor (ACS) and Distributed Common Ground Station - Army (DCGS-A). Potential commercial applications range from security, wildlife management and border surveillance by the Department of Homeland Security (DHS).

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KEYWORDS: MTI, fusion, radar, exploitation.

A08-080 TITLE: Radio Frequency Over Fiber in Airborne Intelligence, Surveillance, and Reconnaissance Platforms

TECHNOLOGY AREAS: Air Platform, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: This effort focuses on developing an optical based Radio Frequency Distribution (RFD) system to include cabling with reduced size, weight and power that will be used in an Intelligence, Surveillance and Reconnaissance (ISR) aircraft.

DESCRIPTION: The US Army is interested in reducing the Size, Weight, and Power (SWaP) of Radio Frequency Distribution (RFD) systems by 30-50% in Intelligence, Surveillance, and Reconnaissance (ISR) aircraft. This would allow an aircraft to carry more ISR payloads. This effort will focus on a point to point implementation of a modulator, fiber cable and demodulator as a proof of concept of a fiber optic RFD. Present commercial photonic products are not designed to meet Army ISR requirements. Most notably, noise figure and spurious-free dynamic range (SFDR) requirements for ISR systems exceed current commercial products capabilities. A minimum of 80 dB SFDR in a 1 MHz bandwidth from High Frequency (HF) to Extremely High Frequency (EHF) is required to be viable in a modern battle space signal environment.

PHASE I: The first phase will be a study of photonics technologies and fielded photonic implementations. Innovative photonic technologies will be assessed to quantify performance, Size Weight and Power (SWaP), technological maturity and cost. The intent is to identify technologies and techniques that could be integrated onto an ISR platform, the benefits from such an implementation, and risks. The effort culminates with a selection of components for a preliminary RF (Radio Frequency) over fiber design documented in a feasibility study. The design is to be implemented in Phase II.

PHASE II: In the second phase, a scaled Radio Frequency Distribution (RFD) prototype will be built based on the preliminary design and selected components from Phase I. This will involve the designing, developing, modeling, and proto-typing of a photonics based RFD that consists of at least three functional elements, e.g. conversion, distribution, and switching. A prototype demonstration shall verify the design meets all performance requirements. Deliverables at the completion of this phase should include 1 prototype system with accompanying documentation. A report shall document the approach, implementation, test results to include Size Weight and Power (SWaP) and performance, and an approach to scale the effort for integration onto a Test Bed aircraft.

PHASE III: The completion of the third phase would result in a mature technology for transition into airborne Intelligence, Surveillance and Reconnaissance (ISR) programs such Aerial Commons Sensor and Guardrail Common Sensor. The implementation of a photonics Radio Frequency Distribution (RFD) would benefit many airborne ISR applications from DoD programs to law enforcement. The reduction in weight would allow for systems like these to carry larger and more capable intelligence payloads. Commercial applications could include but would not be limited to Satellite and Cellular/Radio Frequency (RF) communications and Airline industries.

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KEYWORDS: Photonic, Radio Frequency Distribution, Airborne Intelligence Surveillance and Reconnaissance (ISR).

A08-081 TITLE: Persistent Multi-Intelligence Perimeter Sensing

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: The Persistent Multi-Intelligence Perimeter Sensing (PMPS) program intends to provide friendly forces with a perimeter monitoring capability through cued imagery from sensed Radio Frequency (RF) activity.

DESCRIPTION: This program intends to provide the warfighter with an ability to cue an imagery sensor, utilizing the detection of an active Radio Frequency (RF) event. Existing forces face challenges to monitor multiple persistent imagery sensors in order to identify particular events of interest that may be threatening. Existing cameras used for Forward Operating Base (FOB) perimeter security may be limited in Field of View (FoV) or may be monitored by limited personnel. Perimeter security conducted by security personnel may be limited by the number of personnel available and the amount of area that needs to be monitored. The opportunity to offer many sensors can be realized at low cost however, it is a manpower burden to monitor and interpret all of the imagery sensor information that is being gathered. This program will focus on using active RF events and image processing techniques to automate an alert to the operator to notify them that a change of state has occured within a given area of a particular combined RF and imagery sensor through multi-intelligence sensor processing and fusion. Imagery sensors will be cued by the RF sensor to limit the area of interest being observed by a particular imagery sensor. It is of primary importance that these sensors be low in cost and have good performance. Of secondary importance is to reduce the size, weight, and power of the sensors. The program will involve research of RF emitter detection and location capabilities and techniques and imagery capabilities and image processing techniques. Image processing techniques that will be investigated will include, but not be limited to, facial recognition, motion tracking, and flash detection. The imagery sensor will be capable of effective operation in high light and low light conditions. The program will provide an integrated design of a imagery and RF sensor capability and technique. After the design has been achieved, the program will develop and implement a combined RF and imagery sensor prototype with an intuitive Command and Control (C2) interface and output display for multiple networked RF and imagery sensors. The RF sensing capability will initially be targeted to collect against modern communications devices which are commercially available and would be capable of sensing the direction of an active RF event to within +/- 45 degrees of the actual position of the RF event within a maximum dwell of 1 second in order to cue the imagery sensor. The imagery sensor will be able to detect human activity a minimum range of 1000 feet in an unobstructed environment. Human activity will be detected within 1 second from the subject appearing in the camera's Field of View (FOV). The imagery sensor will be capable of panning at a minimum rate of 45 degrees per second.

PHASE I: The program will identify "best of breed" Radio Frequency (RF) sensing and imagery sensing capabilities and techniques. Once the RF sensing and imagery capabilities and techniques have been identified and selected, a feasibility assessment and architecture design will be developed to plan out if, and how, an integration of these capabilities and techniques may be implemented to automate the cuing of imagery sensors with RF sensing information and how it would benefit the warfighter. Attention must be paid to the cost and performance of these capabilities and must also consider reducing size, weight, and power of the sensor system. Required Phase I deliverables will include a comparison assessment report of RF sensing and imagery capabilities that includes the justification for the selected approach for implementation and an architecture design of how the RF sensing and imagery sensor capabilities will be fused to relieve the burden of the operator required to monitor multiple imagery sensors for activity. At the end of Phase I the program will conduct a critical design review of the proposed architecture design of the combined RF and imagery sensing capability.

PHASE II: The program will implement the combined Radio Frequency (RF) and imagery sensing design to produce a prototpye sensor system capable of network coordinated cued imagery from RF and imagery detection events. The program will produce performance parameters and limitations of the sensor system capabilities through laboratory and field testing of the prototype sensor system. Following field testing the prototype sensor system will be demonstrated, and training and documentation on how to set up, operate, and interpret sensor information will be provided. Required Phase II deliverables will include all sensor system prototype equipment, a turn-key operator's manual, prototype system specification, and test plan, data, report, and analysis.

PHASE III: The outcome from Phase II will be a determination of the utility of performing multi-intelligence Radio Frequency (RF) and imagery sensor from a single combined sensor system. If successful, this technology may be useful for providing persistent perimeter security for forces operating in theater and may also provide an improved capability to surveillance and reconnaissance systems based on the multi-intelligence fusion of RF and imagery technology. This technology may be applicable to transition to Project Manager Robotic and Unmanned Systems (PM RUS). Commercially, this technology is applicable to providing perimeter security to protected areas that are at risk of terrorist or hostile actions such as airports or private property.

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KEYWORDS: Signals Intelligence (SIGINT), Imagery Intelligence (IMINT), Persistent Surveillance, Fusion, Battlespace Awareness, Force Protection.

A08-082 TITLE: Event and Temporal Reasoning Ontology

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a Web Ontology Language (OWL) based data model to support event and temporal reasoning across unstructured multi-source tactical intelligence data. This effort should use the best available existing Command, Control, Communications, Computers, Intelligent, Surveillance and Reconnaissance (C4ISR) data models such as Joint Command, Control and Consultation Information Exchange Data Model (JC3IEDM).

DESCRIPTION: The goal of this SBIR program is the development of a data model and processing tools that supports the correlation of event reports generated in a wide array of structured and unstructured formats. This data model and processing tools are a critical component in the larger system for an all source fusion system.

All source fusion to support military decision making is the overarching goal of the Army's Distributed Common Ground System and the various research and development programs supporting it. A common challenge in all source fusion is the wide variety of formats used by the various sensors libraries and text reporting systems. This challenge is particularly keen with respect to reporting the time at which an event has or will occur as required for determining whether multiple reports are correlated with a single event or represent multiple events. Descriptions range from precise numeric time, but possibly reported with poor calibration (i.e., reported with respect to a clock set fast or slow), to looser semantic descriptions such as "yesterday morning" or "every third Tuesday of the month." At the present time, a standardized ontology that places all these possibilities into an integrated framework does not exist. This SBIR seeks innovative R&D that will gather the various technical and semantic descriptions into a common ontology, and provide for automated temporal machine translation as a feed to the all source fusion process.

PHASE I: Feasibility study to identify potential heuristics and logic that will form the basis of the time event ontologies. The ontologies should be capable of event and temporal reasoning using attributes extracted from tactical intelligence data which will be provided by the government. This study should include the feasibility of applying state-of-the-arts technologies such as: pattern matching, natural language processing, linguistic-based extraction rules, and inference logic.

PHASE II: Develop, demonstrate and validate the prototype of the temporal data model, implementing the approach from Phase 1. Perform evaluation of the prototype, and provide reporting of such an approach that integrates human knowledge interaction within the learning component. Complete the prototype design in support of the event and temporal reasoning data model and logic. A report shall document the final approach, implementation, and results of the overall effort.

PHASE III: The completion of this phase would result in a mature technology to include data model(s) and logic that are capable of implementing event and temporal reasoning. This technology could be successfully applied to both military and commercial applications. Many DoD acquisition programs would benefit from this technology including Future Combat Systems (FCS) Unit of Action (UA) and Distributed Common Ground Station - Army (DCGS-A). Commercial applications include, but are not limited to, computer forensics analysis, internet monitoring for illegal activities such as money laundering, and investigating and prosecution support to civilian government agencies.

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KEYWORDS: Extraction, reasoning, semantics, temporal, data model, JC3IEDM, event.

A08-083   TITLE: Advanced Modular/Reconfigurable Cooling Techniques for Signals Intelligence/Electronic Warfare (SIGINT/EW) Systems

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To study the concept/feasibility of developing modular/reconfigurable cooling techniques that can be easily integrated and applied to various electronic systems where thermal management is necessary.

DESCRIPTION: Signals Intelligence and Electronic Warfare (SIGINT/EW) systems are usually in a rack mount or custom box configuration containing multiple advanced components to achieve extremely small, light weight, and highly integrated assemblies while simultaneously delivering high performance. With the reduced size and densely packaged components, the thermal management of these systems is of paramount concern. The increased thermal load combined with the potentially high ambient temperature can result in excessive temperatures for the components. This can translate into reduced reliability, poor performance, increased maintenance, or total failure.

Current thermal management techniques use a variety of methods to control the thermal problem including fans, closed cooling systems, conduction, convection, cooling pipes, sprays, and other methods. Finding a commercial-off-the-shelf (COTS) cooling technique that is an exact match to the system thermal load can be difficult resulting in custom designs that include non-recurring engineering (NRE) costs. Since SIGINT/EW systems are generally of various sizes and thermal loads, an advanced modular, highly efficient, and scalable method/technique is desirable. This technique would allow the user to design an optimal cooling solution for minimal power consumption, size, and to therefore manage the system/component temperature efficiently. This approach would also allow the user to update the cooling, e.g. eliminate or add additional cooling modules, if the system is modified thus maintaining the optimal size, weight, and performance.

PHASE I: Investigate, model, and analyze various cooling methods that can be configured in a modular and scalable format. Passive and active approaches can be considered, but size, weight, and power (SWAP) must be addressed. During this phase, various system packaging structures, e.g. rack mount, with various thermal loads should be investigated. Also, the standard military operating temperature range, -55 to +125 degrees Celsius, should be considered as the potential ambient thermal environment. The selected approach should be modular thus allowing the user/system designer to easily add or eliminate modules based on the system thermal load. Hybrid cooling techniques are also acceptable. Generally, the components within the system have some form of thermal management included, but the overall heat resulting from the combined components in a packaged environment is still a problem. Based on the above findings, an approach shall be identified that meets the modular need and is generic such that it is applicable to a variety of commercial and military systems.

PHASE II: Develop, test, and demonstrate a prototype cooling module that meets the requirements derived in Phase 1. The prototype module can initially be fabricated in a brass board format for demonstration purposes, but must ultimately be adaptable to production fabrication. Demonstrate the cooling approach on a variety of mechanical packages with different heat loads. Based on the results, identify and recommend a final architecture that addresses performance, SWAP, and manufacturing concerns.

PHASE III: Several specific military/commercial programs that can benefit from this technology include, the electronic warfare (EW) WARLOCK system, high power jammers, the Tactical SIGINT Payload (TSP) program, commercial computer servers, wireless base stations, and high power laser drivers.

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Thermal and Thermomechanical Phenomena in Electronic Systems, 2000. ITHERM 2000. The Seventh Intersociety Conference on Volume 1, 23-26 May 2000
KEYWORDS: ELECTRONICS, THERMAL, RELIABILITY, PACKAGING, MODULAR,COOLING SYSTEMS, ELECTRONIC PACKAGING, TEMPERATURE CONTROL.

A08-084 TITLE: High Isolation Transmit/Receive Antennas for Advanced Electronic Warfare (EW) and Communications Applications

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: There is a critical need for antenna apertures that are co-located on the same vehicle to provide high isolation from other antennas on the same vehicle for transmit and receive functions. The objective is to develop an antenna aperture/apertures that will achieve high isolation, on the order of 50-100 dB over a wide frequency band, with other antenna systems installed on the same platform.

DESCRIPTION: The antenna apertures on a vehicle require the ability to receive from and transmit to the same location in space, therefore technologies utilizing directional nulling may not be applicable. US Army ground vehicles are relatively small and do not allow for significant separation between antenna apertures. The intended application is for ground mobile or fixed site systems, hence the antenna system must be mountable on multiple different Army ground vehicles and not protrude above the top of the vehicle by more than 4 feet. The antenna shall be capable of handling 100 Watts of continuous in-band RF power output from a transmitter. The bandwidth of the antenna system shall be 20 MHz to 6 GHz (as a goal, to 8 GHz) and provide the required isolation of 50 to 100 dB over all frequencies in its bandwidth simultaneously. This wideband level of isolation is required to minimize interference with the receive function of other narrow band antennas/systems co-located on the same vehicle. Conversely, the wideband antenna system must provide the required isolation so as to protect its receivers from being desensitized by the transmissions of the co-located narrow band antennas/systems when they are transmitting. Understandably the success of this effort will depend somewhat on antenna mounting locations. The narrow band antennas may be located on the roof of the ground vehicles near the center, while it is anticipated that the wideband antenna(s) would be mounted near the extreme ends of the vehicle. Some flexibility in antenna mounting locations may be possible. The intended end application of this antenna system is for US military force protection. This effort, if successful, will produce an antenna system with isolation from other nearby antennas that is several orders of magnitude above what is currently available in today's state of the art, including better azimuthal coverage. This represents a level of innovation that currently does not exist in commercially available antennas.

PHASE I: Perform a feasibility study for a high isolation transmit/receive antenna system for ground platforms meeting the requirements provided in the above description. Analyze various antenna geometries and perform an analysis of expected antenna performance parameters for each design. Perform modeling and simulation of the antenna designs to establish isolation performance, antenna coverage pattern and other specifications. Present the various antenna designs and the results of the above modeling and analysis in a deliverable Phase I Final Report.

PHASE II: Design, build and demonstrate a prototype high isolation transmit/receive antenna for ground military platforms based on the best designs from the modeling in Phase I. The design shall be sufficiently rugged in anticipation of having to pass military environmental qualification testing. Develop and document antenna characteristics, specifications and performance data for typical ground vehicle mounting locations and test them in the laboratory and the field. Modeling shall be performed to validate performance, particularly isolation, for various configurations representative of the different anticipated ground vehicle mounting platforms. Deliver the prototype antenna system and a Final Report documenting the above, to include test and modeling results.

PHASE III: The completion of this phase would result in a mature technology fieldable high isolation transmit/receive antenna for ground platforms which could be successfully applied to military applications. This high isolation transmit/receive antenna will be fully field tested and its performance thoroughly characterized. Drawings and specifications will be prepared such that the antenna could be placed into environmental qualification testing and production immediately after completion of Phase III. This technology could be further marketed by transitioning into a commercial product for use by the Homeland Defense and First Responders personnel. Presently First Responders and other local authorities use various communications systems and require multiple antennas. This design will eliminate the interference between adjacent antennas on the same platform. A field ready prototype antenna system, ready for environmental qualification testing and production, shall be delivered. All drawings and all the results of the above testing and analysis shall be delivered in the Final Report. Upon successful completion of Phase III, the effort will transition to PM-Signal Warfare, LTC James Helm.

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KEYWORDS: RF Antennas, High Isolation Antennas, Wide-band Transmit/Receive Antennas.

A08-085 TITLE: Recognition of Non-Native Speakers

TECHNOLOGY AREAS: Electronics, Human Systems

OBJECTIVE: Establish approaches to the recognition of non-native speakers of foreign languages by machine language translation systems.

DESCRIPTION: Identification of non-native personnel may be a critical piece of information on which to make crucial on-the-spot decisions. Identification of a non-native speaker is often readily apparent in normal conversation with a native speaker through speech content and accent. Such identification to an interrogator or intelligence analyst may not be possible when conversing or listening through a human or machine language translator. To overcome this shortcoming, a system is required to identify speakers as native or non-native and identify possible native languages and dialects. The system may use live or recorded speech. The system may be stand alone or used with machine language translation systems. One example of a desired capability is to identify the native dialect of persons that speak multiple dialects of Arabic and related languages when the person is using a non-native dialect.

PHASE I: Phase I will be a feasibility study and establish the approaches and design concept for the identification of non-native speakers using a machine language translation system, develop the parameters to be used in such a system, and the parameters to determine the speaker's native language or dialects. The required Phase I deliverables will include reports that outline the results of the study, design concept, and the parameters used in such a system.

PHASE II: Phase II will develop, demonstrated and validate an initial implementation of a non-native language recognition system using the selected approach from Phase I. The system will indicate that the speaker is a non-native speaker and possible native languages or dialects. The system may have an audio output that can be recorded or routed to a machine language translation system for further processing. The testing will validate the parameters used in such a system and the accuracy of the system. A minimum of 5 languages will be tested. Required Phase II deliverables will include a prototype system for testing by the Army, detailed test plans, procedures and results, and procedures and design documentation.

PHASE III: Phase III will extend the concept to more languages and refine the ability to identify the non-native speakers and their native languages and embed the capability into multiple machine language translation systems. The completion of this phase would result in a mature technology that could be transitioned to programs such as Sequoyah for integration into machine language translation products and CHARCS – Counterintelligence and Human Intelligence Tactical Reporting and Collection. Concurrently, this technology could be transitioned into a commercial product for use by Homeland Security/Defense as well as other defense research and development entities. This technology will have commercial applications for law and immigration enforcement.

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KEYWORDS: Machine Language Translation, non-native, Human Intelligence.

A08-086 TITLE: Common Aperture Ground Moving Target Indicator (GMTI) and Electro-Optical/Infrared (EO/IR) (CAGE)

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

OBJECTIVE: The objective of this effort is to develop and demonstrate a common-aperture sensing system for Future Combat Systems Class I Unmanned Aerial Vehicle being derived from the DARPA Micro Air Vehicle (MAV) system.

DESCRIPTION: With the emergence of Micro Air Vehicles (MAVs) into the Army's repertoire of unmanned surveillance systems, there is a pressing need for payloads to be form-fit and compact. Current Optical systems for these vehicles are limited in their mounting configurations and field of regard (FoR). Radio frequency systems are also limited in capability. A Common-Aperture Ground Moving Target Indicator (GMTI) and Electro-Optical/Infrared (EO/IR) (CAGE) system shall create a system for the FCS Class I UAV and the MAV that allows for an RF GMTI Radar to share apertures with an EO sensor system (with IR and Laser Designation (LD) and Laser Range Finder as objectives). The CAGE system shall provide 360 degrees of azimuth coverage at depression angles sufficient for operational slant ranges of 2-4 km, at a maximum altitude of 1000 feet. A Synthetic Aperture Radar (SAR) mode of operation shall be an objective capability. The system shall be able to use the RF GMTI system to locate moving targets of interest and seamlessly switch to the EO sensor (through the same aperture) for Recognition, Identification, targeting, etc. of the detected targets. Simultaneous collection of GMTI data and EO/IR data shall be possible through the common aperture configuration. The GMTI modes of the system shall focus on the detection of dismount and vehicle targets. The CAGE system shall also be form-fit to the payload bays of the target air vehicle (FCS Class I). The size weight and power (SWaP) constraints for the system shall be ~0.68 kg (~1.5 lbs) in weight, 491cc (~30 in^3) in volume and about 10 watts peak prime power. Platform induced effects on performance shall also be investigated.

PHASE I: Investigate, analyze and document innovative approaches for meeting the CAGE system requirements and its objectives on the platforms of interest. The feasibility of the concept shall be documented in the phase I report. Modeling and simulation shall be used were applicable.

PHASE II: Develop, test and demonstrate a prototype CAGE system that implements the concept from Phase I. The CAGE system shall be tower tested at a minimum. Continue to investigate Objective requirements and methods to further reduce SWaP requirements for the objective system.tested at a minimum.

PHASE III: Successful technologies developed under this effort will be transitioned for military application. Many acquisition programs would benefit from the CAGE system including Future Combat Systems and the DARPA MAV ACTD programs. Potential commercial applications range from security, wildlife management and border surveillance. Ground-based, mast-mounted units could prove useful for law-enforcement and perimeter surveillance.

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KEYWORDS: Common Aperture, GMTI, EO, IR, MAV, OAV.

A08-087 TITLE: Dismounted Combat Identification

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

OBJECTIVE: Develop an innovative dismounted identification system that will identify dismounted personnel at tactically significant ranges.

DESCRIPTION: The contractor shall develop an innovative concept for identification of dismounted personnel. Joint, Allied and Coalition forces require a dismounted combat identification system. The contractor shall explore different techniques and materials that could be used to identify soldiers at tactically significant ranges, such as µ-fiber micro wire or Radio Frequency Identification. These technologies have been proven to work at short ranges in permissive and controlled environments. Innovative Research and Development is required to investigate whether these techniques can be extended, for example, with more complex and robust coding, in order to achieve tactically significant ranges (1200 meter). A key goal of this research is to provide a clear delineation of related commercial market drivers and engineering specifications, identification of specific areas where military requirements differ from commercial and a scientific and engineering analysis indicating exactly how and where modifications to commercial technology can meet military requirements. This critical analysis will form the basis for any design proposals, and ultimately be validated through the development of prototype hardware. While cost constraints argue for maximum compatibility with commercial sources, it is critical to protect these military tag systems from being exploited at very low cost by terrorists using commercial tag readers. These security constraints must be addressed in the initial design study and verified in testing of the prototype.

The ideal system must be vanishingly small and should not weigh more than two ounces. It is desirable for the soldier transponder part of the system to be woven into or placed on the soldier's uniform, and difficult to detect with the naked eye. Similarly, the interrogator part of the system should require minimum size, weight, power consumption and recurring cost, and take into account human factors.

PHASE I: The contractor shall perform a feasibility analysis of the design and demonstrate its efficacy through analysis, simulation, or other means. This analysis shall include, but not be limited to: size, weight, power, sensors, cost, operational and other pertinent issues.

PHASE II: The contractor shall construct a software model to predict and analyze the detailed performance of the system. The contractor shall develop a hardware prototype and demonstrate the concept that was developed in Phase I. The contractor shall test the system and compare the measured sensor performance against expected sensor performance values resulting from the modeling efforts. The contractor shall deliver one or more prototypes. The contractor shall deliver test reports and a final report.

PHASE III: Technologies for identification have a wide variety of application to the military and commercial markets. Personal identification technology such as this could be useful for law enforcement, homeland security, and emergency response applications such as: firefighting and EMT situations. Military applications would be all Future Force Warrior, Land Warrior, Air Warrior, and Future Combat System and Legacy Platforms. If Phase II is successful, the technology would be developed further and tested by the Communications Electronics Research, Development and Engineering Center (CERDEC) Intelligence and Information Warfare (I2WD) Directorate. If successful, it would then transfer to PM Soldier.

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KEYWORDS: Fratricide, combat identification, soldier.

A08-088 TITLE: Command and Control Translation System in a Service Oriented Architecture (SOA) Framework

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a Command and Control (C2) translation system compatible with currently fielded Army Battle Command Systems (ABCS) which supports service discovery and exploitation to provide translation of text, and military symbols, thereby permitting seamless integration of C2 operations with coalition partners.

DESCRIPTION: Today's quick reaction warfighter is expected to operate closely with foreign militaries and local forces in various operations around the world. Oftentimes coordination with these groups is difficult or ineffective due to language barriers, lack of trustworthy or reliable translators, and poor interoperability between coalition command and control systems. Additionally, under Section 4-36 of TRADOC PAM 525-66, the Maneuver Support Force Operating Capabilities (FOC) requires "Universal language translation capabilities". The goal of this SBIR is to develop a C2 translation system that can be used by embedded coalition forces, and takes full advantage of the benefits of a SOA. This system would enable foreign soldiers to interact with ABCS software using their native language and military symbols. Security policies must be established within the framework to control access and the ability to publish/receive information to/from the ABCS. An example security policy might authorize foreign users to send free text or instant messages, but not authorize them to access tactical maps and plans. The dynamic nature of the Service Oriented Architecture (SOA) environment would enable the system to be quickly deployed to another area of the world using a whole other set of translation services. Finally, in order for this SBIR to be successful it is critical that no changes are imposed on the current ABCS.

PHASE I: The contractor shall determine the feasibility of establishing a connection to an existing ABCS, and translating data to and from the system. The feasibility study shall address security issues, bandwidth requirements, and explore other possible services that would be of use to the system including text and map symbols.

PHASE II: The contractor shall demonstrate a prototype system that addresses all requirements in phase I. The system shall also undergo preliminary field testing in a relevant environment where both the accuracy of the translation systems and the ability to change languages and translation services will be determined. The contractor shall also determine the time required to create new translation services, and demonstrate a transition path to an Army Project Management Office (PMO).

PHASE III: The contractor will deploy the prototype system in an operational environment during a scheduled field exercise. Upon successful completion of the exercise, final tests and evaluations will be conducted to ensure the system is ready for transition to a Project Management Office (PMO), namely, the Project Manager Sequoyah. The prototype system will fulfill the PMO urgent and quick reaction language translation needs in support of the warfighter, and thereby permit collaboration with foreign entities. It is envisioned that this or similar systems would be desired for agencies such as the Department of Homeland Security and the US Coast Guard for border control, who frequently coordinate with foreign nations, militaries and personnel. Other potential customers may include those involved with drug interdiction, peacekeeping operations, or disaster relief.

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KEYWORDS: Service Oriented Architecture, Army Battle Command Systems, Language Translation, Coalition Forces, Battle Command.

A08-089 TITLE: Quality of Service Traffic Manager

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Create a Quality of Service Traffic Manager (QTM) that bridges the communication gap between applications, services, and network configuration components. The QTM will provide the ability to actively change QoS policies and packet priorities across the network based on several characteristics of the transmitted packets or high-level priorities imposed by the Commander. The QTM will improve information flow based on network level optimization techniques.

DESCRIPTION: Network Enabled Battle Command (NEBC) is a work package in the Network Enabled Command and Control (NEC2) Advanced Technology Objective (ATO) in the Communications-Electronics Research, Development and Engineering Center (CERDEC), Command and Control Directorate (C2D) focused on developing Command and Control (C2) mission planning and execution monitoring services and enabling technologies. This research effort would be coordinated with the Managed Connector (MC) program, also under NEBC. The goal of

MC is to support interoperability between high and low echelon networks. It also addresses bandwidth mediation in a constrained heterogeneous network using dynamic and adaptive techniques.

As the Army transitions numerous capabilities into network-accessible services, available bandwidth is emerging as the most prominent bottleneck. Services constantly fight for the same bandwidth as they try accessing large amounts of data, such as maps, mission files, and logistics information. This creates a lot of congestion on the network leading to dropped packets. QoS mechanisms are available for shaping the traffic flow, but there are no tools available that permit efficient utilization of these methods. Currently, a user may decide that his messaging program or other traffic requires the highest QoS priority and set it himself. This will lead to degraded performance for other applications and users, and in turn others will increase their QoS priorities. Due to the lack of coordination, QoS is rendered ineffective and the network may suffer congestive collapse, where little useful communication occurs. A need also exists for a method and system for developing data dissemination while the bandwidth is low. With minimum bandwidth we need to enable the data distribution in multi-user applications over low-bandwidth networks. Data storage would also be essential in order to prevent loss of large amounts of data received from other sources.

The QTM would act as the central manager for traffic shaping and QoS policies for all network traffic on the Warfighter Information Network-Tactical (WIN-T) or any other applicable networks including Service Oriented Architecture (SOA) environments. It would utilize similar traffic management tools and algorithms currently employed by Internet Service Providers (ISPs). These tools allow ISPs to manage their traffic by categorizing, prioritizing, and shaping sensitive, best-effort, and undesired traffic to improve overall performance and guarantee performance for specific types of traffic, such as multimedia or Voice over Internet Protocol (VoIP) traffic. The QTM will also provide a service interface and a web interface to administer the traffic management policies and analyze past, recent, and projected future performance. This will allow the administrator to adjust performance based on bandwidth-sensitivity of applications or application types connected to the network and time of day. The QTM should enable multi-tasking between applications and services with minimum degradation of data. It should also be able to adapt bandwidth-insensitive data dynamically with minimal loss. Data can also be disseminated and or stored in order to avoid its loss.

Some techniques may involve identifying and categorizing traffic type and application sender by analyzing the packet headers, allowing the administrator to specify which applications, services, or people require what level of service, and creating policies that take effect during specific time intervals or events occurrences. This will allow the administrator to coordinate and make efficient use of the available bandwidth.

The focus of this research effort will be on shaping and managing network traffic. The resulting product at the end of Phase III will be applicable to network administrators across all organizations and even home network users who wish to prioritize their gaming or multimedia traffic.

The coordination of network traffic management and QoS has been lacking. There is no ability to easily identify and categorize the type of traffic on any given network and implement policies to manage that traffic, or give a larger pipe to certain, high-priority applications in different situations.

There are several products like Packeteer, Netscreen, NetScout that can perform QoS but with only their hardware or a specific hardware. This QTM service will be hardware independent and it would work with WIN-T or any other network applications. The QTM benefits any current system as it does not require any modifications to the current architecture. It will be platform independent. It can reside on any applicable networks. It reduces cost by using existing resources efficiently. As mentioned earlier, there are no tools that perform efficient utilization of QoS and QTM will be able to satisfy this need.

PHASE I: The vendor will outline possible traffic management techniques, such as QoS and traffic shaping based on packet type. The vendor will also perform research analysis on available traffic shaping algorithms and a study on existing hardware solutions. The vendor will deliver a Design Document describing how the QTM will identify, classify, and shape network traffic; interact with existing network components, applications and services; and the interface for creating and administering traffic management policies.

PHASE II: The vendor will implement the QTM described in the Design Document delivered in Phase I into a fully featured service that will be integrated with the MC software for testing and demonstration. During this phase, research will be conducted to determine the optimal coordination and shaping techniques. The vendor will deliver a technical analysis of the algorithms identified in Phase I. The implemented QTM will require a sample application that analyzes the categorized traffic and displays metrics to showcase the performance for demonstration purposes; this can be integrated into the web interface.

PHASE III: Dual use applications. Possible commercial applications include transitioning this service to the communications industry for use in 802.11x products and cellular networks. The QTM would allow for increased performance for applications identified by users or administrators as important for their operations. It would allow users to customize the distribution of their share of the bandwidth pipeline. Similarly, packaging the QTM with Commercial Off The Shelf (COTS) 802.11x hardware would increase the performance of standard networks.

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KEYWORDS: Quality of Service (QoS), Network, Adaptable, Bandwidth Optimization, Service Oriented Architecture (SOA).

A08-090 TITLE: <u>High Performance Electrochemical Capacitor Using Nanomaterials for Electrodes.</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: To develop high performance electrochemical capacitors (also known as electric double layer capacitors, supercapacitors, or ultracapacitors) for fast recharges, and high rate discharging, using electrodes made of nanomaterials. The use of nanomaterials is expected to allow the pore size distribution to be optimized for specific performance goals and for used electrolytes. This ability to engineer the pore size distribution should result in the highest possible usable surface area with the best possible power performance. The minimum goals for a fully assembled capacitors are energy densities of 10 Wh/kg or higher, and power densities of 34 kW/kg or higher. The capacitors should operate in a typical temperature range for military batteries (-30°C to 50°C), with minimal adverse effects on their performance. The feasibility of manufacturing such nanomaterials on large scale, and at low cost, are integral part of this proposal, and critical to its success.

DESCRIPTION: While electrochemical capacitors (EC) do not have the energy density of high performance batteries, they outperform batteries in applications requiring high power density. These capacitors demonstrate higher rates of charge and discharge (by two orders of magnitude), longer cycle life (by three orders of magnitude - millions of cycles versus thousands for typical batteries), high cycle efficiency, and broader temperature tolerance. These performance characteristics are bridging characteristics of battery and common capacitor technologies, and driving the adoption of ultracapacitors in many applications previously handled by these technologies. Ultracapacitors' extraordinary power capabilities make them an ideal technology for pulse power applications. Where energy density is also a priority, they can be combined (hybridized) with a battery system to greatly extend battery cycle life by buffering the battery from pulse charge and discharge cycles. Potential dual applications (military and civilian), that would benefit from success of this program, include communication equipment (radios), sensors, actuators, portable tools, electric and hybrid vehicles.

PHASE I: Identify and characterize potential materials for electrodes and electrolyte of a capacitor. Study the feasibility of processes allowing to make these materials on a large scale - to make the low cost production possible. Build single cell capacitor prototypes and characterize them to verify their performance (power and energy densities, cycle life, safety, temperature effects). Choose the best system for potential Phase II developments. Deliver at least 10 prototypes for verification and demonstration purposes.

PHASE II: Fabricate and demonstrate the performance of a single cell capacitor and verify uniformity of processes and resulting prototypes. Identify applications and design multicell packs to match their requirements - in terms of voltage and required performance. Make prototypes to characterize power density and energy density, safety aspects (possible cell balancing), cycle life capability of the packs, and temperature effects on its performance. As one of the applications built a multipack to withstand the OCV and charging voltage of 4 cell Li-ion batteries at 16.8 volts. Deliver sufficient number of single cell and multicell capacitor prototypes (to be determined - approx. 20 of each) for verification and demonstration purposes.

PHASE III: Based on the outcome from the Phase II, select the best possible candidates for the military and/or commercial markets. Design and mature large quantity manufacturing processes (low cost), and finalize the capacitor or capacitor module (multicell capacitor) design/designs. Deliver a number of small production prototypes of each design for testing and demonstration purposes. Phase III will result in the mature materials manufacturing process and with capacitor technology readiness level allowing small quantity production. The sample capacitors should be available in several different sizes to allow for variety of applications. Capacitor stacks for higher voltages will be assembled and issues with cell balancing while charging or discharging will be resolved. Applications for these capacitors will be verified and tested for. The benefits of the capacitors will be shown in applications, in their respective environments. Possible military applications include the ones that require high power intermittent pulses. On smaller scale these could be radios (for transmit mode), unattended ground sensors, back-up power and voltage regulation. On larger scale the applications could be for electric or hybrid vehicles (or tanks) for electric actuators, load leveling and regenerative breaking. Similar application can be envisioned for commercial markets, where potential breakthroughs in this technology will provide economy of scale benefits.

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KEYWORDS: Nanomaterials, nanotechnology, carbon, electrochemical, double layer, capacitor, supercapacitor, ultracapacitor, manufacturing processes and cost.

A08-091   TITLE: Superior High Energy Density and High Rate Rechargeable Lithium ion Battery for Army Applications

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: To develop ultrasafe high energy, low cost nano cathode material solution for fast recharges and high rate discharging for Smart lithium ion Rechargeable BB-2590 battery. Since we are developing nano anode material for lithium ion cell, it is becoming very important to develop a full nano materials cell to increase the energy density for both high rates discharging and charging. It can reduce the logistic to bring a large amount of batteries to the field and for very high rate application such as NLOS program for missile firing.

DESCRIPTION: Today the BB-2590 lithium ion battery that can only discharge 10 amperes maximum, Army needs higher discharge rate battery can meet other application such as Non-Line of Sight (NLOS) which requires very high power during firing the missile. Currently BB-2590 requires three 18650 cells in parallel to achieve 10 amperes rate. Army is looking for much higher rate of discharge with at 3 times current rates for commercial 18650 rate. For NLOS, we need to parallel 18 each of BB-2590 batteries to meet the rate requirement. If the cell can perform 3 times higher, the number of batteries needed can be reduced by factor of 3. This will reduce the number of batteries needed in the field and save weight and logistic needed to transport of this batteries to the field. This new battery will also allow a soldier to be able to transmit their packet message a much longer distance.
Using the high rate cell as a power source, it will open many other application such as robotic application as well as UAV application.

PHASE I: Identify and investigate the nano material for high rate lithium ion rechargeable cell for BB-2590 battery (which currently consists of 24 18650 commercial cells connected 4/8 in series and 3 in parallel). The cell shall be able to recharge at least 100 cycles at C/3 charge and discharge.

PHASE II: Fabricate and demonstrate the power density and energy density, safety aspects and cycle life capability in the BB-2590 battery.

PHASE III: There are many applications that will be able to use these high rate and high energy density batteries. This will quickly adapter to automobile, drill batteries.

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KEYWORDS: lithium ion, rechargeable battery, lithium iron phosphate.

A08-092 TITLE: Automated Planning Software For A Dynamic Heterogeneous Collection Of Manned And Unmanned Entities

TECHNOLOGY AREAS: Chemical/Bio Defense, Ground/Sea Vehicles

OBJECTIVE: Develop software to create military or commercial plans of action that integrate the range of capabilities provided by a specified collection of manned platforms and robotic entities.

DESCRIPTION: With increasing automation on the battlefield the problems of coordinating both manned platforms and robotic entities into integrated military plans have growing importance. Faced with a collection of people and robots how will future commanders produce plans that insure mission success yet minimize loss of life? As robotic entities evolve and their capabilities increase they have become more widely used in military and commercial applications. It is anticipated that as time passes many more of these entities will act side-by-side as team mates with humans. This evolving set of robotic entities will be heterogeneous in nature. Some entities may be mobile, some may be stationary, some may fly while others may be ground or water based. Each of these entities will have an on board sensor and/or weapons package that can be used to support a part of some tactical operation. These sensor and weapons packages will vary from entity to entity. Currently the planning of the use of these entities to support a mission is accomplished manually. This includes the manual break down of a mission into a sequence of tasks, then the review of available entities and there capabilities and then the actual assignment of the entity to a task. This planning can be complicated and may require a staff of several to complete the planning within planning time constraints. Automated software tools are needed to reduce the amount of time needed to plan and to reduce the number of human planners needed.

For this SBIR the contractor will devise an innovative planner decision aid which reduces unmanned system mission planning time. A necessary attribute of this system is the capability to plan for both small and large numbers of unmanned systems. The system should be flexible enough to easily adapt to new operational uses for unmanned systems. The input to this system would be the current state of the battlefield or world which would include the location, capabilities and availability of the manned and unmanned entity types and any other information important to planning such as terrain, location of friendly or enemy forces, weather conditions, environmental factors, etc. The output from this system would be a near optimal plan as a sequence of actions required to achieve the desired goal using some or all of the available entities. An important SBIR objective is to provide generalized versions of these concepts so that they are not tied to specific entities. This is important because the system may be used to control entities that are not currently defined.

PHASE I: Perform an analysis of alternatives and document the strengths and weaknesses of various planning approaches. Formulate the best planning approach and produce a high level system design. The design must specifically address (1) How the world will be represented, (2) How entity actions will be represented, (3) How current and goal states will be represented, (4) how the data will be searched to produce a plan, and (5) How the system will select between equivalent plans.

PHASE II: Build and demonstrate a prototype system. The demonstration must show how the data describing the world, the entities and the current and goal states are input, and how plans are generated. The demonstration must also show how different plans are generated given similar initial states and goal states but with different collections of entities as well as different entity capabilities.

PHASE III: Develop an automated task planner framework for dynamic collections of manned and unmanned entities. This planner framework would leverage lessons learned in Phase I and II of this SBIR effort. This planner aid algorithm should be designed to be relevant for future Army operations involving the planning of unmanned platforms, such as the Army Future Combat System. This planner should also be relevant to the work being performed under the Command and Control of Robotic Entities (Workpackage) of the Network Enabled Command and Control(NEC2)Army Technology Objective. This planner framework should also have commercial potential in factory automation where agile robotic assembly lines are integrated with human teams.

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KEYWORDS: Decision Aids, Robotics, Man Machine Teaming.

A08-093 TITLE: Counterinsurgency Campaign Design Tool Based on Logical Lines of Operation and Wiki-Inspired Knowledge Capture

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a computer software capability to help commanders design counterinsurgency (COIN) campaigns utilizing logical lines of operation (LLOs) that have been captured from lessons learned on other campaigns through the use of collaborative information collection and sharing technologies similar in concept to Internet Wikis.

DESCRIPTION: Counterinsurgencies have been called learning competitions. With COIN, the side that learns faster and adapts more rapidly – the side with the better learning organization – usually wins. Commanders facing insurgency opponents need to design campaigns in order to achieve specific intent. Campaign design and planning are different yet interrelated activities both essential for solving complex problems. While planning activities receive consistent emphasis in both doctrine and practice, discussion of design remains largely abstract and is rarely practiced. This situation is particularly problematic with insurgencies. With insurgencies, situations do not conform to established doctrine and as such the most difficult part of the problem is figuring out what the problem actually is. Design provides a means to gain understanding of a complex problem and helps offer insights into achieving a workable solution. As suggested in Army FM 3-24 Counterinsurgency, COIN campaigns can be designed through the use of Logical Lines of Operation (LLOs). LLOs are collections of actions and/or decisive points related in time and linked with an objective. A campaign designed using multiple interrelated LLOs allows commanders to visualize and adjust operations over purpose, time, and space to contribute to operational objectives and strategic end-states. Much of the information contained in LLOs is gleaned from in-theater experience local to individual commanders. Institutionalizing this information so that it becomes useful organizational learning is a challenge.

For this SBIR, the contractor will develop a generalized COIN campaign design tool that creatively uses LLOs to assist a commander in the understanding and design of a COIN campaign. The tool will input starting states, desired end states, and use captured experience about what works and what does not work in order to help the commander design the campaign. On the Internet collaborative information gathering techniques commonly known as "wikis" such as Wikipedia have been shown effective at enabling contributors to produce and maintain a useful body of knowledge. In the COIN campaign design tool, experience will be captured by creatively applying wiki-inspired technology enabling individual remotely located commanders to contribute to the stored organizational COIN knowledge, to extend that knowledge and to correct any discovered mistakes. Further, the tool will utilize novel visualization techniques to help commanders better understand their LLO choices, select and maintain the actions associated with the chosen LLOs, and to understand and maintain relationships between LLOs for the campaign being designed. The output of the tool is intended to drive the subordinate planning processes to implement the campaign.

PHASE I: Perform an analysis of alternatives and document the strengths and weaknesses of the approaches. Design the COIN campaign design tool and the knowledge storage wiki-inspired technology. The design must specifically address the user interface that the commander will utilize and the way in which the system will use collaboratively collected knowledge to assist the commander design the COIN campaign.

PHASE II: Build and demonstrate the COIN campaign design tool. The demonstration must show how knowledge is captured and stored in the wiki-inspired technology, how the tool uses the technology, how the commander inputs current state, end state, and designs the campaign. Propose and implement a realistic use case for the demonstration.

PHASE III: The counterinsurgency (COIN) campaign design tool can be transitioned to current or future Battle Command systems to assist the commander and his staff in understanding and designing a COIN campaign.
The ability to plan a COIN campaign has applicability in similar peaceful activities where population opinions need to be changed in a desired direction. Applications include the design of political, sales, and advertising campaigns.

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KEYWORDS: Counterinsurgency (COIN), campaign, Battle Command, Logical Lines of Operation (LLO).

A08-094 TITLE: <u>Dynamic Data Model Implementation for Context Sensitive User Interface and Embedded Semantic</u>

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: This topic addresses the operational problem of dynamically updating net-centric data store structures and auto-generating user interfaces in a timely manner and flow of metadata information essential to update operational database management systems at the enterprise or tactical level with minimum or no downtime. This dual-use effort will invoke implicit and learned user preferences and data model-aware services and or intelligent agents to dynamically reconfigure data stores needed by users to enable and tailor their decision support environments to use preferred metadata for collaboration and interoperability with an acceptable quality of service (QoS). Wherever there is a commercial or military database, there is an associated data model that will most likely evolve as the application and user interfaces are upgraded.

DESCRIPTION: The capability to dynamically update battle command or commercial enterprise application data models in support of enterprise application integration and persistent data stores throughout the tactical enterprise would greatly increase responsiveness to growing data bases for information collection, management, and analysis requirements. Example commercial data bases may be relevant to healthcare, insurance, automotive, education or human resources applications, to name a few. A holistic approach is needed to enable dynamic reconfiguration of data stores for BC Services as well as commercial enterprise services to upgrade and adapt to user preferences. No single database can support the data needs of Battle Command or other enterprise-wide commercial services. The development of enterprise processes, technologies, and tools to provide this capability is the focus of this effort. The move to dynamic data model and persistent store management requires similar moves toward dynamic management of user interfaces based on data model changes. If the meta data representing the data model can be expanded to represent the underlying semantics it may then be possible to auto-generate user interfaces based on mappings of data structures and underlying semantics to visual representations. This concept can be taken a step further by basing the auto-generation of the user interface on the needs/roles of the user, inferred and explicit user preferences, and discourse analysis in addition to the data structures and underlying semantics. Taken as a whole, the ability of enterprise data managers to be timely in their response to growing information requirements simply by updating enterprise meta data followed by the immediate propagation of changes across the enterprise resulting in updated persistent data stores and adaptive user interfaces addresses the difficulty and expense associated with conventional database and user interface design and implementation.

Entity and object based “data models” while differing in representational expressiveness afford the data engineer similar constructs for representing real world objects, attributes, relationships, domain values, and constraints as meta data. This structural meta data when combined with semantic meta data is capable of providing a high-fidelity machine understandable representation of the battle command domain and interactions between battle command actors. The mapping of the combined representation of battle command data with battle command actor’s intents, needs/roles, and preferences to visual representations that can be auto-generated and composed coupled with enterprise propagation of meta data changes encompasses the core technologies of this SBIR. The challenge is productizing these technologies into enterprise applications and reusable components.

The Joint Consultation Command & Control Information Exchange Data Model (JC3IEDM) initiated as a Multilateral Interoperability Program (MIP) and North Atlantic Treaty Organization (NATO) Data Administration Group joint effort will be used as the baseline data model from which meta data updates will be based. Core technology, productized software applications and reusable components / services will be developed in phases. Each phase will expand the types of updates, meta data, and visual representations supported as well as the mappings between same.

PHASE I: Based upon the proposed approach, the concept for dynamic data model implementation for context sensitive user interfaces and embedded semantics will be investigated fleshed, refined and coordinated to support a representative Army tactical environment consistent with the evolving Battle Command (BC) migration plan. A reference architecture with dual use (military as well as commercial) capabilities will be developed to support integration and interoperability with enabling Commercial-off-the-shelf (COTS) / Government-off-the-shelf (GOTS) technologies and possibly any technology shortfalls such as metadata configuration agents, services, frameworks and infrastructure. This will be the basis for a phase II design and a demonstration effort.

PHASE II: Based upon the proposed dynamic data management architecture and tools for context sensitive user interfaces and embedded semantics, a flexible extensible reconfigurable and adaptive dual-use data architecture, agents, services, frameworks and infrastructure design and prototyping will be implemented and demonstrated to support technology transition in a laboratory environment. The Laboratory environment should include candidate BC as well as modeling and simulation (MS) federates that will provide data sources subjected to data metadata configuration. Metadata configuration should be supported by a mixed initiative of users and tools with flexibility to utilize available data models or other relevant databases and scenario data.

PHASE III: As a phase III effort, the vision for a flexible, extensible, reconfigurable and adaptive dual-use data model capability, algorithms and technologies will be realized as componentized and productized set of tools, services and intelligent agents to support commercial Enterprise Application Integration (EAI) relevant to any vertical market such as healthcare, insurance, automotive, education and human resources, to name a few, as well as Tactical and or Strategic systems of systems such as Army Battle Command System (ABCS), Future Combat System (FCS) and / or Network-Enabled Command Capability (NECC). In this phase, the JC3IEDM-Service-Oriented Architecture(SOA) Foundation will be enhanced as a core capability integral to the approved Tactical

Information Technology for Assured Network Operations (TITAN) Army Technology Objective (ATO) BC Services to be transitioned to PM BC . In addition, Phase III effort will be productized to enhance Army test beds and exercises and training Programs such as Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) On-the-Move (OTM) Tested (Fort Dix, NJ), Battle Command Training Program (Fort Leavenworth, KS) and Central Technical Support Facility (CTSF)(Fort Hood, TX).

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2. http://www.dbs.ethz.ch/cgi-bin/pap_detail.cgi@190.html

3. http://adenu.ia.uned.es/adaptaplan/pub/informeTIN2007.pdf

4. http://journals.tdl.org/jodi/article/view/237/191

5. http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/7099/19153/00885999.pdf

6. http://st-www.cs.uiuc.edu/users/johnson/papers/dom/DynamicObjectModel.pdf

7. http://research.microsoft.com/research/detail.aspx?id=2

KEYWORDS: Metadata, Adaptive Database Management, Reconfigurable Data Model, Multi-resolution data representation, Dynamic Schemata, User Modeling, Machine Learning, Online patching, Hot Updates, Agents, Services, Frameworks, Scenario Generator.

A08-095 TITLE: Wireless Intra-Soldier Data Reception and Transmission

TECHNOLOGY AREAS: Electronics, Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: To establish a short range intra-Soldier wireless data transfer capability that would transmit and receive imagery and data (i.e. Range, Compass Heading, and Far Target Location coordinates) between Soldier sensor systems and a Helmet Mounted Display (HMD) or other Soldier borne display. The imagery and data are preferred to be transmitted simultaneously.

DESCRIPTION: Enhanced mobility and improved Soldier-system interface are main components of the Mounted/Dismounted Maneuver Force Operating Capability (FOC) doctrine to improve the Soldier payload. The Soldier must be free to explore the widest range of motion in order to have maximum Situational Awareness (SA) and increase survivability. Dismounted Soldier operations include security checkpoint duties, urban operations, and room clearing. Due to the range of operational environments, a variety of sensors and a more integrated Soldier sensor are required. Weapon sight imagery and data to a HMD has improved Soldier integration to a degree. The weapon sight sensor is used for SA, target location, target acquisition, and engagement in short range situations. Imagery and other information can be sent to HMD in order to free the Soldier from having to look directly into the weapon mounted sight. This allows for searching around corners and through doorways without endangering the Soldier using the weapon. Currently, this interface is done with cabling and connectors from the weapon to the HMD, which does not allow for full mobility by the Soldier. The cables are not only restrictive to the Soldier, but are also a source of failure and a safety hazard. The actual cabling and connector can have simple failures, such as an unseated connector, or more complex failures such as broken wires within the cable. These failures are hardware related that are properties of the materials and cannot be avoided, therefore increased preparation time prior to missions is required to verify proper operation of cabled equipment. The military connectors can also have significant weight due to shielding and weatherproofing. Wireless communications and data would allow for more maneuverability which translates into enhanced survivability, as well as lighter weight payload and lower failure rates due to the absence of cabling between the weapon sight and the HMD.

Bandwidth is a major consideration for current and future systems. The bandwidth is driven by the imagery requirements. The requirements for image transmit and reception depend on the Focal Plane Array (FPA) size, 30Hz or 60Hz operation, and the number of data bits. FPA sizes are currently 320x240 and 640x480 and there are plans for larger format arrays in the future. More bandwidth is required for larger FPAs. Current systems operate at 30Hz, but 60Hz is desired because it has been proven to have less latency, meaning better image quality in a highly dynamic environment, which is desirable for mounted and dismounted operations. The bit depth in current systems is between 8 bits for analog systems and 8-16 bits for digital systems. Image and data quality improves with more data bits, but the bandwidth demand increases. Sensor selection will directly impact the bandwidth required and the protocol and method appropriate for wireless transmission. The wireless protocol should be able to handle the existing bandwidth requirements and possibly be expandable for future systems. The minimum imaging existing sensor bandwidth requirement is 320x240, digital 30Hz progressive scan, and 14 bits of digital data. Other data would be on the order of several bit strings at kHz repetition/update rates.

Low Probability of Intercept and Low Probability of Detect (LPI/LPD) is a very important consideration especially in close-in combat situations such as urban warfare or room clearing. If the signals are intercepted, the Soldier's presence and position could be compromised leaving the Soldier vulnerable to attacks. Depending on the information intercepted (i.e. imagery with troop and vehicle positions, GPS coordinates), the adversary may now have more than just the position of one Soldier. The wireless protocol chosen should have a low LPI/LPD. Because the concept is for intra-Soldier data transmission, the initial range for communications is only about one meter.

The desired transmission/reception distance is approximately one meter because it is an intra-Soldier system. The data may only be transmitted between the weapon sight and HMD but intra-squad interference could occur. Intra-squad interference occurs when the data is sent using the same protocol. This could be avoided using a channeling approach that could possibly be expanded for intra-squad communications. The wireless protocol should eliminate intra-squad interference.

Wireless imagery transmission could also have applications with larger mounted weapons and force protection. For the larger weapons, the Soldier could view a remote display instead of directly through the weapon sight. This would allow for the integrated display in the weapon sight to be put in a low power state thus extending the battery life of the system. Wireless cameras to one central display or set of displays could reduce the number of Soldiers needed for force protection/checkpoints and would allow the Soldier to stay more protected by keeping the Soldier out of the line of fire.

PHASE I: Requirements Analysis and Design Study: Requirements for the spectrum over which the reception/transmission occurs and wireless protocol will be analyzed and determined. Digital or Analog data transmission will be examined in relation to bandwidth requirements and image quality. Image and data latency is an important part of the image quality and 'actionable data'. If too much latency is present, it becomes difficult for the Soldier to use the sensor for SA, mobility, and target acquisition, which is directly related to the data rate and bandwidth. The power and weight are very important because this is a Solider borne sensor. Array size for the sensor, data rate, and 30Hz or 60Hz operation directly affects the power and bandwidth. In Phase I, these elements must be considered especially in relation to the sensor choice. A potential baseline design with performance parameters identified will be provided at the end of Phase I.

PHASE II: Prototype Fabrication, Integration, and Demonstration: During this phase a prototype design will be developed and tested using sensors and displays from existing weapons sight sensors and HMD. Two systems would be provided for data collection activities. Single channel imagery data will be evaluated for image quality, power, weight, size, and LPI/LPD. An objective is to simultaneously demonstrate information data transmission. Phase II will assist in determining whether it is feasible and worthwhile to wirelessly transmit data and imagery from a weapon sight or sensor to a head mounted or other display.

PHASE III: The technology may be transitioned or included in PEO Soldier programs such as Thermal Weapon Sight (TWS) or Digital Enhanced Night Vision Goggle (DENVG) or Pre-Planned Product Improvements for existing programs. The technology may also be included in the Advanced Weapon Sight Technology Advanced Technology Objective Demonstration scheduled for FY 10-12. This technology is already being applied for audio for first responders and could be extended to video and data. The technology may be expanded to commercial use by allowing the removal of cables between audio / visual electronics, such as home theater systems.

REFERENCES:
1. PROPAGATION AND PERFORMANCE ANALYSIS FOR A 915 MHZ WIRELESS IR IMAGE TRANSFER SYSTEM. Author: Oktay Felekoglu. Thesis Advisor: Richard M. Harkins. Naval Post Graduate School, 2005.

2. Adapting Future Wireless Technologies. 2001 Ad Hoc Study Final Report. Author: Army Science Board. Chairs: Ginger Lew and Kalle Kontson. Army Science Board, 2002.

KEYWORDS: Wireless, Intra-Soldier, Data Transfer.

A08-096 TITLE: Precision Gyroscopes for Gyro-Compassing in Man-Portable Target Locator Systems

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To develop prototype precision (Navigation Grade: <.01° bias drif and <.003°/root-hour Angle Random Walk) gyroscope(s) for demonstration in a prototype Gyro-Compassing Inertial Measurement Unit (GC-IMU) with ±1mil azimuth accuracy designed for use in man-portable and/or hand-held Far-Target Location (FTL) systems, such as the Joint Effects Targeting System (JETS). JETS is the Army, USMC, and Air Force joint initiative to develop a common man-portable target locator / designator suite for forward observers, air controllers, and scouts. JETS is scheduled to begin production in FY12 and is managed by Product Manager, Soldier Sensors and Lasers. Night Vision & Electronic Sensors Directorate is investing in component technologies for JETS via the Target Location & Designation System (TLDS) Advanced Technology Objective (ATO) number D.CER.2008.03. This SBIR is intended to feed technology into the TLDS ATO, which in turn, will feed JETS. Accurate target azimuth (±1mil) GC-IMU performance shall be achieved within 3 minutes of turn-on/initialization. The size, weight, and power of the objective GC-IMU module (Phase III) shall be suitable for man-portable and/or hand-held FTL systems (<16 cubic inches, <2 pounds, and <3 watts respectively). Along with the technical parameters, GC-IMU setup and initialization procedures shall be evaluated against the constraints of the forward observer's mission. The GC-IMU module will enable man-portable FTL systems (JETS) to achieve the ±1mil target azimuth error required to "call-for-fire" when employing precision guided weapons. The specific intent of this SBIR is to research and demonstrate precision GC-IMU technology for the express purpose of eventual integration into a man-portable and/or hand-held FTL system (e.g. JETS).

DESCRIPTION: This research is specifically intended to address the need for high accuracy azimuth information for man-portable Far-Target Location (FTL) systems. The largest source of Target Location Error (TLE) in the existing FTL systems is in "azimuth". Target azimuth in today's man-portable target locator systems is determined using an embedded Digital Magnetic Compass (DMC). Though current DMCs provide better than 1° accuracy (<17.8 mils) in a benign environment, the accuracy in a tactical field environment is somewhat less due to the errors caused by nearby magnetic disturbances (e.g. vehicles, buildings, power lines, etc.) and local variations in the Earth's geo-magnetic field. In addition, DMCs require cumbersome calibration procedures.

A highly accurate and non-magnetic azimuth sensor based on precision inertial measurement technology is the focus of this SBIR. Vibratory and optical gyroscopes are of particular interest, as well as very high accuracy Micro Electro-Mechanical Systems (MEMS) devices. Resultant technology which demonstrates the required accuracy of ±1mil has a potential transition path into Target Location & Designation System (TLDS) ATO #D.CER.2008.03 and/or JETS. The TLDS ATO (FY08-FY11) will develop and demonstrate critical technology for JETS (e.g. FLIR, Laser Designaotr, and Azimuth & Vertical Angle Module (AVAM). Results/prototypes from this SBIR will be leveraged by the TDLS as a means to explore new innovative AVAM technolgoy, along with other parallel AVAM research conducted under the ATO. The JETS azimuth related Key Performance Parameters (KPP) form the basis for this SBIR's performace objecitves. The KPPs are unclassified and were presented in the public domain at the JETS Industry Day in March 2007 Ultimately, successful technology developed under this SBIR will transition into the JETS System Development Demonstration (SDD) in FY10. In addition, this research fits well in the “dual-use” arena. There is great potential for commercial technology to “spin-in” to this activity and well as for resultant technology improvements to “spin-off” back into the commercial sector. High precision pointing (antennas and telescopes), robotics, aviation, and navigation applications are among a variety of highly relevant commercial markets into which this research could transition.

PHASE I: Requirements Analysis & Design Study: Requirements for the objective Gyro-Compassing IMU (GC-IMU) will be analyzed in terms of the forward observer's mission requirements. Specific performance parameters will be defined for both the gyroscope and GC-IMU. Once the requirements analysis is complete, a notional architecture and performance prediction will be developed.

PHASE II: Prototype Demonstration: During the early part of this phase, precision gryo components will be designed, fabricated, and evaluated to determine their suitability for integration into the GC-IMU. Subsequently, a bread-board GC-IMU will be designed, fabricated, and demonstrated to determine the inherent performance. A sufficient quantity of gyroscopes will be fabricated to demonstrate gyro performance and populate the GC-IMU bread-board. In the later stages of this phase, the GC-IMU will be demonstrated by the contractor. Data shall be collected which focuses on "gyro-compassing" or azimuth measurement performance. A notional design shall be prepared which reflects an objective GC-IMU module for the JETS target locator. The GC-IMU module size, weight, power, performance, and cost predictions will be assessed and analyzed to determine viability of entering Phase III.

PHASE III: Technology Transition: During this phase, the detailed design process will commence for the objective GC-IMU module. A preliminary design of the GC-IMU module capable of being installed into a TLDS / JETS-like target locator demonstration unit. Up to ten CG-IMU modules shall be fabricated and tested. Two modules will be integrated in a JETS or JETS-like host system for demonstration and validation. The remaining modules will undergo performance and environmental testing under the JETS SSD requirements. Results of this phase will be used to determine if the module is suitable for insertion into the JETS low rate production program managed by PM - Soldier Sensors & Lasers (PM-SSL) under PEO - Soldier. Upon successful test and demonstration, the JETS target locator will be type classified and full rate production of the JETS with a GC-IMU will begin. Additionally, the test and evaluation information will be shared with the commercial sector enabling “spin-off” into commercial applications.

REFERENCES:
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2. Comparison of Hemispherical Resonator Gyro and Optical Gyros, Matthews, A. Rybak, F.J., Aerospace and Electronic Systems Magazine, IEEE, Publication Date: May 1992, Volume: 7, Issue: 5, page(s): 40-46, ISSN: 0885-8985, Digital Object Identifier: 10.1109/62.257091, Posted online: 2002-08-06 18:31:27.0.

3. Hemispherical Resonator Gyro for Precision Pointing Applications, Anthony D. Matthews and David A. Bauer, Hughes Delco Systems Operations (USA), Proceedings of SPIE -- Volume 2466 - Space Guidance, Control, and Tracking II, Walter J. Fowski, Morris M. Birnbaum, Editors, June 1995, pp. 128-139, doi:10.1117/12.211500.

KEYWORDS: Inertial Measurement Unit (IMU), Forward Observer (FO), Digital Magnetic Compass (DMC), Joint Effects Targeting Systems (JETS), Precision Guided Munition (PGM).

A08-097 TITLE: Standoff Detection of Improvised Explosive Devices (IEDs), Explosively Formed Penetrators (EFPs), or Landmines

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: The objective of this SBIR topic is to investigate emerging technology approaches having the capability of detecting and identifying improvised explosive devices (IEDs) and explosively formed penetrators (EFPs), or landmines; at standoff distances of between 100 meters to 250 meters. The candidate technology should also enable the warfighter to attain a 30 kph rate-of-advance while traversing an area having IEDs, EFPs, and landmines.

DESCRIPTION: The Countermine Technology Branch, of the Science and Technology Division of the Night Vision and Electronic Sensors Directorate, has an interest in technologies for detection of IEDs, EFPs, and landmines. The explosive fill material may be TNT, RDX, HMX, or PETN. The sensor must either identify the presence of the device, or the explosive, the explosive detonator or uniquely identify the commonly used metal containers. The following cases are of interest:

For case one the sensor will confirm the presence of an IED, EFP, or landmine that is detected by other means. The amount of explosive in the device may be from 300 gm to 20 kg. The minimum standoff distance is 100 meters and the minimum identification time is 120 seconds. Longer standoff distances and shorter times are desirable. The larger items in this class are commonly mortar or artillery shells. The explosive may be encased in a steel or other metal container of up to 4 mm in thickness. In addition for larger explosive devices the explosive may be buried under 12 cm of rocks or soil. The generic detection of a piece of metal without identification as an IED, EFP, or landmine is not of interest for this case.

The second case involves the primary detection of an IED, EFP, or landmine at standoff distances of 100 m or more. For this case the IED is a mortar or artillery shell and may be covered by rocks or other material. The detection of a large obscured metallic object at these distances is of interest for this case. The sensor must scan a 4m wide path and be capable of moving at speeds greater than 30 kph.

PHASE I: This proof of feasibility phase will focus on laboratory and limited field investigation of IED, EFP, or landmine detection technique(s) as a potential candidate for application in a tactical system. The sensitivity of the mine detection technique to discriminate IEDs, EFPs, or landmines from clutter objects will be determined. Phase I will include a demonstration to experimentally confirm the lab results and analyses by utilizing a variety of appropriate IEDs, EFPs, and landmine types and emplacement scenarios.

PHASE II: The purpose of this phase is to design and fabricate a brassboard field data acquisition system and to use this field data acquisition system to experimentally confirm the detection capability under varied conditions. Practical application of the technology, including proposed host-platform integration, will be investigated. Estimates, with supporting data, will be made of size, weight, power requirements, speed, Pd, false alarm rate and positional accuracy. Even at this stage all specifications such as detection time need not be met but the contractor must show a straightforward path for meeting all the requirements. A demonstration of the technology will be performed at the contractor's facility.

PHASE III: A prototype system will be created during Phase III. Extensive field data collections against target simulants/surrogates will be performed at Army facilities. This technology may have numerous alternative applications in asymmetric warfare, airport security, border security, etc.

REFERENCES:
1. A host of information regarding the current state-of-the-art in mine detection can be obtained through the following conferences: SPIE Defense and Security Symposium (Detection and Remediation Technologies for Mine and Mine-like Targets Session) in Orlando, FL; Mine Warfare Conference; and UXO Detection and Remediation Conference.

KEYWORDS: Explosives detection, IED detection, landmine detection, EFP detection.

A08-098 TITLE: Stabilized Laser Beam Pointing

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Design and build a portable, robust, and lightweight breadboard system to reduce beam pointing error of existing designator and marking lasers. The design will allow handheld operation of laser designation and marking systems by reducing pointing error to less then 100 urad. The beam stabilization will also have an error signal feedback capable of stabilizing an aiming sight. The developed system may be integrated internally or attached to an existing laser designator.

DESCRIPTION: Laser designation and laser marking is critical in today's high precision combat environment. Laser designation and marking performance is limited by how well the user can hold the laser beam onto the target. The current solution to minimize beam pointing error is to provide a 'stabilized' mount. This is usually a fairly heavy tripod. The goal is to reduce this weight and volume to where handheld operation of laser designation/marking is feasible. Electrical, mechanical, and other stabilization methods are acceptable.

PHASE I: Design, simulate, and test high risk components of the design that can reduce pointing error. Demonstrate in a lab environment reduction of the pointing error. Deliverables include monthly reports, any simulation code used, test results, and a detailed design in the final report. The Phase 1 final report will also document the effects of varying wavelength, from NIR to 1550nm, varying energy of the laser, and varying power of the laser. Design tradeoffs of weight, beam pointing accuracy, and power usage will also be discussed in the report.

PHASE II: Demonstrate and deliver a breadboard system capable of reducing laser pointing error. Breadboard system should have a design path to reduce the weight to less then 5 lbs, on power draw of less then 20W, operable between -30C to 50C, and to a size less then then 8 cubic inches. This design path will be documented in monthly reports and a final Phase 2 report.

PHASE III: This research can quickly be applied to the military application of laser designators. Dual use applications include laser rangefinders, laser warning devices, laser illuminators, laser markers, and laser pointers. Increasing the aiming accuracy of our military systems will allow increased mobility and lethality of our soldiers.

REFERENCES:
1. Joint Publication 3-09.1, Joint Laser Designation Procedures
http://www.dtic.mil/doctrine/jel/new_pubs/jp3_09_1.pdf.

2. FM 6-30, Tactics, Techniques and Procedures for Observed Fire
http://www.usmc.mil/directiv.nsf/a59f722371d5130e8525716f004f0d8f/1f3dfce146f45dd085256f580064ea7c/$FILE/FM%206-30.pdf.

3. Lightweight Laser Designator Rangefinder Brochure
http://www.dsd.es.northropgrumman.com/DSD-Brochures/laser/LLDR.pdf.

4. SOF Laser Marker (SOFLAM) AN/PEQ-1
http://www.globalsecurity.org/military/systems/ground/an-peq1.htm.

5. Ultralight Laser Designator Development
http://www.dtic.mil/ndia/2004armaments/07_Nettleton_Ultralight_Laser_Designators.pdf.

KEYWORDS: Laser rangefinding, laser pointing, laser illumination, laser designation, laser marking, platform stabilization, tripod replacements.

A08-099 TITLE: Optimal Detection of Buried Improvised Explosive Devices (IED's) in Clutter

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: In this research the Army seeks to utilize physics-based thermal scene models to study the relationship between disturbed earth thermal signatures and thermal clutter. Based on understanding of this relationship an optimal time to detect buried IED's in clutter can be determined.

DESCRIPTION: IED's are commonly hidden below ground in strategic locations. Evidence of these buried IED's can be detected by sensing temperature differences between where the excavation occurred and the surrounding undisturbed soils. However, in a remote sensing mode it is difficult to differentiate between temperature differences due to disturbed soil and those differences due to clutter or other natural variations in the background, e.g. rocks, depressions, shadows, vegetation, etc. Temperature differences also arise because of small variations in the energy balance due to location and geometry. For example, one side of a rock may receive direct solar heating while the other side is shadowed or a bush may receive more convection than the surrounding soil because of the wind velocity gradient. Guard rails along the roads also cast shadows on the shoulders and medians.

There are fundamental differences in how heat is transferred in the soils when compared with objects giving rise to thermal clutter. Because of these different heat transfer mechanisms and boundary conditions the diurnal cycle drives the heating and cooling of each scene item differently. Consequently, there may be times when the disturbed soil signature is much higher than the clutter signature.

By employing a thermal scene model it may be possible to identify periods of time during the diurnal cycle for a given theater of operation with classes meteorological conditions where the probability of detection the highest with the least number of false alarms. These large scale models allow the study of an aggregate of clutter sources. Consequently, the proposed research is to develop a methodology to identify the best time intervals to detect disturbed soil where IED's may be buried.

PHASE I: Develop several scenes, run the model, and develop the supporting analysis to prove that the concept has merit. It will be important to look at the scene, disturbed soil, and meteorological variability to develop a statistical analysis. It is also important to research how the volumetric soil parameters change between undisturbed and disturbed soil. Perform comparisons between predictive models and empirical data to generate a quick-look model validation.

PHASE II: Develop a methodology for creating a tactical aid which can be hosted on a single processor PC. This tactical aid will use the results of the Phase I study and further Phase II efforts to develop a statistical data set for given theaters of operation. The idea is to enter the forecasted meteorology for a diurnal cycle in a given theater of operation and the decision aid will output a plot or merit rating considering the detectability of disturbed soil and clutter levels versus the time of day. Threshold levels would indicate "go times" for various thermal sensor types.

PHASE III: Military application: Tactical decision aide for mission planning for the detection of buried IED or mine-like targets from air or ground platforms.

Civilian application: Just like buried military targets, the disturbed earth above buried utilities give off a unique signature in the infrared that varies with time of day and environmental conditions. Utility locations are often undocumented or are otherwise difficult to find using other detection means. A planning tool could be developed to allow construction crews to find the best time to locate underground utilities using infrared sensors.

REFERENCES:
1. 1-D Thermal Modeling of Layered Materials in Outdoor Environments. Countermine Phenomenology Program, Curtis, John O., Feb 06

2. Modeling the Thermal Signature of Natural Backgrounds, Gamborg, Marius, Aug 02

KEYWORDS: Heat transfer, IED, sensing, sensors, detection, thermal signature, infrared.

A08-100 TITLE: Visible to Shortwave Infrared Solid State Silicon-Germanium Imaging Camera 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 3.5.b.(7) of the solicitation.

OBJECTIVE: To develop and demonstrate a solid-state visible through shortwave infrared (SWIR) silicon-germanium based imaging camera. The goal is to develop a low cost, small in size and weight, low power, solid-state silicon and/or germanium imaging sensor as a video based technology. A cost effective SWIR sensor utilizing covert illumination would be an effective low light level imaging device as an alternative to image intensifiers on various platforms.

DESCRIPTION: The Army requires alternative digital imaging sensors that are capable of taking advantage of covert illumination relative to proliferated devices and may be fused with other solid state sensors such as Image Intensified Charge-Coupled Device (I2CCD), Medium Wavelength Infrared (MWIR) and Long-Wave Infrared (LWIR) for cave and urban assault missions. Conventional silicon Charge-Coupled Devices (CCDs) and Complementary Metal-Oxide Semiconductor (CMOS) imagers are currently incapable of imaging wavelengths beyond 1.1um to achieve active imaging using a low power infrared illumination source. This topic seeks to develop a mega-pixel, low cost, solid state Silicon Germanium (Si-Ge) imager operating at normal video rates. To achieve required performance the solid state silicon-germanium sensor/imager should be of 1k X 1k format (minimum), 10um pitch or less, 30 Hz operation minimum with 60Hz operation desired, and a spectral bandwidth that includes 0.4 – 1.6um. The system should allow for an integration gate or trigger operation from microseconds to full frame. The sensor performance should be approaching that of lattice matched InGaAs with nominally low dark current.

PHASE I: Demonstrate the technical feasibility of the proposed approaches through design and analysis. The proposed design shall be optimized for low dark current, low read noise, large dynamic range and linearity, low power, and high sensitivity. Test circuits or small format arrays to demonstrate the design concepts are highly desirable in the phase I effort.

PHASE II: Using the results of phase I effort, build, demonstrate and deliver a compact packaged solid state silicon-germanium imager/camera system with significant response from 0.4 – 1.6um that can be evaluated in laboratory and field test conditions. The delivered Ge imaging system is desired to have low noise closed cycle cooling capability that can be stabilized from 150K to near ambient temperature. Demonstrate a clear path to low cost production.

PHASE III: The commercialization of this technology is expected to provide low cost, high performance mega-pixel imagers for potential uses in variety of commercial applications including transportation, security/law enforcement, medical imaging, border patrol, homeland security as well as military applications such as night vision devices.

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KEYWORDS: Shortwave infrared, germanium imager, digital imaging sensors, camera, manportable, solid state sensors.

A08-101 TITLE: Advanced System Tunability for Infrared (IR) Imagers Using Enhanced User-Controlled Parameters

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: To develop, design, and build a flexible, high performance brass board system for operating and evaluating the Army's high performance advanced multi-color cooled infrared focal plane arrays. The Army currently has programs that are producing large format, high frame rates multicolor infrared focal plane arrays (IRFPAs). There is a need to develop a versatile system/brass board that will be use to operate and evaluate these IRFPAs. The system shall be compact in design, as well as rugged for field testing and data collections. The system shall address the U.S. Army advanced IRFPAs functionalities such as variable F number, and dual color MW, LW capability.

DESCRIPTION: The Army currently has programs that are producing advanced large format, high frame rates multicolor IRFPAs. There is a need to develop a versatile system/brass board that will be use to operate and evaluate these infrared focal plane arrays.

PHASE I: Phase 1 is a feasibility study to determine the camera parameters that will best optimize the imaging performance of advanced IR camera systems. Historically the end user has been constrained to adjusting just the gain and level system parameters. The problem with this approach is that it ignores optimizing other important imaging parameters like integration time, field of view, waveband, and dynamic range adjustments. What is needed is a system of systems solution, transferable to any imaging system that will permit system tunability by allowing the user access to more knobs to tune – knobs that will allow for obtaining the best signal to clutter ratio. To date this does not exist and imaging systems are seldom optimized at the component level, to say nothing of optimizing at the system level. This topic will allow for schemes to capture better camera tunability by looking at the correlation between optimized component and system parameters. This parameter space has not yet been explored and phase one will establish a roadmap for the pertinent imaging parameters.

PHASE II: Phase 2 will demonstrate a simple system with algorithms for optimized component/system parameters. As a start a system with capabilities to simply image simultaneously in the midwave and long wave should be considered. Once established for this common spectral range, extension of the protocol to cameras with multiple spectral tunings will be considered. The prototype system must allow for task specific tunability with the end goal of improved probability of search and identification. The system should be worthy of both lab and field testing and address the U.S. Army advanced IRFPAs functionalities such as variable F number, and simultaneous operation in at least 2 bands. The system electronics portion shall have the capability to digitize the IRFPA signals, perform signal processing functions such as non-uniformity corrections, pixel substitution etc. and be able to display and store the image in real-time.

PHASE III: Transition this system of systems concept and associated imaging functionality to the commercial infrared industry. The successful design and development of this system would benefit the military as well as the commercial infrared industry. This path finding technology development will benefit ongoing DOD programs involving the use of multi-spectral and hyperspectral imaging approaches. This technology will allow the commercial infrared industry to manufacture imaging systems with enhanced functionality and the ability to obtain better signal to clutter ratios by the use of internal calibrations not presently employed.

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1. Nahum Gat, Jingyi Zhang, Ming De Li, “Variable Cold Stop for Matching IR Cameras to Multiple F-number Optics”, SPIE Proceedings 6542, Infrared Technology and Applications, XXXIII, Defense and Security Symposium, Orlando FL 2007.

2. Paul Norton, Jim Campbell, Stuart Horn, Don Reago, “Third Generation Infrared Imagers”’ Proceedings of SPIE Vol. 4130, pp 226-236, Orlando FL 2000.

KEYWORDS: Advanced IRFPA, infrared, cooled, focal plane array.

A08-102 TITLE: Cathodoluminescence Defect Characterization for Medium Wavelength Infrared (MWIR) and Long-Wave Infrared (LWIR) HgCdTe

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop and demonstrate cathodoluminescence defect characterization tool for HgCdTe in the MWIR (3-5 micron) and LWIR (8-12 micron) bands.

DESCRIPTION: The army is interested in large format small pixel Focal Plane Arrays (FPAs) for persistent surveillance and the operability and density of defects is too high resulting in a high cost for these FPAs. Dislocation defects reduce the quality of HgCdTe epilayers. Devices produced using layers with high dislocation defects have a corresponding reduced quality. Identifying and understanding these defects is a crucial first step in reducing their numbers. Cathodoluminescence (CL) imaging has been shown to reveal dislocation defects in CdTe. Dislocation defects are non-radiative recombination centers and are thus revealed by a luminescence contrast between the dislocation and the radiative recombination occurring in dislocation-free areas of the crystal lattice. CdTe crystal material provides CL emission in the near visible spectrum, whereas MWIR and LWIR HgCdTe and related materials will provide CL emission in their respective bands.

An innovative solution allowing the defects to be revealed in the MWIR and LWIR is sought. The CL imaging tool will have to take into account the carrier diffusion length of the material and smaller bandgap to achieve the ultimate quality of the CL images that can be achieved in the MWIR and LWIR domains. The goal of this solicitation is to translate the successes of CL defect imaging in the visible and near-visible out to the MWIR and LWIR levels. Successful CL imaging of MWIR and LWIR materials providing dislocation defect characterization will provide an important material benchmarking tool for the infrared community.

PHASE I: Develop concept extending the operation of cathodoluminescence systems from visible, near visible and SWIR operations to MWIR and LWIR bands. Propose a cathodoluminescence defect characterization concept and a device architecture that could implement this concept.

PHASE II: Fabricate and test a prototype MWIR and LWIR cathodoluminescence defect characterization system based upon the Phase I design. Test the device and compare imaging results to established defect characterization methods such as a dislocation highlighting etch.

PHASE III: Cathodoluminescence defect inspection technology will find potential as an improved MWIR and LWIR material defect characterization for the military, space and medical infrared industries. The improved defect characterization is desired in these industries to contribute to the better understanding of these defects so that they can be reduced, consequently leading to lower costs of detector fabrication.

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3. G. Salviati, et al, Applied Physics Letters 65, 3257 (1994).

KEYWORDS: Cathodoluminescence, infrared, MWIR, LWIR, defects, defect characterization.

A08-103 TITLE: Passivation Innovations for Large Format Reduced Pixel pitch strained layer superlattice Focal Plane Array Imagers Operating in the Long Wavelength Infrared (LWIR) Band

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Develop large format reduced pixel pitch strained layer superlattice Focal Plane Array LWIR Imagers.

DESCRIPTION: Persistent surveillance missions require the continuous observation of roadways, road junctions, and other areas of interest from platforms operating at low, medium and high altitude. large format reduced pixel pitch (sub 15 micron) strained layer superlattice Focal Plane Array (FPA)imaging sensors would be ideal to meet this mission, however the requisite high aspect ratio etching and/or steep sidewalls of these FPAs have not had enough process maturation resulting in excess surface current which manifest itself in noise in the imager display and results in non-optimal imager performance.

Recent advances in sidewall passivation such as SiO2, SiNx and polyimide have shown the potential to protect the devices during FPA fabrication and reduce the effect of stress and surface states on the electrical performance of the FPA pixels and increase the overall FPA operability. An innovative passivation solution is sought which reduces surface currents and allow demonstration of a large format reduced pixel pitch strained layer superlattice Focal Plane Array Imager.

PHASE I: Perform an initial feasibility study and preliminary design of the sub 15 micron pitch large format strained layer superlattice Focal Plane Array Imager. This includes a passivation concept, to include chemical species and application process details. The design should allow for 50% or greater external quantum efficiency and the noise mechanisms to be diffusion limited at 77K.

PHASE II: Design, fabricate and demonstrate a prototype large format reduced pixel pitch strained layer superlattice Focal Plane Array Imager. A final design will be produced following review of the Phase I work. The detector will be fabricated and demonstrated to show that it can meet performance goals for the persistent surveillance mission. The goal is to produce a working prototype with sub 15 micron pixel pitch. The prototype array needs to be 99.9% operable with the material having greater than 50% external quantum efficiency and the noise mechanisms to be diffusion limited at 77K.

PHASE III: Develop a plan for the large scale production of advanced sub 15 micron pixel pitch large format strained layer superlattice Focal Plane Array Imager. Demonstrate successful sensors for military persistent surveillance missions and commercial applications.

Devices based on the structures to be fabricated during this project could be used for persistent surveillance, night vision and poor weather imaging for military operations, night driving, aircraft landing, commercial trucking, ship navigation and search and rescue; target identification; surveillance; fire rescue in smoke-filled environments; industrial applications such as process control, large area temperature monitoring and preventative maintenance; environmental monitoring for pipe leaks, hazardous material spills, automobile exhaust emissions, and the status of high power electrical systems; and non-invasive medical measurements of temperature for tumors and blood flow.

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KEYWORDS: Passivation, strained layer superlattice, sls, Focal Plane Array, fpa, long wavelength infrared, LWIR.

A08-104 TITLE: <u>Armor Embedded Metamaterial Antenna</u>

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Design a metamaterial antenna embedded in the vehicle armor. Ballistic performance of the armor and electrical performance of antenna is maintained after ballistic testing. Metamaterials will be used to improve antenna performance in the reduced size form factor necessary to integrate these antennas into the vehicle armor, reduce antenna to platform coupling, and improve soldier safety.

DESCRIPTION: Current antennas are subject to gunfire to in order to destroy the antenna and reduce the effectiveness of the systems using those antennas. Designing a survivable, low profile or conformal antenna would reduce the enemy’s ability to target and destroy vehicular antennas. Antennas embedded in ballistic armor have a number of unique advantages. Ballistic material types will add to the survivability of the antenna. Antennas will be conformal to the vehicle, and because armor material types are common to many vehicles across the army inventory, a single armor embedded design can be made modular to be used across many army vehicles. The use of metamaterials is also a key component in this design. Suitable armor locations for mounting embedded antennas will be greatly limited; therefore real-estate must be optimized. Metamaterials, present the opportunity to reduce the antenna size to 1/10 their original size.

Additionally, metamaterials can be used to reduce currents that flow on the vehicle platform this will make the antenna performance more independent of the vehicle on which it is mounted. Reducing the currents on the vehicle will additionally improve soldier safety by reducing the shock hazard associated with vehicular currents. This is a challenge with all embedded antennas. This SBIR directly supports the Breakthrough Antenna Technologies (BAT) ATO. Customers interested in the topic DARPA , PM - FCS, PM - CREW, PM – WINT.

This topic addresses PEO C3T T2 Matrix gaps: Army practice is to add military C2/EW systems to the military platforms after the vehicle has been assembled rather than during the assembly process. The intent is to identify opportunities to integrate military systems during vehicle manufacturing process. MBCOTM ORD, February 2005; SICPS CPD 8 August 2005; SICPS ORD 8 July 2004; JLTV Industry Day, 2 August 2006.

PHASE I: The Phase I effort will result in research, analysis and simulation results of armor embedded metamaterial antennas. This will determine the types of antennas, armor, and metamaterials that best compliment each other within an antenna design. This research will also determine the frequencies, bandwidth and waveforms to which this technology is most applicable.

PHASE II: Application specific armor geometry will be chosen in Phase II. Platforms that are targeted by the BAT ATO will be candidate platforms for this phase of the program (FCS, Stryker, MRAP, etc). Deliverable from this phase will be a metamaterial antenna embedded within the vehicle armor that will withstand ballistic testing, and maintain an acceptable level of electrical performance.

PHASE III: For military applications, this product will directly support the Breakthrough Antenna Technologies (BAT) Antennas ATO in designing conformal, survivable, multifunction antennas for Stryker, MRAP, FCS, and other tactical vehicles. In the end state, antennas for communication, CIED, and other Electronic warfare applications will be directly integrated into the tactical vehicle. Much of the research from this SBIR also has potential for commercialization. Research in to Armor Embedded Metamaterial Antennas will produce a wide breath of information on conformal metamaterial antennas that can be applied to the auto, and aircraft industries for designing smaller conformal antennas. These conformal and survivable vehicular antennas could be used for local Fire and Police forces, and federal forces such as the FBI, Home Land Security, CIA, and IRS for covert operations and search/rescue missions.

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2. Novel Electrically Small Antennas and Metamaterial High Impedance Surfaces, SEP 2005, Office of Naval Research Grant Number:N00014-04-1-0619.

KEYWORDS: Survivable, low profile, conformal, antenna, metamaterial, armor, multifunction, ballistic.

A08-105 TITLE: <u>Multicast Admission Control for Multi-Domain Secure Ad Hoc Networks</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: This SBIR program will be developing a multicast admission control technology/scheme that works with existing multicast routing protocols in secure multi-domain mobile wireless ad hoc networks. The SBIR will not be developing a new multicast routing protocol, but rather will be developing an approach that can work with existing multicast routing protocols to provide an admission control mechanism for multicast traffic for added message reliability. The approach shall operate within red-black networks, where multicast traffic originates from users residing in red enclave networks and traverses through black or colorless core networks before reaching other users in red enclave networks. The solution must also work across multi-domains that are operating with different unicast and multicast routing protocols in order to provide inter-domain admission control.

DESCRIPTION: The majority of traffic in military networks is inherently multicast in nature. Therefore, providing quality of service (QoS) to multicast traffic is of the utmost importance. This topic deals with developing a technology for admission control of multicast traffic in secure mobile ad hoc networks, where multicast traffic can traverse from one enclave to others over a diverse set of domains that are operating with different unicast and multicast routing protocols and having a diverse set of wireless links with varying bandwidths. Proving QoS to users within these environments is a challenge. The solution must work not only within a single routing domain, but should also be applicable between different multi-domain networks to provide inter-domain admission control. The technology of admission control should work with existing widely used multicast protocols, to include the Protocol Independent Multicast (PIM) routing protocol,as well as with existing QoS mechanisms such as Differnetiated Services (DiffServ). The work performed under this topic is applicable to WIN-T and any other network that connects to it.

There is a need for reliable or guaranteed delivery of multicast traffic in commercial and military mobile ad hoc networks. To provide this guarantee, various networks offer QoS mechanisms such as Diffserv, however, it this not sufficient to guarantee that multicast traffic will reach the intended recipients, because Diffserv mainly provides differentiation between various traffic flows/types. Other mechanisms, such as reliable multicast protocols operating within a network, are available to provide reliability of traffic delivery. An innovative research in admission control mechanisms is sought for multicast traffic given that both or one of the above mentioned mechanisms exist in the network. The admission control methods can either allow or reject new multicast sessions or new receivers and sources from joining based on knowing of the fluctuating network conditions. This offers added guarantees to existing recipients that their level of quality does not degrade.

There are admission control techniques currently available for admitting unicast traffic based on probing or actively measuring available resources. However, for multicast traffic, admission control techniques are at a research stage, addressing various difficulties that are arising with the nature of multicast in general. This effort is unique in the sense that it is looking at developing an implementation of admission control that can operate not only with in a single multicast domain, but which can also operate over multiple heterogeneous multicast routing domains. Commercialization potential is strong with the advent of IPTV over cable and video conferencing over the internet The effort will be supporting military networks of the future like PM WIN-T and FCS, through the PILSNER and Network Design Programs. All of these are dealing with a dynamic wireless mobile network environment having heterogeneous network links. In this environment, the network nodes are all wireless nodes and can have multiple front-end RF links. This includes diverse RF links including high bandwidth links, low bandwidth links, satellite links, etc., all of which would be available at each of the mobile network nodes. All nodes are assumed to be mobile at any given time. There is no fixed stationary communications network infrastructure. Network traffic type is to be assumed to comprise VoIP, data and video and mainly utilizing multicast transmission, unicast and broadcast modes. Proposers shall address commercialization of this technology accordingly. Partnership/collaboration with academia is highly encouraged.

Proposed multicast admission control methods shall:
1. Operate with in single multicast routing domain as well as multiple heterogeneous multicast routing domains. An example is one domain operating PIM-SM multicast routing protocol and the other operating Multicast Dissemination Protocol (MDP). Hence, the technique should work within a single PIM-SM domain as well as between PIM-SM and MDP domains.
2. Be scalable in terms of both the number of users per session and number of sessions that it can handle.
3. Be simple enough that it works with existing multicast routing protocols.
4. Work with both IPv4 and IPv6 addressing structures.
5. Work in networks with dynamic receivers and sources.
6. Have some security and be able to operate within red-black networks having security constraints such as outlined in PILSNER program.

PHASE I: This effort will entail a preliminary multicast admission control architecture and design plans with identified requirements, techniques, algorithms and methodologies. Relevant experimentation suitable for feasibility of practical implementation of the admission control techniques will be indentified. Innovative and mature techniques, algorithms and mathematical models from all areas of network protocols are encouraged. The Phase I effort can include proof-of-concept implementations and laboratory demonstrations through modeling and simulation. All types of trade-off analyses and results are encouraged. The result of Phase I must be a high level design showing all proposed approaches and their interactions with existing routing protocols. Proof-of-concept demonstration is required.

PHASE II: This effort shall fully implement the admission control mechanisms as outlined in Phase I. It shall also include the porting, characterization, testing, and lab demonstration of the implemented design. The overall goal is to fully develop the designed mechanisms that can then be verified with modeling and simulation tool and/or a small network simulation with relevant nodes.

PHASE III: Commercial applications: Mobile telecommunication networks for Commerce and Homeland Defense, IPTV service from cable providers. Video conferencing over the Internet. Ad hoc network for the first responders. Military Applications: WIN-T, JTRS, Sensor networking, Future Combat System (FCS).

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KEYWORDS: Multicast in Mobile Ad- Hoc Network (MANET), Admission Control, Multi-domain technology, On-the-Move communications, multicast gateways, Multi-layer protocols, Quality of Service Protocols, MANET Unicast Routing, MANET Multicast routing.

A08-106 TITLE: Advanced Cooling for Satellite Communications On-the-Move Antennas

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To develop advanced cooling techniques for satellite communications (SATCOM) on-the-move (OTM) antennas to enable smaller antenna systems with higher radiated power and lower input power requirements.

DESCRIPTION: Current cooling systems for satellite communications (SATCOM) on-the-move (OTM) antennas are large and relatively inefficient air to air or air to liquid cooling systems. The challenge is to reduce the size and simultaneously increase the efficiency of these cooling systems.

These cooling systems will be utilized in Satellite Communication (SATCOM) antennas for the Warfighter Information Network-Tactical (WIN-T). These on-the- move SATCOM Antennas are for Global Broadcast Service (GBS), Wideband Gapfiller Satellite (WGS) and Advanced Extremely High Frequency (AEHF). Currently, these antennas suffer from excessive power consumption and a resultant heat removal problem. The current heat exchangers required for phased arrays are 7 inches high, turning a low profile antenna (< 5 inches high) into a high profile antenna (> 12 inches high).

It is desired that the cooling solution be applicable to as many low profile antenna systems as possible. The cooling system should add no more than 4 inches to the antenna height. Phased array advances have made them <2 inches high, resulting in a complete antenna system <6 inches high. The cooling solution needs to remove up to 600 watts of heat without adding more than 4 inches (2 inches desired) to the height of a phased array. Heat pipes and microcapilaries are examples of newer technologies that need to be considered to reduce the size and weight and increase the efficiency of heat exchangers for phased arrays. Specific requirements vary according to the design of the array. A 20 GHz receive array with 512 receive elements required a 1.5 KW heat exchanger to remove 560 watts of heat. Some future applications may require removal of >1KW of heat. An example heat exchanger needs to be able to transfer the required 600 watts of heat from a 24 inch diameter phased array (with MMIC amplifiers evenly spread across the area) to the mechanical structure with forced air over the heat removal fins on the structure. Efficient coupling from the MMIC packages to the heat exchanger is critical. In one array, a Chromerics product used to couple the MMIC devices to the heat exchanger added such a high thermal resistance that the cooling system needed a redesign. Universality and/or adaptability of the cooling system will provide the Communications On The Move (COTM) terminal developers the ability to integrate an efficient compact cooling solution regardless of antenna type.

Systems must operate from -40 to +71 degrees Celsius. The high temperature includes the effect of solar radiation. MMIC device temperatures in the arrays must be limited to +85 degrees Celsius.

The acceptable cost for a single band phased array with an integral cooling system <$100K. The cooling solution needs to be <5% of the total cost or <$5K.

It is therefore highly desirable to both shrink the current cooling systems and enhance cooling efficiency simultaneously. A smaller, lighter, and more efficient cooling design will provide for both Maneuver Support through savings of Communications On The Move (COTM) terminal overall Size Weight and Power (SWaP) and Force Protection by lower the visibility (optically and thermally) of the communication system.

PHASE I: The Phase I effort will consist of research to determine new cooling technologies available to apply to cooling low profile antennas including but not limited to phased arrays. Systems utilizing techniques such as heat pipes and microcapillaries, among other technologies, will be considered. Low profile, high efficiency and cost will be used as factors in evaluating new technologies.

PHASE II: Utilizing research information gathered in Phase I, preliminary designs for alternative prototype cooling systems will be undertaken. These designs will be finalized and preliminary cooling prototypes fabricated and tested for cooling capability, low profile, and cost. The most promising of the systems will be chosen for design refinement and construction of a final deliverable prototype. The cooling system prototype will be demonstrated by the contractor to highlight the cooling performance and low profile. The production cooling solution should add no more than 5% to the cost of a phased array, be <4 inches in height (2 inches desired) to remove up to 600 watts of heat. Projected production cost will also be given.

PHASE III: PM WIN-T program dish antennas and multibeam phased arrays for GBS, Wideband Gapfiller and Advanced EHF. Commercial phased arrays for high data rate communications.

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Thermal and Mechanical Simulation and Experiments in Microelectronics and Microsystems, 2004. EuroSimE 2004. Proceedings of the 5th International Conference on 2004 Page(s):423 - 428.

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KEYWORDS: Low profile, efficient, cooling, COTM, Communications On The Move, antenna, reliability.

A08-107 TITLE: Secure IPv6 Multicasting

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: To produce a technical architecture and a detailed implementation description of Secure IPv6 Multicast that successfully functions within the typical constraints of the tactical operating environment, including an evaluation and demonstration of an architecture to support group policy management and a scalable key management process. Typically tactical networks at and below the brigade suffer from many constraints which will not occur at higher echelons and in commercial applications. The timing, power (signal to noise ratio, Shannon's Law) and frequency constraints will have greater variability due to their asynchronous nature and relative location (i.e. distance, terrain) than their upper echelon or commercial alternatives. Consequently the radio networks and supporting crypto logical infrastructure which supports them must have a greater degree of tolerance for this variability.   At the same time whatever cost savings which may be achieved by adapting workable commercial products should be taken advantage of in these fiscally constrained times when technically feasible.

DESCRIPTION: Multicast is commonly implemented by the Army because it greatly improves the efficiency of bandwidth utilization in low-bandwidth tactical network environments and for purposes of operational synchronization. However, multicast security is much more complex to implement than point-to-point unicast security. Multicast security has two components: multicast group management and multicast key management. The vendor is to develop a technical architecture and an implementation description for both components using IPv6.

Successful implementation will:
• Maintain confidentiality of group membership. The network should be immune to the greatest degree possible to enemy traffic analysis while permitting friendly force network analysis, network diagnosis, and data collection.
• Provide admission control to a secure multicast group by authenticating the identity of potential multicast participants prior to registering with the multicast group.
• Provide a group key management protocol that is scalable throughout the area of operations in which the echelons below brigade will operate and maintain a capability to interface to higher echelons and supporting units.

• Authenticate the sender of the original multicast message.
• Ensure the integrity and confidentiality of multicast messages.

PHASE I: Evaluate the use of IPv6 with various multicast security (MSEC) group management architectures and the Group Key Management Protocols (GKMP) currently being developed by the IETF and determine their applicability to tactical applications and networks. Conduct a scalability analysis that is representative of the scope of the tactical operational environment.

PHASE II: Using an emulation or live test bed environment, configure the selected architecture and protocols for implementing IPv6 multicast security. Include wired and wireless networks and real-time applications (voice, video, or streaming) to measure the efficiency of the key distribution and authentication protocols.

PHASE III: Develop an implementation guide that includes the protocol implementation/option details (i.e., technical architecture) and software installation instructions for the wide-scale deployment of secure IPv6 multicast, given a government-furnished operational and system architecture. The guide shall be detailed enough to serve as a configuration manual/reference. Develop and provide or identify the source of all necessary software modules or protocols. Include instructions for executing all required IETF RFCs and their configuration options. Provide instructions for all aspects of the deployment, including group membership admission control, authentication, and confidentiality; group key management; message integrity and confidentiality; and message source authentication. Use the findings of this phase and the previous phases to optimize the configuration that will be recommended in the guide.

The end product will serve as the reference technical architecture for secure IPv6 multicast in a tactical environment, and be transitioned to all Army programs of record required to implement IPv6.

REFERENCES:
1. RFC 3740: The Multicast Group Security Architecture.
This document provides an overview and rationale of the multicast security architecture used to secure data packets of large multicast groups. It describes a Multicast Security Reference Framework and identifies the security services that may be part of a secure multicast solution. Website: http://www.faqs.org/rfcs/rfc3740.html.

2. RFC 3830: MIKEY: Multimedia Internet KEYing.
This document describes a key management scheme that can be used for real-time applications (both for peer-to-peer communication and group communication). In particular, its use to support the Secure Real-time Transport Protocol is described in detail. Website: http://www.faqs.org/rfcs/rfc3830.html.

3. RFC 4046: Multicast Security (MSEC) Group Key Management Architecture. This document defines the common architecture for Multicast Security (MSEC) key management protocols to support a variety of application, transport, and network layer security protocols. It also defines the group security association (GSA), and describes the key management protocols that help establish a GSA.
Website: http://www.faqs.org/rfcs/rfc4046.html.

KEYWORDS: IPv6 multicast, secure multicast, multicast security, MSEC, group key management, GKMP, group security association, multicast group policy.

A08-108 TITLE: <u>Software Defined Radio Tool Suite</u>

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: Develop a tool suite that will enhance Software Defined Radio programs by providing new diagnostic capabilities to development, qualification testing, standards compliance, porting of waveforms and establishment meaningful analysis metrics.

DESCRIPTION: The proposed tool suite will include two different tools: Core Framework (CF) analysis tool and Software Defined Radio (SDR) Diagnostic Tool.

A Software Defined Radio (SDR) system is a radio communication system where components that have typically been implemented in hardware (i.e. mixers, filters, amplifiers, modulators/demodulators, detectors. etc.) are implemented using software. The CF defines the essential, "core" set of open software interfaces and profiles that provide for the deployment, management, interconnection, and intercommunication of software application components in an embedded, distributed-computing communication system. In this sense, all interfaces defined in the Joint Tactical Radio System (JTRS) Software Communications Architecture (SCA) are part of the CF. Since the software application components determine the output signal of the system, they are referred to as "waveform software" or a "waveform."

CF Analysis Tool: Develop a software tool and define a methodology to evaluate and quantify waveform/radio performance and porting risks, integration characteristics, and risk impacts associated with the interaction of waveforms and CF. This tool and methodology will positively influence future JTRS waveform developments and porting efforts through the establishment of meaningful porting metrics. This tool will aid JTRS developers in analyzing CFs and determining which will best meet the needs of their programs. While all JTRS CFs need to follow the SCA standard, there are differences between each CF that could impact the system utilizing them. Porting efforts that move a waveform application from one CF to another face unknown challenges and new radio development efforts face the task of choosing which CF best suits their needs. The challenge in developing this tool is in coming up with metrics to define the various aspects of the CFs that affect performance, porting and integration.

SDR Diagnostic Tool: Develop a software tool to provide radio/waveform performance data, standards compliance diagnostics and generate event logs. This tool will aid in the development, integration, and testing of JTRS waveforms by providing access to critical information that makes diagnosing issues and observing technical test scenarios a reality. The challenge in SDR is the distributed nature of the applications developed for radios. Applications are split onto multiple processors that have little or no interaction with each other in terms of debugging. This test tool will bridge the gap between these various processors allowing for debugging of an application as a whole rather than piece by piece. In addition, it will be challenging to develop this tool to be used on a broad range of processors and provide real-time debugging compatible with multiple platforms.

This SBIR will deliver a suite of government purpose rights software tools that can be utilized by waveform developers, testers, troubleshooters and future maintainers to aid in the development, qualification testing, and porting of waveforms. This tool suite will further enhance the programming environment available to developers and provide for decreased development schedules by providing additional access to performance and debugging information.

The tool suite will be capable of analyzing compliance to software defined radio standards. Initial development will be done for JTRS using the Software Communications Architecture (SCA) standard, but the software will remain flexible to permit incorporation of additional standards at a later time.

PHASE I: The Phase I effort will be a study on the feasibility of developing the SDR Tool Suite including small scale simulations to show proof of concept.

CF Analysis Tool: The feasibility study for the CF Analysis Tool will incorporate research efforts to determine the metrics that the tool should measure. The study should include determination of the level of flexibility necessary for the tool to be capable of running on various CFs. The offeror shall submit high level design documentation showing the feasibility and viability of creating this tool along with a document describing the metrics that will be incorporated. In addition a simulation should be provided so show how the tool will function.

SDR Diagnostic Tool: The study for the SDR Diagnostic Tool will incorporate efforts to determine what data and metrics are most relevant and meaningful for waveform and SDR developers. This data will be incorporated into the tool to provide the appropriate diagnostic information to the user. The diagnostics should include data about hardware/software interaction and the interactions between various software components running on the radio. The tool should be designed to collect metrics on the various types of software and hardware processes on the radio in run-time. The simulation should demonstrate how the tool will incorporate run-time debugging metrics on multiple processors in a single radio.

PHASE II: Phase II will continue with the performance investigation of the SDR Tool Suite through the refining of metrics, development and testing of the tools. Further research on the speed, latency and size requirements of CFs will be necessary to ensure the CF Analysis Tool is capable of providing metrics to determine if the CF is compatible with radio in question. The SDR Diagnostic Tool should have the capability to provide debugging data on multiple processors and the interaction between these processors. The final delivery should include tangible evidence and demonstration of prototype software. The CF Analysis Tool should be demonstrated with a sampling of CFs to test the capabilities of the tool. For the SDR Diagnostic Tool a few radio platforms should be selected to prove out the tool.

PHASE III: The SDR Tool Suite will provide new and enhanced capability to SDR developers. The capability to assess CFs early in the development cycle will help developers of new waveforms and those porting existing waveforms to save time and money by understanding the CF early in the process. The SDR Diagnostic Tool will provide new capability by allowing debugging of a waveform application as a whole rather than piece by piece.

The SDR Tool Suite will allow commercial software developers to more easily port and debug SDR applications. Commercial industry can refine the SDR Tool Suite Phase II delivered capabilities to include enhanced performance and metrics. Through this action the SDR Tool Suite will encourage commercial software developers to take advantage of the additional diagnostic capabilities and develop software that will be more reliable and efficient.

The SDR Tool Suite will be transitioned to various JTRS organizations including the Network Enterprise Domain (NED) and industry waveform developers throughout its development from Phase I to completion. The tool will also be utilized by various organizations in CERDEC and give insight to CF analysis and radio software diagnostics. CERDEC supports NED in portability assessment and waveform testing therefore this tool suite will enhance their support of PM NED. The tool will also be useful to private industry for SDR development and research.

REFERENCES:

1. JTRS Home Page: http://jtrs.army.mil/index.

2. Software Communication Architecture Specification v 2.2.2, May 16, 2006 http://sca.jpeojtrs.mil/.

KEYWORDS: SCA, SDR, JTRS.

A08-109 TITLE: Enhanced Magnetic Communications

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To explore the concept of generating magnetic fields to communicate through material which is otherwise opaque to electromagnetic radiation.

DESCRIPTION: Conventional communications utilize a pair of electric and magnetic components which are dependent upon each other for propagation. Under normal circumstances, when used in air or in a vacuum this mechanism is an optimal technique to communicate. However, there are some materials where the electromagnetic field will suffer a larger amount of attenuation then either the magnetic or electric component by itself. In these types of material the separation and favoritism of one component over the other would show increased range of penetration. For example, an electromagnetic wave impinging upon a sheet of conducting non-ferrous materials such as aluminum would be blocked by this sheet of aluminum but a magnetic field would propagate through the aluminum much better. Similar problems in propagation are seen in an underground environment where military units must proceed. It is in these underground, or structure enclosed environments where an enhanced magnetic field may show improved penetration.

When the military or other organizations, such as firefighters, rescue, or mine workers need to communicate in an environment that is more restrictive to electromagnetic waves then the environment which those electromagnet waves were optimized to propagate in, the result is loss of communications and inefficiency in their task and possibly death. This type of environment is typically underground where communications between individuals, who are both underground, is not possible nor is communications between underground units and the surface.

Some communication can be realized in underground environments by using very low frequency signals that have near fields out to 100's of meters. In these cases the non paired electric and magnetic fields present in the near field take advantage of the penetration properties of the magnetic field allowing magnetic and inductive coupling between the source and receiver transducers. However, due to the large wavelengths involved at these low frequencies requires a correspondingly large or alternately inefficient transducer. This investigation is to study the potential of manipulating the magnetic and electric fields so that one of those fields can be manipulated to dominate and secondly to allow this dominant signal to extend beyond that normally seen in the near field of the transducer.

PHASE I: Phase I is a feasibility study with a theoretical approach that shows the technique and the performance of such a generated signal. This effort will culminate in a report that describes the physics and feasibility of producing this signal and a comparison to the conventional techniques and why those conventional techniques are its closest competitor.

PHASE II: Phase II will produce an prototype device to demonstrate the concept and be delivered to the government. This device does not need to be mass produced or optimized but must show practical generation and penetration of the signal significantly superior to its closest competitor. A description of the hardware and theory of operation will be provided in a technical report.

PHASE III: The system using the design in this project will allow communications through rock in a mineral mine, deep into boxes of containers, building rescue operations, clandestine monitoring with sensors embedded in construction material, communications in tunnels, communications from within engine compartments or other opaque material.

Specific users include:
Mineral Miners, Inventory management and control, Special Operations Forces for clandestine monitoring, Police and Fire rescue teams to support communications, Architecture/Structural engineering where the communications device can be placed inside RF opaque material.

REFERENCES:
1. http://www.edn.com/index.asp?layout=ednPDF&file_name=/contents/images/150828.pdf.

2. Detection of Trapped Miner Electromagnetic Signals Above Coal Mines by Robert L. Lagace at http://www.cdc.gov/niosh/mining/pubs/pdfs/j0188037.pdf.

3. ISM-Band and Short Range Device Antennas by Matthew Loy at http://focus.ti.com/lit/an/swra046a/swra046a.pdf.

4. "Transmit Antennas for portable VLF to MF wireless mine communications" by Robert L. Lagace, David A. Curtis, John D. Foulkes, John L. Rothery at http://www.cdc.gov/Niosh/mining/pubs/pdfs/h0346045.pdf.

KEYWORDS: Near field antenna, magnetic field, electric field, EM field, magnetic penetration, underground communications, signal attenuation in solids.

A08-110 TITLE: <u>Gallium Nitride Monolithic Microwave Integrated Circuit Power Amplifier</u>

TECHNOLOGY AREAS: Electronics

OBJECTIVE: The goal of this effort is to develop a Gallium Nitride (GaN) Monolithic Microwave Integrated Circuit (MMIC) power amplifier (PA) for satellite communications.

DESCRIPTION: Current SATCOM On The Move (OTM) amplifiers have fairly low Power Added Efficiency, about 15%. This results in high operating temperatures as well as high Size Weight and Power (SWaP) requirements. Current research indicates that the utilization of GaN materials has the potential of increasing Power Added Efficiency (PAE) while decreasing overall amplifier power requirements. The Warfighter's communications capability will be greatly improved through the use of technologies that increase PAE while decreasing power input. Performance enhancements provided by technologies such as Gallium Nitride Monolithic Microwave Integrated Circuit amplifiers will enable the design and fabrication of Power Amplifiers with power outputs of >10 watts at Ka Band with a 30% power added efficiency. High power added efficiency is critical due to the mounting of the power amplifier on the dish antenna contained within a sealed radome. The successful implementation of a GaN MMIC PA may also give the OTM terminal increased throughput.

PHASE I: Successful completion of this Phase I SBIR will yield a circuit design for implementation of a GaN MMIC PA.

The specifications for the design are as follows:
- Frequency Band: Ka (29.5 - 31 GHz)
- Power Output: 10W (P1dB - Linear)
- PAE: 30% or greater

The phase I effort will culminate in the preliminary design of a GaN power amplifier with an output power of >10 watts at a power added efficiency of >30%. GaN device models from multiple foundries will be examined to determine the optimal foundry to utilize for detailed device design and device fabrication in Phase II. A technical report is required, which contains the PA circuit design, its analysis, and documentation of all activities in this project.

PHASE II: Successful completion of a Phase II will yield a prototype GaN MMIC PA following the specifications carried through Phase I. Phase II will result in the detailed device design, fabrication, test and delivery of power amplifier chips and packaged power amplifiers. The prototype will be tested by the contractor and the Government according to MIL-STD-188-164A. The results will be analyzed and compared with current GaAs PAs. A final technical report is required, which documents all activities in this project and provides technical specifications for the prototype PA.

Our application is for antenna systems under design for Program Manager WIN-T. The MIL-STD-188-164A requirements for linearity and spectral regrowth are essential to determine if the amplifiers will be suitable for their intended use and transition to an ATO for any additional development required prior to transition to PM WIN-T.

PHASE III: Successful implementation of a GaN MMIC PA could be utilized by all Services in various communication systems. Development of GaN PA technology has been compared to the early Gallium Arsenide (GaAs) design work. GaAs is now the standard technology. The promising results from current GaN research indicates that GaN could be the replacement technology for GaAs throughout all Satellite Communications (SATCOM) systems.

REFERENCES:
1. Wideband AlGaN/GaN HEMT low noise amplifier for highly survivable receiver electronics Cha, S.; Chung, Y.H.; Wojtowwicz, M.; Smorchkova, I.; Allen, B.R.; Yang, J.M.; Kagiwada, R.; Microwave Symposium Digest, 2004 IEEE MTT-S International Volume 2, 6-11 June 2004 Page(s):829 - 831 Vol.2.

2. High heat flux cooling solutions for thermal management of high power density gallium nitride HEMT Bhunia, A.; Boutros, K.; Chung-Lung Chen; Thermal and Thermomechanical Phenomena in Electronic Systems, 2004. ITHERM '04. The Ninth Intersociety Conference on Volume 2, 1-4 June 2004 Page(s):75 - 81 Vol.2.

3. Progress in GaN Performances and Reliability Saunier, P.; Lee, C.; Balistreri, A.; Dumka, D.; Jimenez, J.; Tserng, H. Q.; Kao, M.Y.; Chao, P.C.; Chu, K.; Souzis, A.; Eliashevich, I.; Guo, S.; del Alamo, J.; Joh, J.; Shur, M.; Device Research Conference, 2007 65th Annual, 18-20 June 2007, Page(s):35 - 36.

KEYWORDS: Gallium Nitride, GaN, GaAs, Gallium Arsenide, power amplifier, temperature, power added efficiency, PAE, PA, on the move, OTM, SATCOM, satellite communications, Ka.

A08-111 TITLE: All Digital Transmitter Digital to Analog Converter and High Bandwidth Signal Combiner

TECHNOLOGY AREAS: Electronics

OBJECTIVE: This SBIR topic has two objectives. The first objective entails the development of a Digital to Analog Converter (DAC) for multi-carrier RF transmit waveforms. The second objective is the development of a digital generator and/or combiner for the purpose of synthesizing a broadband (1 GHz or more) transmit waveform for X-band and/or Ka-band. Both objectives are to be developed for use on an All Digital Transmitter (ADT) and utilize cryocooler and/or superconductor technology.

DESCRIPTION: Digital receivers for X-band and Ka-band satellite communications (SATCOM), featuring direct digitization of multi-GHz RF signals, are being developed using ultrafast digital technology. The first laboratory demonstration for an X-band digital channelizing receiver was recently performed with a superconductor integrated circuit. This SBIR seeks to develop digital SATCOM transmitter technology to complement the receiver development.

The first goal is to generate a multi-carrier RF transmit waveform by combining multiple independent transmit signals. Multi-carrier broadband power amplifiers for transmission of this waveform are notorious for their non-linear behavior and generation of intermodulation distortion. Approaches that include digital preprocessing to improve post-amplification spectral purity will be preferred.

The second goal will be to develop a programmable broadband transmit system to accommodate instantaneous bandwidths of up to 1 GHz. Although most transmit waveforms are generated digitally at baseband, at RF they are handled in the analog domain. Analog RF components are lossy, expensive and bulky. Extension of digital processing to the RF domain enabled by recent advances in ultrafast digital circuits, such as superconductor electronics, offers a far superior system solution compared to traditional analog RF systems. The receive side of such digital RF systems is rapidly maturing; direct digitization has been demonstrated up to Ka-band (20 GHz) with superconductor analog-to-digital converters. The second portion of this SBIR seeks to extend digital processing to multi-GHz RF transmitters. Approaches should include amplification of the composite multi-carrier wideband RF transmit signal, and be compatible with advanced digital processing schemes to improve transmitter linearity.

PHASE I: Phase I will consist of two parts. The first Phase I goal is to develop a scheme capable of generating an RF signal of minimum 250 MHz bandwidth centered at 1 GHz or higher, and delivering to the transmit antenna.The second part of Phase I is to design a digital processing circuit that combines multiple digital RF waveforms in the same SATCOM transmit band into a composite multi-carrier transmit waveform.

A technical report is required, which contains the circuit designs, their analyses, and documentation of all activities in this project.

PHASE II: Phase II deliverable will be a prototype that consists of merging parts 1 and 2 from Phase I, and manufacturing both circuits together on a single superconducting semiconductor chip. The circuits will then be tested and integrated with other portions of the All Digital Transmitter. The Government will provide access to the existing ADT components, and the contractor will perform integration.

A final technical report is required, which documents all activities in this project and provides technical specifications for the prototype system.

PHASE III: Phase III will consist of further development and integration of the All Digital Transmitter (ADT) with the All Digital Reciever (ADR). The ADR is expected to be transitioned to PM DCATS through a proposed Technology Transition Agreement (TTA) currently under review. It is expected that ADT technology will also be transitioned in a like manner following system development.

Commercialization opportunities include civilian SATCOM terminals and high bandwidth, compact terrestrial communications terminals, i.e. cell phone base stations.

REFERENCES:
1. Adam Gerner, Richard Hitt, and Wesley Littlefield, “Digital-RF Linearizer for improved broadband multi-carrier power amplifier,” Proceedings of MILCOM 2005.

2. Alex Kirichenko, Deepnarayan Gupta, and Saad Sarwana, “RSFQ Asynchronous Switch Matrix,” IEEE Trans. Appl. Supercond. Vol. 17, no. 2, June 2007.

3. Oleg Mukhanov, Amol Inamdar, Timur Filippov, Anubhav Sahu, Saad Sarwana, and Vasili Semenov, “Superconductor Components for Direct Digital Synthesizer ”, IEEE Trans. Appl. Supercond. Vol. 17, no. 2, June 2007.

KEYWORDS: Superconductor, superconducting, all digital reciever, all digital transmitter, high bandwidth, multiple channel, multiple frequency, multiple carrier, multiple beam.

A08-112 TITLE: Conformal Omni-Directional Antenna Design for Unmanned Aerial Vehicle (UAV)

TECHNOLOGY AREAS: Electronics

OBJECTIVE: To develop a duel element, conformal antenna with frequency ranges of 30 – 88 MHz and 225 – 450 MHz to provide Communications Relay Capability to an Unmanned Aerial Vehicle (UAV) for Single Channel Ground to Air Radio System (SINCGARS) and Enhanced Position Location and Reporting System (EPLRS) radios and provide the capability to handle Wideband Networking Waveform (WNW) and Soldier Radio Waveform (SRW) for ad-hoc mobile networking.

DESCRIPTION: A flat, flexible antenna that can conformally fit onto the skin of a UAV needs to be developed in order to reduce the antenna size, weight, as well as the drag, on the light weight UAV aircraft, to increase its communications range and loitering capability. The antenna will be designed to be flexible enough to form to the contours of the UAV’s wing surface and produce a uniform antenna pattern around and below the aircraft in the frequency ranges of 30-88 MHz and 225-450 MHz. This dual-port antenna will provide two antenna connection points to allow connection to both standard military airborne comms relay radio transceivers and WNW or SRW radio transceivers mounted inside the UAV airframe. The uniqueness of this program is the application of various technologies to produce small, lightweight conformal antennas that operate effectively in the military frequency bands specified for SINCGARS and EPLRS radios as well as handle SRW and WNW waveforms, and with a simple means to adhere them to the skin of the airframe or other solid surface.

PHASE I: Select the type of antenna material, along with the antenna design, that will demonstrate appropriate gain and omni-directional pattern, in the two frequency bands of interest, while also handling SRW and WNW waveforms.

It is expected that at the end of Phase I, the contractor will provide, but not be limited to the following:

1. The reasons why the specific antenna design was chosen.
2. Pros and Cons of the antenna material type chosen for this antenna.
3. At least two prototype antenna models appropriate for laboratory testing in an RF anechoic chamber.
4. Provide antenna gain plots in each of the two bands: 30-88MHz and 225-450MHz, when mounted on an appropriate ground plane in a RF anechoic chamber.
5. Provide antenna patterns that were achieved when mounted on an appropriate ground plane in an RF anechoic chamber.

It is expected that all this data will be included in a final report in sufficient detail so as to allow the gov't ample assurance that continuing into Phase II is appropriate.

PHASE II: The contractor will develop and demonstrate a prototype conformal two-port antenna system that will easily adhere to a solid curved surface and provide acceptable gain and omni-directional patterns below it. This conformal antenna will ultimately be installed on the wings or fuselage of a Shadow 200 UAV.

Develop an antenna design, utilizing the appropriate material technology, that will allow the Phase I antenna prototype design to be conformally mounted to a solid curved surface. This surface could be metallic or constructed of a composite material.

Construct at least two conformal antennas that will easily adhere to both curved metallic and composite material solid surfaces. Demonstrate that these 2-port conformal antennas can provide omni-directional patterns and appropriate gain when they are mounted to solid curved surfaces, in an RF anechoic chamber, in the two frequency bands of interest and be able to handle SRW and WNW waveforms.

Demonstrate that these conformal antennas will continue to meet all technical requirements and still adhere to the curved solid surfaces, when subjected to environmental conditions that are experienced by a UAV (eg. temperature extremes, shock, vibration, wind, rain, etc.) during a mission.

PHASE III: It is expected that the contractor will provide technical personnel, along with their conformal antennas to assist CERDEC S&TCD to measure the performance of this antenna design in our own RF anechoic chamber, as well in our ground test system mounted on our Shadow UAV model, located at the CERDEC Flight Test Facility at Lakehurst, NJ.

Performance measurements on the Phase II conformal antennas will be made when the antennas are attached to the skin of a model of a Shadow 200 UAV and tested in an RF anechoic chamber. Acceptable gain for these conformal antennas will be equivalent to what is currently available from a single port, multi band antenna in the following bands:

1. 30-88 MHz; -15dBi
2. 225-450 MHz; -2dBi

The contractor will also provide data to demonstrate that their conformal antenna meets the same environmental requirements required of the Shadow 200 UAV.

This conformal antenna design could be used in a range of military and civilian applications wherever the need for this type of antenna is required. This antenna design will have usefulness in both piloted and unmanned aircraft and could prove effective for use with the commercial airline industry, in Homeland Security scenarios and with both federal and local law enforcement agencies.

REFERENCES:
1. "Conformal Array Antenna Theory and Design" by Lars Josefsson and Patrik Persson; published by John Wiley & Sons, March 2006; ISBN 13-978-0-471-46584-3.

2. "Smart-skin antenna technology" by Varadan, Vijay K. and Varadan, Vasundara V.; Pennsylvania State University; Proceedings of the Society for Optical Engineering, Volume 1916.

3. "Array and Phased Array Antenna Basics" by Hubregt Visser; published by John Wiley & Sons, September 2005; ISBN 978-0-470-87117-1.

4. "Low Profile Dual-Band Conformal Antenna"; US Patent #6603432; issued August 5, 2003.

5. "Textile-Based Antennas" by J. Slade, J. Teverovsky, B. Farrell, et al; Proceedings of the Material Research Society, Fall 2002 Symposium D; Paper # D3.9.

6. "Macroelectronics: Perspectives on Technology and Applications" by Robert H. Reuss, Babu R. Chalamala, et al; Proceedings of the IEEE Volume 93, Number 7, July 2005.

KEYWORDS: Conformal Antenna, UAV, Comms Relay, SINCGARS, EPLRS, WNW, SRW, ad-hoc mobile networking.

A08-113 TITLE: Acoustic Detection and Verification of Intrusions against Military Facilities

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: Develop an autonomous exterior sensor system triggered exclusively by speech or vehicle noise, for alerting security personnel of possible break-in or trespass. System transmits audio segments to designated receiver(s) for assessment of detected activity, enabling mobile elements to respond appropriately.

DESCRIPTION: Acoustic sensor systems for detecting and assessing intrusions are needed to counter destructive acts against unoccupied and/or remote military facilities. Large range complexes, for example, are vulnerable to destructive acts (e.g., vandalism, equipment theft, damage to ecologically sensitive sites) because of their isolation and the pilferable equipment installed on them. One means of protecting military facilities is to install sensors at likely sites of intruder activity for early awareness of actions against the facilities. To be effective, the sensors must exclusively trigger on human activity and enable installation personnel to remotely assess the nature of the activity by means of audio transmissions. This requirement is not met with current sensor systems.
• Current acoustic sensor systems do not detect personnel and lack the capability to trigger on speech.

• Current acoustic detection systems are capable of detecting vehicle engine noise, but they are designed to activate their microphones only intermittently to avoid power draw-down on battery operation. Continuous acoustic monitoring for vehicle triggers is not possible with current systems.
• Current acoustic systems transmit only an alarm status (alarm on, alarm off); they do not transmit audio segments by which an identification of the detected activity can be made.
• There are commercial sensor systems (other than acoustic ones) suitable for remote/unattended sites that can detect the movement of personnel, but these systems do not incorporate a means of remote assessment of the detected activity. Separate camera systems are required for assessment, with effectiveness limited by the quality of the wireless video transmission.

As detection devices, the acoustic sensors must respond preferentially to speech or vehicle noise and discriminate against other sounds. They must extract speech and vehicle signatures from acoustic clutter associated with legitimate activity at a military facility.

To enable installation personnel to remotely assess the activity that triggers the acoustic sensor, the system must transmit comprehensible audio segments of the associated speech or vehicle noise to a designated central location (e.g., Military Police) for monitoring and recording, and to mobile receivers (patrol or range vehicles, handheld devices) for possible quick response. Audio transmitters and receivers must integrate with established communication protocols and equipment in use at military facilities, including compatibility with bandwidth designated for installation Range Operations and Security.

The acoustic sensor system must be configured to be activated by alarms from other sensors (e.g., passive infrared) as a user-selectable option, but to transmit an audio segment only if its internal criteria for discriminating speech and vehicle noise from other sounds are satisfied.

There must be two-way communication between the sensor system and the central location, such that installation personnel can initiate additional transmissions from the sensor system to assist in assessing detected activity or can remotely put the sensor system in stand-by mode when legitimate activity will be occurring in its vicinity. The communications hardware must be compatible with the use of repeaters (satellite or ground-based hardware).

The sensor system must be configured for both battery operation and hard power, and for wireless and hard-wired communication. The battery setup must be adequate for at least 500 valid transmissions before battery replacement becomes necessary. A single transmission must be adequate for determining whether the audio record is speech or vehicle noise, and if speech, be intelligible.

The acoustic sensor, power supply and communications hardware must be packaged in an all-weather enclosure for surface mounting or ground placement. Packaging that also enables direct burial of all equipment other than the acoustic transducer (such as a microphone) and communications antenna is favored. No dimension of the package should exceed 25 cm. The power supply must support transmitting the audio segments a minimum range of 2 km; under battery power, at least 500 valid transmissions at this range must occur before battery replacement becomes necessary. The total weight of the field unit should not exceed 15 lbs; this excludes repeaters and the receivers at a central location and with mobile elements.

PHASE I: Phase I focuses on methodologies for discriminating between acoustic sources of interest (speech, vehicle noise) and nuisance sound. Speech signatures are investigated and key features for use as triggering criteria are isolated. Options for triggering on vehicle noise are identified and investigated. Criteria for the transmitted audio segments are developed based on typical listeners' requirements for sound to be comprehensible and recognizable. A power budget for continuous operation of an active acoustic sensor (e.g., microphone) and transient transmissions of audio segments is designed that meets specifications for battery operation.

Phase I also includes developing both a working knowledge of existing wireless communications in use with military facilities and a concept for integrating acoustic sensor system transmissions. The concept must be approved by ERDC-CRREL and be compatible with Army requirements for licensed or unlicensed devices, as appropriate.

Deliverables are a report on the elimination testing of the discrimination methodologies, a plan for further evaluation under Phase II, and a design concept for integrated sensor system transmissions.

PHASE II: Phase II develops, demonstrates and validates the selected means of discriminating between acoustic sources of interest (speech, vehicle noise) and nuisance sound. A discrimination methodology is finalized following testing against acoustic data of speech and vehicle noise contaminated with acoustic clutter relevant to military facilities, including training activities. Phase I design concepts are implemented and tested for integrating sensor system transmissions with existing communications. A prototype acoustic sensor system is constructed, tested and demonstrated.

Deliverables are a prototype sensor system that is triggered by speech or vehicle noise, that can be activated by alarms from other sensors, that transmits audio segments necessary and sufficient for assessment of activity at the sensor site, and that integrates compatibly with existing communications at military facilities. For devices requiring a license, compatibility is based upon operation in the Federal band and meeting all requirements of the National Telecommunications and Information Administration.

PHASE III: The commercialized acoustic sensor system enables real-time detection and assessment of on-going human activity at remote or unoccupied facilities on military installations. By autonomously triggering only on speech or vehicle noise, the sensor system supports implementing sensor-based security measures at otherwise unsuitable sites, i.e., sites that would create an alarm management burden if instrumented with sensors that did not reliably discriminate between the presence of personnel or vehicles and benign occurrences, such as weather events or animal movement. The sensor system's transmission of audio segments provides a low-cost, readily implemented alternative to camera-based assessment of detected activity. Its communication to both fixed location and mobile elements enables rapid response to intrusions.

The Corps of Engineers Electronic Security Center (ESC) is "very supportive" of development of the acoustic sensor system for its potential enhancement of fixed-facility intrusion detection and assessment capabilities.

The acoustic sensor system enables implementation of the Range Security component of AR 350-19, The Army Sustainable Range Program, with protective measures at training facilities that do not interfere with the training mission.

The acoustic sensor system meets demand for technology to provide awareness of activity at isolated cultural sites or endangered species habitats on Army installations, as part of the determination and quantification of outside sources of impacts on natural resources.

KEYWORDS: Intrusion detection, remote assessment, acoustic sensor, speech signatures, audio transmission.

A08-114 TITLE: <u>Large Area Spatial Urban-Noise Characterization for Anomaly Detection</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 3.5.b.(7) of the solicitation.

OBJECTIVE: Demonstrate innovative signal processing technology for spatial and temporal urban baseline noise characterization from stand-off seismic listening posts, and validate a design approach for the seismic arrays to allow use of beam-forming techniques, applicable to anomaly detection in urban zones of interest for early warning of threat development.

DESCRIPTION: Analysis methods and best practices are not available to support persistent assessment of ambient sound and vibration signatures from ground sensors for application to large-area urban situational awareness. Two broad questions require investigation for military surveillance: (1) can urban ambient sound and vibration signals be characterized as a baseline for actionable warnings, and (2) can sensor arrays quantify ambient sound and vibration over wide urban areas from offset locations? These respective questions arise because persistent noise and vibration monitoring can produce unmanageable volumes of data, and because sensors will not always be locatable within zones of interest. Our goal is find statistical feature sets that could reveal anomalous energy sources based upon loudness, frequency content, and duration, and whose locations can be mapped by urban zones or regions, allowing focusing of higher-fidelity tools in these areas of anomalous activities. The related technical goal is a technique to reduce these feature sets to manageable sizes, while retaining their ability to detect both short-duration-transient and slow-changing anomalies.

To answer these questions and meet these goals, the objectives are (1) to synthetically generate urban ambient sound and vibration data from single- and multiple-location transducers within an urban area and from beam-forming arrays placed outside an urban area; (2) to investigate temporal and spatial signature patterns within the data as baseline measures; and (3) to investigate detection and location of anomalous events of interest, with offset beam-forming monitoring as the ultimate baseline-, anomaly-, and location-characterization objective. In short, this work will investigate whether there can be any statistically meaningful indicators in surveillance data to discern if, when, and where something important happens.

The research approach will follow a three-part hypothesis: (1) that a single-location persistent ambient signal from a ground-based location within an urban area contains temporal signature patterns that sliding-time-window principle-component analysis (PCA) or other statistical analysis can efficiently reveal and quantify as a time-of-day, day-of-week, etc. baseline for anomaly detection; (2) that multiple-location persistent ambient signals from within an urban area or areas contain spatial information that sliding-window statistical analyses can quantify for location-specific or relative-location anomaly detection; and (3) that ground-based beam-forming arrays placed outside an urban area can characterize ambient noise in selectable angular directions, which, when combined with multiple arrays, can estimate noise levels at urban sectors of interest, thereby providing baseline sliding-window-temporal and spatial data for anomaly detection from offset locations.

PHASE I: Phase I focuses on developing innovative methodologies for finding statistical feature sets using synthetic noise data which can be used to quantify and discriminate background noise from noise generated by anomalous energy sources. Major classes of candidate methodologies are identified and tested. The poorer performing methodologies are eliminated, and a plan for more rigorously evaluating the remaining candidates under Phase II is developed. The results will quantify relationships between signal power, frequency content, propagation scattering and decay, temporal and spatial variation, and offset array designs and placement. These results will impact development of offset persistent-surveillance ground-sensor systems capable of wide-area coarse-resolution characterization of urban activity relative to a baseline and useful for assessing effect of activity on operations. Deliverables are a report on the elimination testing of the statistical characterization methodologies, a plan for further evaluation under Phase II, and a design concept for sensor array placement over wide urban areas from offset locations. The design concept will consider the tradeoffs between offset distance, size of the urban sectors that can be discriminated, and frequency ranges of detection, all relative to the signal-to-noise ratio as a function of frequency. (For example, as frequency decreases to the infrasound regime, the offset distance increases, while the background noise at the chosen frequency ranges dictates the relative strength of a detectable anomaly).

PHASE II: Phase II develops, demonstrates and validates the selected statistical characterization methodology. A discrimination methodology is finalized following testing against urban ambient sound and vibration data from single- and multiple-location transducers within an urban area and from beam-forming arrays placed outside an urban area. Phase I design concepts are implemented for the sensor placement to acquire the test data in an environment characteristic of urban areas. Deliverables are a prototype ground-based beam-forming sensor array with the necessary signal processing to estimate noise levels at specific angular regions of interest. As a target, the urban sector size of interest could be considered to be 500 m square, with an offset distance of 1 km.

PHASE III: After commercialization of the ground-based sensor system, soldiers will have a means of detecting and assessing activities within an urban area from offset measurements. The extent to which anomalous activities can be detected will be determined by the effectiveness of the statistical characterization methodology, and the ability of the beam-forming signal processing to be sensitive to noise from specific angular regions while simultaneously suppressing noise outside of those regions. Non-DoD applications for this technology include border and perimeter security, where long distances can be monitored in this zonal way, and detected anomalies in any one zone would trigger higher-fidelity sensor arrays. Otherwise, using continuous high fidelity sensor arrays along, say, the U.S. southern border would result in an unmanageable amount of data to process.

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KEYWORDS: Unattended ground sensors; seismic sensing; signal processing; statistical characterization; remote sensing; anomaly detection; threat detection.

A08-115 TITLE: Fast-Scan, High-Performance, Portable Imaging Spectrometer for Chemical-Biological Sensing

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors

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

OBJECTIVE: To design and develop a fast, high-performance, portable, field-operable chemical-biological imaging-sensing system, which consists of a spectrometer and a “system-on-a-chip” data acquisition, processing, and analysis unit. The system will possess a significantly enhanced ability to detect and selectively analyze chemical and biological agents, through the integration of recently developed portable Fourier Transform Infrared (FTIR) spectrometers and high-performance field programmable gate array (FPGA) technologies. The resulting system will be small in size, be rugged in design, be easy to use, and consume minimal power.

DESCRIPTION: The anticipated imaging sensor system should be built upon recent advances in the technology of miniaturized FTIR spectrometers [1-6] with portable, fast, and reliable field instrumentation that can achieve scan rates of up to 1,000 scans per second, without the need for an extra laser reference channel normally required in an

FTIR spectrometer. It should have desirable features such as small size, ruggedness, high speed, and very low power requirements; and it should be suitable for high-vibration environments such as on board a truck or a helicopter. These spectrometers have various processors, data acquisition boards, and associated software, such as Labview software packages, for the acquisition, display, and storage of data and images. One major challenge is that the amount of computation and processing required for a system with 100 or more pixels and with a scan rate of more than 1,000 scans per second is simply too overwhelming for the current systems, which would take too long to perform such a task. Currently, most of the data processing must be accomplished using a separate computer system. This kind of task and the required computational throughput is best dealt with using parallel computation/processing, which is one of the key advantages of FPGA-based approaches. FPGA is ideal when handling large quantities of data in multiple channels in a short time and to perform such tasks as Fast Fourier Transforms (FFTs). FPGA has a clock rate of more than 500 MHz for each logic block and 100 or more such blocks on a single chip; it has both 16-bit and 32-bit resolutions, with massive, sophisticated interconnects among the blocks and built-in CPUs, analog to digital converters, and onboard memory units. Furthermore, FPGA-based hardware is field reconfigurable/reprogrammable. Because of these unique capabilities, it is ideal to build spectrometers based on FPGA technology. Indeed, in recent years, there have been increasing efforts to use FPGA technology in sensing, imaging, and spectroscopic applications in astronomy, particle and nuclear physics, and RF beam forming, data conversion, imaging processing etc. [7-9].

This topic seeks to investigate the potential of a new technological approach based on the integration of a fast, portable FTIR imaging spectrometer and FPGA technology for data acquisition, processing, and analysis. The integration of these two state-of-the-art technologies should produce an imaging spectrometer that can be fast, reliable, rugged, and portable, while producing identification, detection, and imaging in real time or near real time in the battlefield environment. More importantly, the combination of multiple target pixels and a two-order-of-magnitude increase in scan speed will provide sufficient information to increase the current threat biological cloud detection probability from 50-70 percent to > 90 percent, which will meet the requirements for a Field Biological Agent Detection System. Additionally, the Chemical Agent Detection capability will correspondingly increase, exceeding current field requirements.

PHASE I: Phase I will explore feasibility studies utilizing FPGA technology in a proven imaging sensor system, such as a 8x8 pixel, 500-scan-per-second, 16-bit resolution FTIR imaging spectrometer for use in the detection and analysis of chemical agents at very low concentrations, and also for scenarios to potentially extended the technique for biological agent detection. This effort should also develop quantitative predictions and conduct initial experimental studies to determine the advantages of this technique for the characterization and discrimination of chemical and biological agents. The work should be performed in the context of enhancements to existing sensors and should clearly demonstrate the unique and innovative advantages offered by the “system on a chip” approach afforded by the FPGA technology. Note that it is acceptable to utilize agent simulants in assessing the performance of the sensor system.

PHASE II: Phase II will be used to perform an engineering-analysis validation of the FPGA-based platform design that incorporates existing sensor technology. This sensor prototype design should be compact and should be capable of achieving enhanced chemical (and possibly biological) agent detection as well as selective imaging and analysis. It is expected that the new imaging sensor should feature 100 or more pixels, with a scan rate of 1,000 scans per second and with 32-bit resolution, and should be able to provide imagery and incorporate image processing software to optimize signature interpretation capability. The prototype design should target capabilities that allow for battlefield deployment and that will operate as autonomously as possible (i.e., with minimal operator calibration and tuning). The operational capability of the sensor system should be analyzed against a set of chemical (and possibly biological) agents that have relevance to military defense applications. Note that it is acceptable to utilize agent simulants in validating the operational capability of the sensor system.

PHASE III: The technology developed under this topic has important relevance to reducing the threat posed by chemical and biological warfare agents. Therefore, the primary commercialization opportunity is for detection/identification sensor systems which will reduce the chemical/biological threat of adversaries and terrorist groups to the military, civil governments, and the private sector. However, this technology will also target capabilities for selective imaging and analysis of general targets and, therefore, has potential for numerous dual-use commercial applications. Examples include, but are not limited to, medical diagnostics, pharmaceuticals analysis, pollution monitoring, food-safety inspections and quality control of packaging.

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KEYWORDS: FTIR, portable spectrometer, imager, FPGA, chemical agent, biological agent, detection.

A08-116 TITLE: Integrated Power-Microclimate Cooling System for the Soldier

TECHNOLOGY AREAS: Chemical/Bio Defense, Electronics

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

OBJECTIVE: Design, construct, and evaluate a microclimate cooling device for the individual soldier with enhanced performance, reduced weight, and increased duration of operation beyond state-of-art hardware by integrating components of an advanced power subsystem with components of the cooling subsystem. The overall device must be capable of being used with current chemical defense garments.

DESCRIPTION: The design and operation of current microclimate cooling devices for the soldier assumes that their power source is a stand-alone subsystem whose sole purpose is to provide the energy needs of the cooling subsystem. The present topic proposes research to progress beyond this approach and utilize opportunities to improve overall system performance by integrating synergistically the power and cooling subsystems by, for example, using waste heat from the power source to supply enthalpy needs of the cooling subsystem or reducing weight through elimination of redundant components between the two subsystems. Presently employed battery power sources do not permit this integration and also have a relatively low-energy density that requires multiple batteries be carried by the soldier to meet mission needs.

There are several maturing power technologies to fill the gap between low-power applications where batteries compete well and high-power applications where internal combustion engines are prevalent. Studies have shown that in the power range of 30-50 W, which is the power required for soldier microclimate cooling, several advanced, high-energy density power systems are viable alternatives to batteries to support a microclimate cooling device.

This topic is not requesting a drop-in replacement for batteries in existing cooling devices. Rather, it is anticipated that improved performance and a more compact device will be achieved if the power and cooling subsystems are integrated from the onset in the design and operation of the overall system. For example, fuel cells, Stirling engines, and thermoelectric power sources may share common components with microclimate cooling devices such as pumps, heat exchangers, blowers, condensers, etc. Some of these “balance of plant” components may be combined to reduce overall system weight, or heat integration of the two subsystems may lead to improved overall performance.

Performance requirements of the microclimate cooling device include: minimum 150 W of cooling; more than 4 hours between resupply of any system consumable; 5 pounds (2.27 kg) maximum weight; 200 cubic inch maximum volume (3.28 l); and capable of operation in any orientation.

PHASE I: Develop overall system concept for a solider microclimate cooling system that includes specifications and design of the cooling and power subsystems that are integrated synergistically. Quantify the anticipated performance gains obtained through subsystem integration in comparison to battery-powered device. If necessary, experimentally demonstrate critical components of the subsystem integration.

PHASE II: Design, construct, and evaluate an integrated prototype power-microclimate cooling system for the soldier. Demonstrate performance requirements provided in topic description.

PHASE III: A compact microclimate cooling system can be used in a broad range of military and civilian security applications beyond chemical defense garments, for example, under other protective clothing such as body armor or bullet proof vests. There are many potential applications for personnel working in heat-stress environments such as construction workers, miners, firefighters, etc.

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KEYWORDS: Microclimate cooling, power, integration.

A08-117 TITLE: Imaging Device for the Assessment of Airways in Combat Casualties with Inhalation Injury due to Burns, Smoke, or Toxic Gases

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To develop an ultrahigh resolution (micron level) noninvasive imaging device that is capable of delivering real-time, near-histologic-level images of airways with flexible and rigid probes. The system will be used in the diagnosis and monitoring of acute inhalation injury patients and in assessing response to therapy.

DESCRIPTION: Inhalation injury is an important cause of morbidity and mortality in military personnel and civilians. The mortality rate of burn patients increases 20% when concurrent airway injury is present, and this increases by an additional 40% when airway injury is accompanied by pneumonia. Inhaled toxins and thermal injury frequently affect the trachea, bronchi, and proximal lower airways resulting in injury to the epithelium, mucosa, and submucosal tissues. Smoke inhalation, thermal injury from exposure to smoke, fires, and heated vapors, as well as inhaled chemicals such as chlorine and mustard gas that have direct damaging effects on airway surfaces are ongoing threats to military personnel. These injuries may result in swelling, edema, desquamation, infection, obstruction, and airway compromise (1-4).

A novel, minimally invasive method is needed to detect changes in airway tissues that occur following inhalation exposure in order to enable assessment and triage with diagnostic sensitivity and specificity, correlate physiologic changes with tissue injury, and improve methods for monitoring therapeutic response. In order to permit early screening, triage, and treatment of such inhalation exposures, a compact, cost-effective, ultrahigh resolution diagnostic endoscopic airway imaging device is needed. Such a device should be capable of providing near-real-time quantitative, minimally invasive diagnostic assessment and monitoring of airway tissue injuries to facilitate efficient management of inhalation injury and provide ongoing assessment of response to therapy.

The focus of this effort is to develop a flexible and rigid endoscopic, ultrahigh resolution, near real time, minimally invasive, field deployable, airway imaging system that can be used in Forward Surgical Team and Combat Support Hospital settings, as well as tertiary referral centers. The device should provide qualitative and quantitative tissue structural and functional information including near-histologic-level assessment, with depth of visualization to levels approximating 2 mm in order to include the epithelium, mucosa, submucosa, and related structures. The technology should enable the operator to visualize not only tissue structure in 2 and 3 dimensions, but also 2 and 3 dimensional subsurface microvasculature and blood flow. In order to obtain high quality images in near-real time with minimal motion artifact the rate of data acquisition and analysis must be sufficiently rapid.

One example of such a technology is optical coherence tomography (OCT). OCT is an emerging technology that utilizes non-ionizing, reflected near-infrared light to provide near-histology-quality images, and is being commercially employed to image ocular pathology and coronary artery disease (5-11). Other technologies with similar capabilities will be considered.

PHASE I: The purpose of phase I is to optimize the design of an instrument directed towards optimal airway imaging and inhalation injury applications.

PHASE II: The goal of phase II is to produce a rugged, compact, user-friendly, field-deployable prototype which can be used by providers following minimal additional training.

PHASE III: The goal of phase III is production of units to support pre-clinical testing in relevant animal models. Specific military applications include rapid diagnosis of inhalation injury due to smoke, toxic gases, or chemical agents. At present, it is anticipated that this technique will be deployed at Level III and higher (Combat Support Hospital). Also, commercial applications include use in civilian trauma centers, intensive care units, and emergency departments as an adjunct to diagnostic bronchoscopy for patients with similar problems.

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KEYWORDS: Optical imaging, airway, mucosa, submucosa, inhalation injury, toxic industrial chemicals, burns, bronchoscopy.

A08-118 TITLE: <u>Malaria Diagnostic Methods to Replace Microscopy in Clinical Trials</u>

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: The objective is to develop and achieve FDA approval of a highly specific and sensitive test to detect malaria parasitemia and/or exposure.

DESCRIPTION: Malaria is a major infectious disease threat to U.S. forces deployed worldwide and can rapidly incapacitate large numbers of personnel. Recent experience in Liberia exemplifies the problem. Of 290 troops who stepped ashore there, 80 developed malaria (28%), and 69 of the 147 who spent at least one night ashore acquired it (44%). Five of these marines required intensive care unit support. We are fortunate no lives were lost.

Malaria smear preparation and interpretation are poorly standardized processes worldwide, leading to marked variability in results. Many of the expert microscopists in both the developed and the developing world are retiring and not rapidly being replaced with a new generation of experts. Newer technologies such as Rapid Diagnostic Tests and PCR are not yet acceptable endpoints in clinical trials, and thus the FDA (CDRH) has maintained that microscopy should still be considered the “gold standard” for malaria diagnosis.

The U.S. Army malaria research efforts have been directly and very tangibly affected by inaccurate malaria diagnostic slide reading (1). Modeling reveals that ~1% false positive smears will lead to substantial underestimation (10-25%) of protective efficacy (2).

The purpose of this topic is to identify and validate either improved microscopic technologies or alternative technologies to replace microscopy as the primary endpoint in malaria prevention clinical trials. The new technology must be acceptable to US FDA, highly specific, and reasonably sensitive.

PHASE I: Identify appropriate innovative technologies to ensure accurate diagnosis of malaria in DoD-sponsored clinical trials using methods that will be acceptable to the FDA. Collaboration with Malaria Diagnostics Center of Excellence is strongly encouraged so that critical reagents (appropriately validated positive and negative controls) are available. Collaboration with institutions having experience with malaria-prevention clinical trials and diagnostic development is strongly encouraged. Accurate clinical trial endpoints are defined as protective efficacy estimate no more than 5% different from actual, as well as count and species error rates that will not significantly impact outcome in malaria vaccine or drug treatment trials (2). Must demonstrate proof of concept of new technology. The gold standard comparator should be expert microscopy, as documented with performance testing using standardized tests sets. A rereading paradigm with microscopy and other technologies should also be used to confirm microscopy results as valid for new samples collected. BinaxNow, validated PCR, and other validated technologies can be confirmatory if appropriate.

PHASE II: Must develop specific technology to be used in clinical trials. Must field test the technology in clinical trial setting. Must demonstrate desired specifications. Must take technology to US FDA for approval for clinical trial use. Publish results.
Technology must be available for purchase by US military for use in clinical trials. Must make technology available for other military and civilian applications. Such applications for both will include as an endpoint in clinical trials, for diagnosis of the disease (350 million cases annually worldwide), for screening the blood supply, and for monitoring that malaria is not being introduced into malaria-free areas. Technology will have potential for use in other diseases diagnosed with similar techniques.

PHASE III: Must maintain methods for iterative improvement of any limitations identified.

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KEYWORDS: diagnostics, microscopy, malaria, innovative, clinical trials, endpoint, prophylaxis, vaccines

A08-119 TITLE: <u>Non-invasive near-infrared devices for monitoring hemodynamics, tissue viability, and perfusion for combat casualty care</u>

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop field-deployable, near-infrared devices to accurately determine components of blood concentration and oxygenation, tissue, and organ function in combat casualties; to improve monitoring capabilities over what is currently available for Soldiers and casualties.

DESCRIPTION: Injury on the battlefield leads to alterations in hemodynamic status, perfusion, and organ function in critically ill patients. Unfortunately, existing vital signs like the heart rate and blood pressure are late warning indicators for casualties who have sustained life threatening injuries, and new sensors or vital signs are needed to detect these casualties sooner and to track their resuscitation (1). While near infrared spectroscopic analysis of organ perfusion, tissue oxygenation, cytochrome redox states, and tissue chromophore concentrations have been promising in providing an indication of need for interventions in order to improve casualty outcome, it has been limited in the past by inaccuracies due to spatial and temporal variations in tissue light scattering properties (2-4). Recently described technologic advances in fields such as diffuse optical spectroscopy and frequency domain photon migration have the potential to overcome these prior limitations (5-6), and provide field deployable devices for assessment of degree of injury, progression of disease, and adequacy of resuscitation. Thus, compact, cost-effective, user-friendly diagnostic devices for accurate quantitative assessment and monitoring of tissue oxygenation, perfusion, and organ function will be a valuable tool in the process of optimization of diagnosis, monitoring, and treatment of patients with a broad range of critical illnesses.

The focus of this effort is to develop portable, user-friendly, point-of-care technologies that will provide broadband monitoring of tissue and organ function including the capability to assess dynamic changes in tissue oxygenation, perfusion, and cytochrome redox states during shock, hemorrhage, toxic exposures, and organ damage. The resulting instrument must be capable of quantitative determination of oxy and deoxyhemoglobin, total hemoglobin, oxygen saturation, water (edema) and accurately determine the contribution of scattering to the signals in the region of interrogation. The rate of data acquisition and analysis must be sufficiently rapid to facilitate decision making in field and critical care monitoring conditions.

This technology may be embodied in a sensor which attaches to the body (like existing NIRS probes), or may be incorporated into an imaging device (like hyperspectral imaging systems).

PHASE I: The goal of this phase is to optimize device and probe design, specifically directed towards combat critical care applications. The method should be based on quantitative determination of tissue blood concentration, saturation, and cytochrome redox states; and should render physiological status of tissue and organ function in critical combat casualty situations. The focus will be on designing a system which is lightweight, ruggedized, and user friendly, for use by minimally trained combat medics.

PHASE II: The design in phase I will be used to build a prototype system. The device should be sufficiently compact and low-profile to not interfere with normal patient care in combat critical care settings, and should be operated by users with little training.

PHASE III: The near infrared device will be tested, validated, and refined in pre-clinical animal studies. As a result of this phase, the device should be ready for future clinical testing in human patients or normal volunteers, as a pathway to anticipated FDA 510K approval. Military applications include: use by individual combat medics; use at Level II treatment facilities and higher; use during evacuation. The most likely path for transition to operational capability for this device will be FDA approval, and commercial availability for use in both combat and civilian trauma patients. Non military commercial applications include use in civilian emergency department, operating room, and ICU environments.

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KEYWORDS: Near infrared spectroscopy, shock, hemorrhage, optical scattering.

A08-120 TITLE: An Integrated Physical Therapy/ Rehabilitation Robotic System for Military Healthcare Enhancement

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a reconfigurable medical robotic system for physical therapy and rehabilitation to enhance healthcare capabilities with advanced system functionality, telepresence and teleconsultation at Department of Defense and Veteran Administration Hospitals.

DESCRIPTION: Physical therapy provides healthcare services in evaluating and treating people with healthcare problems resulting from injury or disease by means of assessing/enhancing joint motion, muscle strength and endurance, and performance of daily living activities. Physical therapists are in short supply in both the US military and civilian community (rural areas in particular) resulting in congressional legislation to counter this trend through education in physical therapy. Physical therapy was introduced into US Army in 1917. To date, besides common injuries caused by regular training missions and motion dysfunctions on duty, 70% of combat injuries are linked to traumatic brain injuries, extremity injuries and spinal cord injuries, resulting in musculoskeletal and neuromuscular functional problems. Physical therapy rehabilitation via computer controlled robotic systems for motion function recovery can be provided not only near the front line but, in military hospitals, VA rehabilitation centers, nursing homes, schools, local health centers and potentially in the patients' homes.

Today's robot physical therapy and rehabilitation systems, have been emerging as a new direction of technology development to assist and enhance healthcare since the end of 20th century. Reports on rehabilitation robotic systems such as "MIT-Manus" demonstrated that a computer controlled electro-mechanical system can be applied in dedicated stroke treatment for upper limb rehabilitation. A treadmill based physical therapy and rehabilitation platform (Locomat®) is capable of providing therapy to patients with lower limb injuries in locomotion recovery. However, so far there is no rehabilitation robotic technology available for progressive, reconfigurable procedures and multi-purpose training. In physical therapy centers and healthcare centers, ONLY passive (or resistive) training equipments are utilized for physical function recovery and physical conditioning. There is no existing robotic physical therapy system to provide actively computer controlled and motorized strength training and physical conditioning.

A reconfigurable physical therapy /rehabilitation robotic system is highly desired to deliver rapid motion recovery for patients with musculoskeletal or neuromuscular problems thereby enhancing the healthcare capabilities, and meeting the special needs of the US military and civilian healthcare beneficiaries through active reconfiguration of system structure, and remote accessing /monitoring of computer procedures and parameters. Such a reconfigurable robotic physical therapy system can have compact and configurable hardware and software systems, as well as multiple optional training procedures for upper limbs, lower limbs and body motion control functions. The key requirements for this medical healthcare robot system are: 1) range of motion treatment capabilities, 2) precise force and strength treatment, 3) progressive development procedures according to real-time patient monitoring of the joint motion profile (position, velocity , acceleration), force sensing and other physiology sensing, 4) training for amputees with prosthetic devices in body balancing, posture control, gait and strengthening, 5) telepresence capabilities for remote consultation and supervision.

PHASE I: Conduct research and collect data focused on previous and current work in robotic physical therapy/rehabilitation system development to design a reconfigurable robot for healthcare enhancement. Provide a detailed report describing the conceptual design as well as different applications of the proposed medical robotic system for physical therapy and rehabilitation. Identify design features and applications that will improve the quality, access and cost of medical care in subsequent phases of this project.

PHASE II: Based on the recommendations developed in Phase I, design, develop and demonstrate a functional prototype of such a medical robotic system to enhance healthcare capabilities with desirable function integration in physical therapy, optional procedures, viable interactions and remote access of physical therapy supervisor. System hardware and software should be able to cover all /or a subset of requirements listed below:

- Training procedures with range of motion functionality recovery.
- Training procedures for strengthening and conditioning with active force control.
- Training for patients using prosthetic devices to help recover normal motion function of limbs.
- Being compact and reconfigurable for multiple therapy treatment procedures with training performance optimization.
- Work safely and robustly with or without monitoring of a physical therapy assistant or technician.
- Work well for upper /lower limb treatments for neuro-musculoskeletal motion functions.
- Perform well under interactions and supervision of a physical therapist via telepresence or teleconsultation.

PHASE III: The ultimate goal of this research is to provide a new physical therapy robot system for use in military and civilian rehabilitation hospitals to enhance healthcare quality and extend staff capabilities. This system will also have the potential for applications in other healthcare and allied care facilities including nursing homes, long-term care of the disabled, and athlete exercises centers, providing treatments on orthopedic injuries such as sprains, back pain, and joint pain; wound care due to diabetes or trauma; neurologic impairments such as stroke, paraplegia, and balance dysfunction; and lower extremity prosthetic use due to amputation.

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KEYWORDS: Reconfigurable medical robotic system, telepresence, teleconsultation, physical therapy, rehabilitation.

A08-121 TITLE: Unmanned Ground & Air System for CBRNE Contaminated Personnel Recovery

TECHNOLOGY AREAS: Ground/Sea Vehicles, Biomedical

OBJECTIVE: The purpose of this topic is to design, develop and demonstrate a working prototype of a combined unmanned ground and unmanned air system (UGS/UAS)for the recovery of incapacitated, wounded or killed personnel suspected of having been exposed to chemical, biological, radiological, nuclear, or explosive (CBRNE) hazards.

DESCRIPTION: The threat of CBRNE exposure to our military personnel is an increasing concern. The Department of Defense (DoD) must have the capability to recover injured personnel or fatalities from contaminated areas, in a timely manner, without risking the health or lives of other personnel. Additionally, civilian ‘first responders,’ whether reacting to a manmade or natural disaster, have similar requirements. Within the DOD Medical Community work has been underway for several years to extract combat casualties from hazardous areas and from under fire using unmanned systems technologies; likewise development of various arrays of robotically employed chemical and biological sensors is well underway. The Joint Mortuary Affairs Working Group has identified robotics as a potential technology for recovering contaminated remains. This is a very complex problem, requiring a small, yet strong and maneuverable robotic system or system of systems, capable of working outdoors or indoors; in all weather conditions; and various CBRN contaminated environments. A combined ground and air unmanned systems design approach offers the most potential for timely and efficient extaction of both comaminated casualties and KIA remains.

Specific research challanges of this topic include:
1. Integration of the ground and air unmanned system such that recovery of remains can be made by the UGV and further extracted by the UAS; innovative research approaches that consider a single ground/air system, detachable ground and air modules, or separate but tightly integrated ground and air systems.
2. Autonomous or semi autonmous ground and air mobility to include autonmous flight controls, autonomous landing and takeoff, and autonmous landing site selection; significant work has been performed in these areas under oversight by the topic author and by elements of the Army Aviation Missile Research Development and Engineering Command.
3. Implementation of technologies on a UAS/UGV that can support a payload sufficient to accomplish the mission of extracting a combat soldier wearing body armor and carrying standard weapons and equipment, approximately 300 lbs; while minimizing weight and cube of the extraction UAS/UGV system(s).
4. Secure military deployable command, control, and communications systems sufficient to support the intended mission and associated onboard sensors and robotic support systems. Research should address the mission requirements for line-of-sight (LoS) and beyond line-of-sight (BLoS) operations out to 10 km (this is an especially challenging problem requiring innovative solutions for the UGV because of inherent communications problems inside structures; and for the UAS because of the difficulty of transistioning and maintaining command and control of UAS systems as they pass from one control operator to another).
5. Integration of innovative chemical, biological and nuclear contamination detection technologies to enable verfication and identification of contamination (design and development of those technologies is not part of this SBIR; but enabling technologies should be identified for integration in Phases II or III).
6. Implementation of command and control standards that can be implemented on both the UGS and the UAS. The Joint Architecture for Unmanned Systems (JAUS) has been mandated for UGS and STANAG 4586 is considered the standard for UAS; research should focus on an integrated approach that combines or supports both standards.

As well as focusing on immediate technologies needed to prototype and demonstrate a system, the research proposal should address long term mission oriented supporting research and development needs such as:
1. Operating in all-weather conditions in large open areas (fields, parking lots, desert, etc.), wooded and rugged terrain, urban ‘canyons’ and other areas where mobility and LoS are restricted, as well as in the interior of buildings.
2. Climbing stairs, traversing obstacles and small bodies of water, mud, sand, bog, debris, etc. that might be reasonably expected in the operating environments described above, and detecting and avoiding both stationary and moving obstacles.
3. Decontamination of robotic systems and equipment after use.
4. Onboard autonomous or semiautonmous physiological monitoring and medcal intervention for casualties during extraction operations.
5. Sound and light discipline.

PHASE I: Develop a concept for design for a UGS/UAS CBRNE Personnel Recovery System. Develop a concept of operations (CONOPS) and technical models which identify and translate functional requirements into implementable technical system designs demonstrating the feasibility of the CONOPS and capabilities defined in the Description paragraph above and in the Phase II demonstrable tasks below. Identify and demonstrate prototype system technical components to the greatest extent possible, using modeling and simulation, breadboards, and/or actual hardware/software. Develop a prototype development work plan and test and evaluation plan for Phase II.

PHASE II: Develop or adapt, and demonstrate a prototype UGS/UAS CBRNE contaminated personnel recovery and casualty extraction system capable of detection and identification of CBRNE agents, and recovering contaminated and/or incapacitated wounded or killed personnel from the contaminated area. The prototype should be able to demonstrate some or all of the enabling technologies described in the Description paragraph above. Further develop and execute an operational testing and evaluation plan; and develop a detailed commercialization plan for execution during Phase III.

PHASE III: Assist the military in the transition of the UGS/UAS CBRNE Personnel Recovery System to a Joint Concept Technology Demonstration (JCTD) or other pre-acquisition, development program. Once validated conceptually and technically, the dual use applications of this technology are significant in the area of civilian emergency services. Coordinate with civilian ‘first responders’ and Homeland Security agencies to transition the capability to civilian responders for emergency response in hazardous or contaminated environments.

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KEYWORDS: Personnel recovery, UGS, UAS, contaminated, remains, rescue, unmanned systems, robot.

A08-122 TITLE: Multiplexed Assay for the Detection of Wound-related Pathogens

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop benchtop diagnostic system that can rapidly identify up to 30 causes of bloodstream infections complicating treatment of combat wounds; must endure temperature extremes and be simple to operate.

DESCRIPTION: Wound-related pathogens such as Acinetobacter baumanii and Pseudomonas aeruginosa are a major challenge affecting the care of soldiers injured in Iraq and Afghanistan. The rapid determination of the cause of bloodstream infections complicating the treatment of combat wounds is a critical requirement for which no solutions currently exist.

The goal of this SBIR topic is to develop a hand-held or table-top diagnostic system that is capable of simultaneously detecting and identifying up to 30 relevant bloodstream pathogens from a clinical sample. The 12 targets for this effort include Acinetobacter baumannii-calcoaceticus complex (ABC), Candida, Enterobacter, Enterococcus, Escherichia coli, Klebsiella, Proteus, Pseudomonas aeruginosa, Serratia, Staphylococcus aureus/methicillin-resistant S. aureus (MRSA), and coagulase-negative Staphylococci.

The assay must be rapid (<60 min), one- or two-step format, stable (storage at 35 degrees C for 2 years) and be battery operable or require no power to operate. The assay should be 80% as specific and 80% as sensitive as conventional microbiology. The assay must be soldier-friendly (i.e., easy to operate), inexpensive, portable, use heat-stable reagents, and have no special storage requirements. The assay should be flexible enough to allow the battery of target organisms to be modified as the etiologies of bloodstream infections in this population change over time.

PHASE I: Determine the feasibility of the concept and develop a detailed plan for a diagnostic assay that has the potential to meet the broad needs discussed in this topic. Contractor provides a detailed plan, including results of preliminary testing as appropriate, to the Contracting Officer Representative (COR).

PHASE II: Development of a prototype assay that provides at least 80% sensitivity and 80% specificity when compared to current gold standard assays for each pathogen. Once sensitivity/specificity requirements have been met, the selected contractor conducts laboratory evaluation of assay performance characteristics (sensitivity, specificity, positive and negative predictive value, accuracy and reliability). The selected contractor will also conduct stability testing of the prototype device in Phase II in accordance with Food and Drug Administration (FDA) regulations. Stability testing will use both real-time and accelerated (attempt to force the product to fail under a broad range of temperature and humidity conditions and extremes) procedures.

PHASE III: Carry out studies required for FDA approval and commercialize the assay. The WRAIR may provide support (funding, clinical study sites, etc.) to this effort; however, careful advance coordination by the selected contractor will be required.

Military Use of this Product: This product can be used by a military treatment team in a Combat Support Hospital, fixed-wing theater evacuation platform, or a fixed medical facility to determine if wound-related pathogens are present in the bloodstream of an injured patient with clinical signs of bloodstream infection. Upon successfully obtaining FDA clearance for the assay, the selected contractor will coordinate with the COR to arrange for assignment of a National Stock Number (NSN) to this diagnostic assay. Subsequent to assigning a NSN to the assay, the contractor will work with the COR to arrange to have this product included in appropriate "Sets, Kits and Outfits" used by medical forces.

Civilian Use of this Product: Bloodstream infections are a significant problem in civilian trauma centers. This assay will have a significant commercial market worldwide.

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KEYWORDS: Diagnostic, Assay, Bloodstream Infection, Wound-related, Acinetobacter, MRSA .

A08-123 TITLE: <u>Prodrugs</u>

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Over the last half-century, the development and synthesis of medications that treat diseases or their symptoms of disease has been quite dramatic. One the earliest breakthroughs was the synthesis of Reserpine as reported in 1958 by RB Woodward1. Today, modern medications are used to treat a plethora of conditions ranging from depression to circulatory disease. Undoubtedly, the treatment of solid tumors has benefited from the development of novel therapeutics. Medications in use or in clinical trials for the treatment of solid tumors now range from biologic agents such as antibodies2 to porphyrin complexes3. The wide breadth of agents available today is partly in response to the current limitations associated with drug delivery. Many promising therapeutics have not translated into the clinic due to limited in vivo bioavailability at their targets. In order to counteract the limited bioavailability, one approach has been to prepare small molecules as inert species that do not activate until within close proximity of their target4. This request for proposals would seek out innovative molecular strategies for the delivery of IND-approved therapeutic agents based upon this prodrug concept. Proposals should emphasize the applicability of this approach to the treatment of solid tumors such as breast or prostate cancer. It is hoped that the novel delivery vehicles will optimize treatment by minimizing side effects and simultaneously boosting efficacy.

DESCRIPTION: Modern drug discovery certainly has prolonged and improved patients' lives for a variety of diseases, including breast cancer5. In some cases, therapeutic regimens are presented as alternatives to surgeries6. Prodrug-based drug delivery systems have the promise to augment the efficacy of compounds with limited bioavailability to solid tumors. Proposals are sought that would seek to develop better molecular vehicles for IND-approved small molecule therapeutic agents for solid tumors such as prostate or breast cancer.

PHASE I: The goal of this phase is to explore the feasibility of the proposed research towards enhancing the efficacy of IND-approved small molecule therapeutic agents for breast and prostate cancer. Proposals should clearly outline the principles and history preceding the proposed project, and address how IND approved small molecule currently elicits its function. Furthermore, proposals should then discuss how the prodrug-based delivery system would enhance the efficacy of the agent against its target. If applicable, describe any relevance of the molecular vehicle to military medicine. Use of human cells and tissues and/or animals requires approval by the appropriate US Army Medical Research and Materiel Command regulatory office. Phase I should include approval of appropriate regulatory documents necessary to execute Phase II.

PHASE II: Based on the outcomes of Phase I, prototype development will commence with the aim of demonstrating the enhanced efficacy of the prodrug vehicle using in vivo animal models. Preliminary clinical testing in human tissue samples may also be conducted. Experimental plans including the appropriate positive and negative controls should be outlined clearly. The offeror should demonstrate the benefits the research will extend to warfighters and their family members. The platform should decrease the need for secondary surgeries and recurrences of cancers (i.e. breast cancer). Furthermore, proposals are encouraged to demonstrate the universality of the platform to show a wide range of use in military and civilian medical applications.

PHASE III: This phase would involve optimization and clinical testing of the prodrug (molecular device) to demonstrate FDA marketability. The candidate product should also demonstrate its capability as a state-of-the-art drug delivery system for small molecules used in the care of military personnel and DoD beneficiaries. The commerciality potential of a Phase III project is expected to be high. Prodrugs that demonstrate effectiveness in reducing tumor sizes or recurrence will have widespread application for the treatment of cancer patients with solid tumors in both military and civilian sectors. It is anticipated that these agents will translate into clinical trials and be used as vehicles for any number of IND approved agents to boost their efficacies. Additional benefits may include improving the diagnostic accuracy of intraoperative biopsies, as they could be used to release contrast agents, to reduce the cost and discomfort of surgical cancer treatments for solid tumors.

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KEYWORDS: Prodrugs, nanotechnology, small molecules, molecular vehicles.

A08-124 TITLE: <u>Highly Agile Command Deployable Vehicle Arresting System</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop an innovative, easy to deploy, then remove, and redeploy, vehicle arresting barrier capable of stopping high weight vehicles bearing explosives or other weapons capable of attacking civilian or military assets along vulnerable avenues of egress.

DESCRIPTION: A variety of perimeter security products, barricades, crash barriers, bollards, vehicle arresting devices, or vehicle disabling systems exist on the market today. These systems can be effective when strategically placed to guard civilian or military assets from terrorist attacks along a defined avenue of approach, however most system require considerable planning, substantial time to erect, and guard assets which are more fixed than mobile. Fixed barrier systems usually require checkpoints and generally impede vehicle flow.

An innovative approach which potentially incorporates rapid explosive inflation of the arresting device, clever mechanical systems which can be integrated with the avenue of approach yet can be quickly put in place to block the avenue, or other techniques which provide a significant improvement over existing systems in terms of stopping power as well as logistics to deploy and redeploy are desired. Although intent of the barrier system is to provide arresting of a vehicle by non-destructive means, the barrier effect could be designed to be scalable depending on vehicle size and velocity, allowing significantly more damage for highest weight/highest velocity vehicles.

The technical challenges and salient characteristics of the barrier can be described as: 1) Stealthy emplacement profile so as to minimize the enemy's ability to detect the barrier and adjust tactics around the barrier zone. 2) minimize planning, logistics, manpower and time to emplace the system. 3) provide substantial standoff and width protection along a likely avenue of approach. 4) provide the ability to be command deployed from a distance of about 200 feet. 5) provide rapid ability for redeployment and maximize restoration of the stopping mechanism after usage. 6) minimize time and distance to arrest the vehicle. 7) potential use of area surveillance sensors to assist in effectiveness of barrier activation as well as a means of improving the effectiveness of the stopping technique

PHASE I: Define and substantiate the technologies necessary to realize the approach, the essential physics of erecting the barrier and stopping a vehicle, or other essential key performance related aspects of system functionality through simulation and/or testing. Full up prototype system testing shall take place in Phase II but subsystem testing should be pursued in Phase I to substantiate as much of the critical technologies involved. Define the salient features of the Phase II prototype system including erection system, stopping mechanism, and command deployment system. Define resources, time and schedule requirements for construction of the demonstration system for Phase II.

PHASE II: Construct prototype demonstration system capable of command deployment, system erection, and evaluation of barrier effectiveness against a live vehicle. Goal is to stop a 65,000 lb. vehicle moving at 50 mph in 100 feet or less. Easy of erection, increased width and depth of the barrier effect, and reduced distance/time to stop charging vehicle will be key evaluation factors. Full definition of the barrier design including all mechanical subsystems involved, sources, availability and producibility considerations shall be provided at completion of Phase II. Commercial off-the-shelf communications systems are recommended as a means of activating the remote deployment mechanism for the Phase II demonstration, however the remote controllable barrier erection mechanism should be designed to allow retrofit of future Army approved communications systems should decision be made for field trial or eventual fielding.

PHASE III: System will be used by US military forces to protect civilian or military assets which cannot be effectively protected using existing vehicle arresting devices or barriers. System will find widespread use in GWOT applications where terrorists continue to adjust tactics and adapt to new possible vulnerable entry points. System will find widespread use in civilian applications to protect existing fixed sites and especially those which change with prevailing political social conditions.

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KEYWORDS: Barrier, arresting, disable, vehicle, standoff, terrorist.

A08-125 TITLE: Advance Antenna and Processing Solutions for Multi-Functional Target Detection System

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a man-portable, robot deployable, or vehicle deployable radar system capable of high resolution scanning of the target area for IEDs in-road or off-road, EFPs off-road, or other weapons either hidden in ground, walls, floors, behind doors, or otherwise camouflaged by the enemy.

DESCRIPTION: The available sensor technologies for remote detection of IEDs typically exploit electromagnetic spectrum ranging from the visible through millimeter wavelengths. Techniques which are gaining prominence involve Micro-Impulse-Radar (MIR) pulse penetrating methods, Synthetic Aperture Radar (SAR) for improved target resolution, advanced signal processing techniques to remove noise and accentuate image clarity, and advanced antenna solutions employing advanced beamforming/beamsteering to optimize penetration through wall, ground, or other obstacles intended to hide the presence of the target.

One technology area of interest is polarimetric coherent change detection. Polarimetric coherent change detection is accomplished by using cross correlations of complex signatures using vertically transmitted –vertically received, horizontally transmitted, horizontally received (HH), and vertically transmitted, horizontally received signatures from a wide-band vehicle-mounted radar illumination. Polarimetric wide-band radars have been shown to be useful for effective detection of buried mine-like objects at varying burial depth, hence making them valuable for real-life implementation. Polarimetric radar also has potential benefits in detection of wires used for detonating IED's since recent studies have shown that IED wires result in high intensity HH polarized signatures. Through polarization synthesis, an image can be created to improve the detectability of selected features.

The challenge in this topic is to achieve the optimized synergy of current radar penetrating technologies using a combination of the most advanced antenna designs, beamforming techniques, and associated processing of the received target feature information to achieve outstanding target resolution and near real time performance. The system should allow functionality as a quick scanner to check specific points of interest or as a continuous scanner to develop scanning maps of a particular surveillance area. With the appropriate combination of technologies the goal is to develop a man-portable radar system which can scan target areas with a field of view of approximately 90 degrees or better and a depth of penetration through soil or other obstacles to approximately 6 feet or better, revealing target image information with sufficient clarity to actually identify specific IED, EFP, or other booby trap type target. Such a system will inherently fill needs for IED/EFP/booby trap detection whether these targets are in-road, off-road, in-wall, in-door, or otherwise obscured.

PHASE I: Define antenna design, beamforming technique and processing technique. Verify antenna design through modeling or other lab demonstrations to achieve the desired man-portable/robot portable requirements to scan an area of at least 6 foot swath and depth. Conduct proof of principle for the proposed advanced radar pulsing, beamforming, signal processing, and image processing techniques. Demonstrate ability to provide target images to a laptop computer with high resolution, near real-time operation, and at speed of greater than 15mph in the continuous scan mode.

PHASE II: Demonstrate a self-contained system which can be man-deployed, robot-deployed, or vehicle deployed, with data link to a laptop computer and sufficient data storage to cover spans of target detection in the continuous scan mode which could be as great as 50Km.

PHASE III: The realization of this system will provide a breakthrough for target surveillance and minimize the need for the development and fielding of different systems for in-wall, through wall, in-road, or off-road target detection.

As a commercial product, the system can be used as a means to combine with other explosive detection technologies to ensure the public with the most easy to afford and proliferate anti-terrorist scanning system.

REFERENCES:

1. Reedy, E.K., of MMW RAdar Systems," in Principles and Applications of Millimeter-Wave Radar, N.C. Currie and C.E. Brown, Eds., chapter 2, pp. 19-71, Artech House, Norwood, MA, 1987.

2. Sarabandi, K., L. Pierce, Y. Oh, and F.T. Ulaby, lines: Radar measurements and detection algorithm for polarimetric SAR images," IEEE Trans. Aerospace and Electronic Sys., vol. 30, no. 2, 632-648, April 1994.

3. Lynx: A high-resolution synthetic aperture radar, S. I. Tsunoda, F. Pace, J. Stence, M. Woodring, W. H. Hensley, A. W. Doerry, B. C. Walker, SPIE Aerosense 1999, Vol. 3704.

4. “Lightweight Synthetic Aperture Radar for Unmanned Aerial Vehicle Applications”, J. Ackenhusen, N. VandenBerg, D. Ausherman; IRIA State of the Art Reports, 2003.

5. Novak, L. M., Sechtin, M. B., and Cardullo, M. J., of Target Detection, Algorithms That Use Polarimetric Radar Data ," IEEE Trans. Aerospace and Electronic Systems, vol. 25, no. 2, 150-165, March 1989.

KEYWORDS: Penetrating, Radar, Aperture, Polarimetric, EFP, IED, Through-Wall, In-Road.

A08-126 TITLE: Improved mini Ku band antenna for TCDL

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Design and build a small, lightweight, omni-directional Ku band antenna compatible with current Tactical Common Data Link (TCDL) systems and hardware. The improved antenna should exploit innovative designs and technologies to improve the coverage pattern and maximize the range. The improved antenna should support both air-to-air and air-to-ground communications while rigidly mounted to maneuvering manned and unmanned Army aircraft.

DESCRIPTION: During common maneuvers conducted by Army aircraft, current data link systems struggle to maintain link due to the limits of the antenna coverage patterns. Current omni-directional TCDL antennas are a compromise between antenna coverage pattern and maximum range. Future Army mission requirements require both air-to-air (helo to UAV, helo to helo) and air-to-ground communications. Low total power levels, omni-directional coverage, and long range requirements combine to create a demanding antenna design problem. Current omni-directional antennas have fixed coverage patterns that are optimized for hemispherical coverage, range, or any number of coverage patterns to meet their application. When rigidly mounted to an aircraft, the antenna coverage pattern moves as the aircraft banks, turns, or changes pitch. If the aircraft maneuver moves the antenna coverage pattern off the receiving antenna, such as in a banked turn, the data link is broken, interrupting the mission. Systems using both an omni-directional antenna and a mechanically steered directional antenna have also been used with mixed results. Directional antenna pointing requirements and pointing data latencies limited aircraft maneuver rates.

This effort will focus on developing a small Ku band antenna that is simple, robust, has an omni-directional capability, has an antenna pattern that maintains link during manned aircraft maneuvers or modifies the antenna coverage pattern to maintain link, is small enough to meet Shadow UAV space, weight, and power requirements, and is compatible with current TCDL systems and hardware. Operational ranges out to 17km are required, with 25km desired. Combination omni-directional and electrically steered systems are potential candidates, or some other innovative system such as mercury gravity switch, or perhaps some other roll stabilized antenna system. Total antenna weight should not exceed 5 lbs, with 3 lbs total weight desired.

PHASE I: Through trade studies identify appropriate, relevant technologies that can be used to design the improved small Ku band antenna. Design the antenna and predict its range performance, coverage pattern, power consumption, weight, and projected unit cost for builds of 10, 100, and 1000 units. Construction of proof of concept builds is encouraged. Designs will be down selected for construction in Phase 2, if awarded.

PHASE II: Develop, build, and test the antenna design from Phase 1. The antenna must be built and tested in both bench tests and in representative, outdoor conditions. All weather testing is not required during Phase 2. Antenna range, and power consumption should be tested, and the antenna coverage pattern should be mapped. Comparison to Phase 1 predictions must be made, documented and reported. Major discrepancies should be identified and explained. Demonstrated compatibility with current TCDL systems and hardware is desired.

PHASE III: Productionize the antenna for operational use. Suitability for use in all weather, operational temperature ranges, flight worthiness certification, and the like will be required. Support for integration and flight testing on operational Army aircraft will also be required. Adaptation to other platforms such as military boats, ground systems, and vehicles should be explored.

REFERENCES:
1. The control of adaptive antenna arrays with genetic algorithms using dominance and diploidy, Weile, D.S. Michielssen, E., Dept. of Electrical. & Computer Eng., Delaware Univ., Newark, DE; IEEE Transactions on Antennas and Propagation, Oct 2001.

2. Adaptive antenna control, W. D. White, 1973 IEEE Conference on Decision and Control including the 12th Symposium on Adaptive Processes, Dec. 1973, Volume: 12, 232-237.

KEYWORDS: UAV, Helicopter, Ku band, antenna, TCDL, Data link.

A08-127 TITLE: <u>Emergency Anti-torque System for Rotary Wing Aircraft (Manned and Unmanned)</u>

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: A properly working anti-torque system (tail rotor) is critical for all single rotor rotorcraft. There are many reasons that the system may not work effectively. A light-weight emergency anti-torque system would many times enable the pilot to successfully land the aircraft without further damage.

DESCRIPTION: The Emergency Anti-torque Thruster System (EATTS) offers emergency recovery from: 1) Internal and external tail rotor failures (TRF), 2) Loss of tail rotor effectiveness (LTE), 3) Lack of tail rotor authority due to high altitude flights, 4) Center of gravity (CG) and yaw changes due to the loss of the tail rotor section, and 5) settling with power (SWP). EATTS would be helicopter-type specific, taking into consideration differences in gross weight, center of gravity, power requirements, as well as different components and electrical equipment. On many helicopters it would be possible to utilize some of the existing equipment while on other helicopters more equipment would be required. It should be noted that in most of these activation systems information would have to be gathered, processed, and relayed before activation could occur. Also, in order for the system to be efficient the amount of fuel dispersed would have to be regulated to maintain specific control.

PHASE I: This effort would encompass a feasibility study to identify and define information that would detect tail rotor failure and CG changes from several devices on board the helicopter. Several examples are: 1) the existing helicopters tail rotor tachometer could be used to detect a run up or slow down of the tail rotor RPM and 2) a strobe, vibration sensor, tail rotor gyro, a fight data information processor and/or other sensors could indicate a tail rotor strike, gearbox or shaft failure, or a failure that is about to occur. The study would develop approaches for this specific information. When these parameters are exceeded, the information would be relayed in order to activate the anti-torque propulsion system as necessary in order to maintain control of the aircraft.

Phase I would perform modeling and simulation which would lead to a plan for the design and practical employment of the means of anti-torque propulsion, i.e. nozzle. Phase I deliverables will include documents that confirm the feasibility of the EATTS technology.

PHASE II: Phase II should finalize and validate the design of the EATTS technology described in Phase I.

This effort should investigate the systems needed for the EATTS technology. The simplest system, once defined, should be demonstrated by experiment. Control of the anti-torque propulsion system should be accomplished via the best regulated flow of each torque conversion nozzle. The system should be designed at the component level and tests performed as to its capability.

A self test and should be performed and indicated by specific information on an EATTS display panel. Tests should be conducted to indicate the test is complete and all components are functioning properly. This should support methods and testing that will determine tail rotor failure and determine whether the failure is a false alarm. The system should make sure all of the monitoring systems and related components are correctly receiving and relaying signals. Additional tests on certain individual components in the loop could be made during as a part of the self test.

Information that would detect tail rotor failure and CG changes should come from several devices, including emergency automatic activation. Efforts from the design in Phase I should identify the cause and initiate the activation. Components should be fabricated and tested during this phase that identifies the specific cause. A plan should be developed that will identify potential causes and remedies for each cause. This specific information would be relayed to the on-board sensors with preset yaw and CG parameters. If these parameters were exceeded, information would be relayed in order to activate corrective measures to stabilize the aircraft.

The pilot should also be able to activate the system with a switch on the cyclic that bypasses the specific tail rotor information. If preset parameters were exceeded that information would be relayed in order to activate the correct the anti-torque propulsion system as necessary in order to maintain the helicopter within those preset parameters, thereby maintaining specific yaw control. Testing should be performed to confirm the design of pilot activation of the system.

As a result of the design and test from phase I and phase II testing described above, life cycle and environmental testing should be conducted. The best approach from Phase I into hardware and software should be implemented and a prototype should be designed and fabricated. Characterization should also be performed on the components fabricated. Field testing should be anticipated in phase III and test plans should be defined in preparation. The design from phase I should be finalized.

PHASE III: Phase III should follow into specific efforts that would be useful in an operational environment. The effort should determine uses and scenarios for the EATTS systems as experimentally validated in phase II. System development on the specific helicopter should be developed for situations such as survivability and rescue, settling with power, high altitude missions and deactivation once landed. Also the effort should determine the reliability of the EATTS with planning and development of airworthiness test and evaluation.

The transition of the EATTS technology should be actively pursued and the method to transfer to a helicopter platform should be determined. The transition should include the vision and end state of the technology and identify commercial applications.

REFERENCES:
1. Emergency Anti-Torque Thruster System, Brochure, from Website, www.911antitorque.com, Aug. 2007.

2. Statement before Tactical Air and Land Forces Subcommittee, Committee on Armed Services, by BG Mundt, 22 Mar 2007.

3. Patent Application, “The Emergency Anti-Torque Thruster System”, No. 7,032,860 B1, 4-25-2006.

KEYWORDS: Emergency Anti-torque, emergency recovery, tail rotor failures, Loss of tail rotor effectiveness, helicopter.

A08-128 TITLE: <u>JP-8 Fuel Effects on High Pressure Common Rail Pumps</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: To identify and demonstrate JP-8 related fuel property reliability and durability issues with current high pressure common rail pumps for medium-duty diesel engines and subsequently resolve this issue through improvement in pump reliability and durability while operating on JP-8.

DESCRIPTION: The Army currently procures commercial off the shelf (COTS) diesel engines for use in ground vehicle applications whenever possible. Current medium and heavy-duty engines include emissions control technologies such as cooled exhaust gas recirculation (EGR), nitrous oxide traps, catalyzed particulate traps, and diesel oxidation catalyst that were not originally developed to be compatible with JP-8 and thus present Army ground vehicles with reliability and vehicle system integration issues. To resolve this issue, the Army has obtained National Security Exemptions (NSEs) from meeting the 2004 and 2007 on-road diesel standards for a majority of its unarmored tactical vehicles and has a NSE from meeting all emissions standards for armored tactical vehicles. In addition to the aforementioned emissions control technologies, a number of OEMs employ high pressure common rail fuel systems as part of their combustion system package in order to provide flexible, multiple injections for reducing in-cylinder pollutants and also for use in either regenerating or enabling use of various aftertreatment devices. Such fuel systems in general require a fuel lubricity filter when operated on JP-8 that require frequent maintenance intervals in comparison to Army needs. Elimination of the fuel lubricity filter would reduce this maintenance burden and thus improve the overall reliability and durability of such fuel systems for Army ground vehicle applications.

This topic will strictly focus on modifying a high pressure common rail pump for use on JP-8 without inclusion of a lubricity filter or any other type of fuel additive device for diesel engines in the rated power range of 250 to 400 BHP.

PHASE I: Identify and determine a candidate high pressure common rail pump and potential methods for modifying the pump to eliminate use of a lubricity filter or any other fuel additive device while operating on JP-8. Additionally, identify potential reliability improvement that will occur with any such potential methods to eliminate fuel lubricity additives.

PHASE II: Investigate, demonstrate and validate experimentally a method or methods for eliminating the need for a JP-8 fuel lubricity additive as part of a high pressure common rail fuel pump system of interest to the Army as identified in the description.

PHASE III: Develop either an aftermarket kit or license a high pressure common rail pump method for improving the reliability of such a fuel pump while operating on JP-8 without use of a fuel additive device(s). Such a technology would be directly applicable for future Army medium- to heavy-duty applications through Army engine OEMs. Such a technology would be strictly beneficial to vehicle applications that rely on JP-8 as the fuel source.

REFERENCES:
1. "The U.S. Army, Diesel Engines, and Heavy-Duty Emission Standards", P. Schihl, 2007 Annual Automotive Research Center Conference.

2. "Development of an Optimized Slow Release Lubricity Enhancing Filter", H.R. Martin and P. Herman, SAE Paper 2006-01-3362, 2006.

KEYWORDS: JP-8 lubricity, high sulfur fuel, military diesel engines, fuel lubricity filter, fuel additives, JP-8 fuel properties.

A08-129 TITLE: Encrypt/Decrypt Mobile Devices with Biometric Signature

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Enterprise Information Systems

OBJECTIVE: Design, build and demonstrate the capability to encrypt/decrypt data on mobile device or removable storage media using Biometric, similar to email with the Public Key Infrastructure (PKI)/Common Access Card (CAC).

DESCRIPTION: Army missions require data residing on mobile device or removable storage media to be treated as sensitive information and mandates encryption of data at rest. The availability of commercial products with Biometric signature encryption provides limited capability. It only allows the individual encrypting the data to decrypt it and no one else. Other non Biometric encryption solution requires sharing keys and relying on the users to provide access control when distributing the keys along with the encrypted data. The Army seeks a “Biometric Key Infrastructure” system, which will use Biometric signature as one of the factor in a 2 factor authentication, and manage the Public and Private keys to encrypt/decrypt data.   This infrastructure could be maintained at various command/unit levels depending on the mission need. The system will maintain operational capability when connectivity to the Biometric Key Infrastructure is not available or in remote location where there is no connectivity by replicating minimum instance of its infrastructure to be deployed by other mechanical means.

PHASE I: Prepare a technical approach for a Biometric Key Infrastructure that includes specific performance parameters, anticipated system limitations, proposed test plan, an assessment of technical risk, estimated development costs for prototypes, and a proposed schedule (Microsoft Project) using an incremental development approach and including any essential integration and testing tasks.

PHASE II: Develop, test and demonstrate prototype(s) under representative operational environments.

PHASE III: The initial path for transition will be to the U.S. Military Entrance Processing Command (USMEPCOM), which has a recurring requirement to pass sensitive data from its 600+ Military Entrance Test Sites

(METS) to the regional Military Entrance Processing Stations (MEPS) all across the United States. NIPRNET connectivity is not available at most of the METS and exchanging data on encrypted mobile device would provide feasible alternative solution. The techniques, processes and technology developed may be applied to the commercial business facing similar need to protect their corporate data on mobile devices with access control that is centrally managed.

REFERENCES:
1. FIPS 140-2, 140-3, "Security Requirement for Cryptographic Modules"

KEYWORDS: Biometric Encryption.

A08-130 TITLE: <u>Dexterous Manipulation for Non-Line-of-Sight Articulated Manipulators</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: The objective of this SBIR topic is to increase the autonomy of manipulators (both their vision/sensing and dexterity), so that they can manipulate a squad-level load non-line-of-sight (NLOS).

DESCRIPTION: Over the last several decades, the international shipping industry has seen a lot of change, from break-bulk shipping to standardized ISO containers that move seamlessly from ships to trains and trucks [1]. Even in the continental US (CONUS), we have seen a trend toward portable moving and storage containers that are lightweight and easy to load/unload [2]. We'd like to extend this seamless concept right up to the battle lines. The Army's Future Combat Systems (FCS) envisions robotic assets such as the Multifunctional Utility/Logistics Equipment (MULE) resupplying others that are engaging the enemy [3]. The question becomes: How can we remotely load/unload these robotic assets such as the MULE?

To accomplish this task, we need several key areas of innovation 1) The dexterity of the manipulator itself; its ability to open and close the container doors as well as manipulate the loads 2) The sensing and vision system; its ability to orient the arm even in varying conditions such as sunlight, rain, and night-time operations 3) the creative design of the entire system, taking into account the container design, remote tracking, and transport of the loads intermodally via land or air.

PHASE I: The state of the art for manufacturing robots does not take into account inclement conditions. During Phase I, a feasibility study must address how these conditions will be addressed. The Phase I deliverable is a report outlining the effort and a concept video describing the idea.

PHASE II: Deliver a prototype demonstration of the concept: The prototype should be designed to operate a standard set of doors like those on a 20' ISO container [4]. The prototype should include (but not limited to) a manipulator arm [5] or conveyor system to allow movement of equipment into and out of the container. The prototype must work in inclement conditions such as direct sunlight, rain, and darkness. If the prototype resides on a mobile robot, the robot must be able to operate within the confines of a 20' ISO Container. The individual boxes of equipment must be at least 20lb up to a total squad load of 500-1000lb. These boxes may be uniform in shape, and they may be specifically designed for robot handling. The Phase II deliverable is a demonstration of the operation from start to finish and a report summarizing the entire project.

PHASE III: This technology would be useful for both military and commercial logistics operations. Commercially, if loading and unloading were automated, you could picture a driver that is unconstrained by loading/unloading their vehicle: They would merely pull up to the curb and load/unload from the comfort of the cab. Besides providing crew-comfort and standoff distance, this could save time and money as well. The loading/unloading equipment could be picked up by the driver after all their rounds are done.

REFERENCES:

1. The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger by Marc Levinson 2006 Princeton University Press.

2. www.pods.com.

3. http://www.army.mil/fcs/.

4. www.seabox.com.

5. Robot Dynamics and Control by M.W. Spong and M. Vidyasagar 1989 Wiley.

KEYWORDS: Robotics, logistics, manipulators.

A08-131 TITLE: Tools, Techniques and Materials for Lightweight Tracks

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Define current logistic and installation shortcomings with current and future lightweight track systems. Establish approaches to alleviate the logistic burden of field installation, inspection and repair for lightweight track systems.

DESCRIPTION: Track systems have an inherent logstics burden associated with them. They may be heavy, require daily inspection and maintenance, and in cases require repairs which must be accomplished in field. All of these items put the vehicle and crew at risk if they have to exit the vehicle to perform an inspection or repair while in the field. With the recent push toward lighter track systems a new logsitical challenge is emergining. While these lighter track systems offer reduced maintenance they also bring the challenge of installation, field transportability and repair into question. New, lightweight track systems are using the approach of segments or sections of track which are broken in lengths to reduce overall ownership and operating costs as well as keep weight down. These segments may be either steel or rubber and may vary in length from 2 ft to 10 ft. The U.S. Army has a need to determine what the top logisitic burdens are associated with tracks and develop new methods, processes, tools and equipment to help the soldier maintain, repair or replace these track systems in a short time frame both in the shop and in the field environment. Specifically field installation and repair of current track systems is a daunting task requiring the work of several crew members to safely repair or replace track in conditions ranging from extreme heat, deep cold, mud and sandy environments. Certain tasks may even require the vehicle to be elevated or pulled to rotate the track system to allow access. Tools, and techniques should be analyzed to determine how best to perform the following tasks using only two crew members in under 30 minutes: track installation, daily track inspections, track repair in the field and in the shop, track handling (physical track manipulation), and carrying spare track segments to and from the vehicle.

PHASE I: Define and determine the leading track system logistic burdens. Develop approaches for improving track installation (in field and shop environments), maintenance and repair. Investigate processes allowing a two member crew to perform track related maintenance in under 30 minutes. Conceptulize and define an innovate solution to track system maintenance. This Phase will demonstrate the feasiblity of producing a system for track maintenance and repair, and will outline demonstration success criteria as well as provide a detailed plan for improving track installation, inspection and field repair. Phase I is 6-month, $70K (max) effort.

PHASE II: Demonstrate several concepts for installing a segmented track system both in a shop environment as well as a field environment. This phase will deliver specialized tools and the procedures to use the tools to demonstrate changing a segmented track system in the shop and field environment in under thirty minutes using only two individuals and no heavy lifting equipment (i.e., forklift, overhead crane, etc). Fabricate any necessary hardware to demonstrate these findings. Phase II is a 2-year, $730K (max) effort.

PHASE III: Potential application for these tools, techniques and materials may be applied to the Abrams, Bradley, M113, and Future Combat Systems (FCS) Manned Ground Vehicle (MGV) fleet. Additionally the techniques, processes and tools developed may be applied to the commerical industries fleet of tracked agricultural and commerical grade equipment such as those found at construction sites or on farms.

REFERENCES:
1. Operator's Manual for Carrier, Personnel, Full Tracked, Armored, M113A2 -Chapter 6 Maintenance Instructions for Maintenance of Carrier.

2. Soucy Rubber Track User Manual for M113A3 Vehicle Family.
KEYWORDS: Track Systems, Installation, Repair, Tools, Techniques, Processes, Materials, Human Systems.

A08-132 TITLE: Variable Optical Transmission Lens for Integrated Eyewear Protection

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Incorporate current or emerging technology in variable optical shuttering to develop and demonstrate a variable transmission lens capable of meeting size, shape, weight, and power constraints of ballistic fragmentation protective spectacles compatible with the Army Combat Helmet.

DESCRIPTION: Army missions require continuous movement between bright and dark environments with operations in daylight, twilight and nighttime conditions. In full daylight, the see-through lens must maintain enough contrast to reduce staining and fatigue of the eyes. Under low light environments and twilight conditions, natural vision is still superior to night vision sensors for situational awareness provided as much light as possible reaches the user’s eyes. Currently the Warfighter is forced to change out tinted and clear lenses before entering and exiting buildings and photochromic variable transition lenses alone require too much time to transition between a clear and tinted state. Army regulations require vision protection while operating outside the forward operating base. Current technology has shown the possibility to demonstrate variable transmission through a power driven technology. The Army seeks a variable transmission technology that allows one to switch from ambient attenuation for bright and daylight conditions to low light and twilight conditions at the push of a button. A luminous transmittance range of 18% to 85% or better is desired.

PHASE I: Demonstrate the feasibility with innovative approaches to the application of variable transmission technology to complex curvature optical elements. To maximize the desired luminous trasmittance range of the device while minimizing the time for the device to change optical states, a combination of approaches (such as electrochromic and photochromic) may be employed if deemed feasible. The platform for demonstration will be ballistic fragmentation protective spectacles.

This study should examine an integrated candidate approach and at a minimum address the following items: 1) rate of transmission change, 2) range of photopic and scotopic transmission, as well as degree of UV absorption, 3) distortion caused by spherical aberration or other optical aberrations, 4) compatibility with complex curved substrates including toric and toric asphere, 5) weight, 6) total power consumption, 7)environmental susceptibility, 8) Environmental emissions, 9). ballistic performance equal to or better than current items 10) haze/abrasion performance better than current product performance 11) ANSI Z87.1 compliance (required by Office of the Surgeon General for protective eyewear) and 12) integrated hearing protection.   Submit for Government review physical test data from laboratory measurements on one or more candidates of the variable transmission technologies. Establish preliminary concept design and prototype based on the integrated study. The most effective designs and materials will be determined and proposed for Phase II efforts (Technology Readiness Level 5, TRL-5).

PHASE II: Refine prototype developed in Phase I and deliver a working prototype system to the Government of a functional, integrated lens with see through variable transmission to the external scene for evaluation and compatibility testing. The phase II prototype shall contain a variable transmission lens integrated into a ballistic protective spectacle set. The system delivered to the government shall include variable transmissive drive electronics and associated cables. The Phase II prototype shall demonstrate see-through display interaction with various ambient lighting conditions in the ability to modify the ratio of external scene luminance to display luminance reaching the operator's eye.

Deliver a report documenting: (1) the design of the variable transmission device and its integration method; (2) the fabrication processes; (3) the experimental procedures and results that demonstrate the effectiveness of the variable transmission system to meet various requirements (to include ballistic, optical distortion, haze/abrasion, effective transmittance range over the visual spectrum, UV absorption, and ANSI Z87.1 performance); (4) produce 5 prototype devices to demonstrate the innovative technology in a relevant environment. In addition, prototypes will be tested on a system level to ensure integration and operational performance. The success of performance evaluation and testing results, if favorable, will lead into Phase III applications. All research, development and prototype designs shall be documented with detailed descriptions and specifications of the materials, designs, processes, and performance (TRL-6).

PHASE III: Upon successful completion of the research and development in Phase I and Phase II, the Variable Optical Transmission Lens will be manufactured. Prior to use in an operational environment, the product must, at a minimum, demonstrate compliance with ballistic fragmentation and ANSI Z87.1 requirements. In addition, this Variable Optical Transmission Lens can be applied to civilian law enforcement and outdoor equipment with similar operational and recreational purposes (TRL 6).

REFERENCES:
1. Core Soldier System Capabilities Production Document. Force Protection Attributes, Eye Protection. June 2007.

2. Brown, Mark GEN. PEO Soldier Town Hall, Soldier Needs. Fort Belvoir, VA. Program Executive Office-Soldier. September 2007.

KEYWORDS: Variable Transmission, Optical Lens, Eyewear, Transition Lens.

A08-133 TITLE: Dynamic Terrain System Process Development

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: (1) Develop and demonstrate a low-cost, efficient communication mechanism to rapidly distribute terrain database and feature database changes to distributed simulators and simulations allowing the simulation community to proliferate a common mechanism for dynamic terrain communication. (2) Develop innovative low-cost algorithms and tools to implement the distribution mechanism.

DESCRIPTION: Requirements exist for composable and communicable dynamic terrain for virtual environments. Current virtual training environments do not have the ability to communicate terrain changes across distributed simulations efficiently and effectively. Military operations in urban environments require ability to breech building, accurately simulate building rubble, create and navigate pot holes in roads or terrain. Interoperability and fair fight would be possible if linked distributed simulators and simulations had the ability to exchange evolving terrain data in common scenarios. There is an unfulfilled current training requirement for building rubbling, breaching buildings, terrain for construction or combat engineer vehicles (graders, dozers, etc) that dynamic terrain would answer. Better training of forces in urban environments would be possible. Dynamic Terrain techniques have been demonstrated on standalone systems, but the ability to rapidly distribute those terrain changes has not been accomplished. This distribution of dynamic terrain changes will revolutionize fair fight among virtual simulators and has the potential to rapidly allow correlation of terrain changes to semi-automated forces (SAF).

PHASE I: Develop a high level design concept for developing composable and communicable dynamic terrain for virtual environments. The concept should consider and leverage, as appropriate, any technology investigation to create integrate composable and communicable dynamic terrain for virtual environments.

PHASE II: Develop algorithms, data and tools to allow terrain changes to be rapidly distributed among distributed simulators. Develop a sample application demonstrating the use of multiple simulators sharing real time terrain changes. Demonstrate the potential for SAF to use the terrain messages to rapidly correlate to the terrain. Develop and demonstrate a prototype system in a relevant virtual training environment (driver training or ground or air vehicle military training). The demonstration must include integration of composable and communicable dynamic terrain for virtual environments.

PHASE III: Dual use applications. Composable and communicable dynamic terrain for virtual environments will augment training in a variety of simulators and simulations in the Us Army inventory. It will allow more accurate and more realistic interactions between trainees in a common distributed training environment. It will permit training at a fidelity level that is not achievable with today's limited technology. The envisioned end state is a truly immersive virtual environment that allows all trainees or participants to interact with the terrain and each other in real time status. Commercial applications include: building industries that move earth or interact with terrain, driver trainer in convoys, disaster relief simulations with real-time terrain changes (floods, landslides, hurricanes), and any other simulations that involve interactions with changing terrain.

REFERENCES: None.

KEYWORDS: Modeling and simulation, military training, dynamic terrain, military operation sin urban environments (MOUT), and computer generated forces.

A08-134 TITLE: Game Interface for the OneSAF Computer Generated Forces Simulation

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

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

OBJECTIVE: Develop a game interface for the One Semi-Automated Forces (OneSAF) simulation for use in military training applications.

DESCRIPTION: Efforts to adapt commercial game technology for military training applications have increased significantly over the past several years. Often, the training use case has been to adapt a commercial game to the military domain. However, these games often do not have underlying modeling to support realism, accuracy, and precision based on validated and verified (V&V) mathematical and physics-based models. At the other end of the spectrum, military simulations may provide the appropriate modeling, but lack the ability to truly immerse and fully engage a user in a training scenario. The intent of this effort is to create an appropriate hybrid involving an intuitive, easy-to-use game-based graphical user interface (GUI) and the OneSAF simulation engine.

PHASE I: Conduct a review and feasibility assessment for integrating a game-based GUI into the OneSAF architecture. The review must consider and leverage, if appropriate, a technology investigation already conducted by the Institute of Creative Technologies (ICT) to create a prototype capability. Results of this investigation will be provided as GFE/GFI. The feasibility assessment must consider the ability for the user to author the user interface content to accommodate different warfighting functions and allow the ease of use to apply art content (2.5 or 3-dimensional) to existing and new terrain databases. The contractor will use the most current OneSAF baseline and documentation at the time of award. A high level design concept will be delivered at the conclusion of the phase.

PHASE II: Develop and demonstrate a prototype system (TRL 7) in a relevant training environment. The design and development of the prototype must comply with the OneSAF architectural standards. The demonstration must include multiple warfighting functions and use at least two different OneSAF terrain databases, one of which contains an urban area.

PHASE III: The OneSAF system will replace a variety of legacy simulations in the Army's training inventory. In addition, the OneSAF baseline with source code will be made available free-of-charge to other organizations both in and outside of the Department of Defense (DoD) to include joint, multi-service, intergovernmental, and industry/academia that support these organizations. The potential number of OneSAF users is vast. The availability of a game-like interface for OneSAF should further broaden the pool of potential OneSAF users by making it more usable for a broader range applications. The envisioned end state is a tailorable game interface capability that engages the user to provide effective training for any of the Army's warfighting functions, as well as for various potential dual use applications to include Homeland Defense. This Game GUI will be available as an alternate interface to OneSAF to meet various users' needs.

REFERENCES: None

KEYWORDS: Commercial game technology, modeling and simulation, semi-automated forces, military training and computer generated forces.

A08-135 TITLE: Development of a small LADAR sensor for a Small Unmanned Ground Vehicle (SUGV)

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: To develop a small LADAR sensor for a small robotic platform, such as the Future Combat System (FCS) Small Unmanned Ground Vehicle (SUGV). The sensor shall provide sensor data that enables specific capabilities including: assisted teleoperations, obstacle detection and avoidance, waypoint navigation, sentinel behaviors, and automated local mapping for a small, man-portable, (i.e., less than 50 lbs.) robotic platform.

DESCRIPTION: Physical agents, such as robotic platforms, will be ubiquitous on the future battlefield, significantly lowering the risks to our soldiers. These robots must be able to not only collaborate amongst themselves but also with their manned partners. Their roles will range from scout missions, performing reconnaissance, surveillance, and target acquisition, to urban warfare, urban rescue, or explosive ordinance disposal. The human/robot interaction with these agents must be highly efficient and minimally intrusive. The interaction with the robots must not encumber the soldiers. Additionally, communications between the robot and soldier must be minimized to reduce bandwidth. Therefore, a small integrated LADAR sensor is necessary on small robotic platforms to enable soldier-assisted teleoperations and local obstacle detection, while minimizing user interaction. The envisioned characteristics of the small LADAR are: a range on the order of 25 feet; with resolution and accuracy for navigation applications; horizontal field of regard, greater than 60 degrees; vertical field of regard greater than 30 degrees; eyesafe wavelength; a volume of approximately 10in3; rugged (for military applications), produces a volumetric (3D) scan; a low-cost design, operates at low-power; RS-232 or USB interface; and for use outdoors and indoors.

A small LADAR design is required to facilitate autonomous behaviors for small robots. The proposed small LADAR sensor design needs to consider tradeoffs between the above characteristics, including power from the host robot, mission duration, physical interaction, and mobility constraints with existing small robotic platforms. It is anticipated that this small LADAR sensor and a small robotic platform will be utilized for experimentation. A proposal that focuses on optical system designs utilizing MEMS or LCD scanner and a foveal approach is strongly encouraged.

Prospective candidates should adequately address the following small LADAR sensor design features: 1) sensor characteristics listed above, 2) proposed mechanical and electrical design characteristics such as physical size, power consumption, mission duration, and interface with a small robotic platform.

PHASE I: Conduct engineering design phase in which all components for the small LADAR sensor are identified. This should include the physical layout of the module and the sensor specifications as outlined above. A demonstration of critical components for feasibility is strongly encouraged.

PHASE II: Develop and build a fully functional prototype small LADAR sensor that is integrated and operational with a GFE small robotic platform (i.e. Packbot).

PHASE III: Homeland defense, law enforcement, and urban search and rescue are the most natural dual-use applications for this technology. A small robotic platform outfitted with a small LADAR sensor will facilitate assisted teleoperation behaviors, and enhance autonomous behaviors. A small robot outfitted with a small LADAR sensor would be most useful in an urban environment or building environment for search and rescue.

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2. "Battlefield Agent Collaboration," P. Budulas, S. Young, and P. Emmerman, published in the Proceedings of SPIE, Unmanned Ground Vehicle Technology III, Vol. 4364, Orlando, USA, 16-17 April 2001.

3. http://www.robotfrontier.com/papers/auvsi2005.pdf Wayfarer: An Autonomous Navigation Payload for the PackBot, Brian Yamauchi, Proceedings of AUVSI Unmanned Vehicles North America 2005, Baltimore, MD, June 2005.

4. Future Combat Systems-Small Unmanned Ground Vehicles (FCS-SUGV), www.fcs-sugv.com or www.boeing.com/defensespace/ic/fcs/bia/combat/15360.html

5. iRobot’s Packbot, www.packbot.com

KEYWORDS: Robotics, LADAR, autonomy, Future Combat Systems (FCS), SUGV.

A08-136 TITLE: Video Compression Techniques for Tactical Wireless Networks

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

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

OBJECTIVE: Develop an advanced video compression algorithm and codec optimized for operation over low-bandwidth unreliable networks such as the mobile ad-hoc networks used in tactical operations (i.e. RESILIENT TO PACKET LOSS). The developed codec should be capable of operating at data rates of less than a megabit, produce usable video given moderate rates of packet loss, and be able to rapidly recover from periods of high packet loss. The codec should also exhibit low latency.

DESCRIPTION: In the past few years, various organizations have made many advances in video compression technology and developed algorithms capable of very high compression ratios. These developments have primarily been motivated by consumer electronics applications such as video-on-demand and high-definition television, along with business applications such as videoconferencing. However, such applications usually make use of networks or other transmission techniques that are relatively reliable, guaranteeing that a high percentage, or possibly all, of the data sent will be received. As a result, modern compression techniques such as MPEG and H.264 use techniques sending only the changes between frames (delta frames), and only occasionally sending a full frame worth of data (key frames).

Wireless networks in general, including mobile ad-hoc networks and other forms of tactical wireless networks used by the Army, are often considered unreliable environments due to the possibility of packet loss. Depending on conditions, much of the data sent will not be received, be received late, or out of order. Tests conducted by ARL have shown that video compression techniques that make use of delta frames generally do not perform well over such networks. Using typical current generation codecs, the ability to reconstruct a frame of video depends on having received all previous delta frames back to the last key frame. When some of the frame data is lost, the result is often a scrambled image or no image at all until the next key frame is received. An additional challenge results from key frames often being larger than delta frames as they contain more information. Some networks are more likely to drop larger packets, such as packets comtaining key frames. The result often is that when data starts being dropped, key frames are not received properly and the video display never recovers.

Due to these challenges, military applications such as teleoperated robotics, soldier-mounted cameras, and remote surveillance often use older compression technologies such as motion-JPEG that do not use key frame/delta frame techniques. These older technologies exhibit better recovery from network data loss, but produce higher data rates for a given video quality than more recent technologies. Bandwidth in tactical networks is extremely limited and the large amount of data generated by older compression technologies can saturate the network, limiting the amount of devices that can be used at any given time.

The requirement to transmit video over an unreliable tactical network will be present for the forseeable future. It is necessary to develop advanced video compression techniques that are well-suited to the tactical network environment. We do not necessarily rule out the use of technologies that make use of the key frame/delta frame concept, but any technology that will perform adequately over an unreliable network must be able to recover from high rates of packet loss. In order to facilitate remote operation of unmanned vehicles, new compression technologies must also have minimal latency.

PHASE I: Develop a design for an advanced video compression system for tactical networks and produce a design document describing the proposed compression system. The design document shall contain a detailed description of the compression algorithm that will be used, a discussion of why it is expected to perform well over an unreliable low-bandwidth tactical network, and a comparison of the expected performance with respect to a baseline motion-JPEG codec. Performance comparison data should be obtained from theoretical mathematical models of the codec and an evaluation of a prototype software implementation of the codec. The design document shall also address the feasibility of implementing the proposed video codec in hardware using ASICs or programmable logic and include a discussion of the advantages and disadvantages of a hardware-based approach.

PHASE II: Develop a software library implementing the compression algorithm designed during phase I. The library shall be written in a portable language, preferably ANSI C, and shall be designed so that it can be easily incorporated into a wide range of software packages. Create a comprehensive set of documentation describing the library and associated APIs. Conduct an extensive performance evaluation of the compression library in a controlled environment with various levels of packet loss and bandwidth restriction. Motion-JPEG and MPEG-4 Part 2 video should be used as baselines for comparison. Conduct a final demonstration of the developed library on a tactical network testbed. Develop a design for a hardware implementation of the video codec and produce a design document containing a detailed description of the proposed hardware implementation.

PHASE III: The system developed under this effort will have a range of uses in military and civilian markets, ranging from remote vehicle operation to video distribution over civilian data networks. In particular, increasing use of mesh-networking technologies in civilian markets presents many challenges that are similar to tactical ad-hoc networks and the developed system will have many applications in this area.

REFERENCES:
1. Future Combat Systems-Small Unmanned Ground Vehicles (FCS-SUGV), www.fcs-sugv.com or www.boeing.com/defense-space/ic/fcs/bia/combat/15360.html.

2. iRobot's Packbot, www.packbot.com.

KEYWORDS: Codec, video, compression, tactical wireless networks, robotics, Future Combat Systems (FCS).

A08-137 TITLE: High Energy Laser Component Technology for Eye-Safer Fiber Lasers

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To research and develop innovative High Energy Fiber Laser component technologies that will continue to advance the state-of-the-art in 1kW class Eye-Safer Fiber Laser devices in the 1.5 to 2.1um with a goal of eliminating free-space optics. Component technologies of interest include fiber isolators, high power couplers and combiners, optical modulators, fiber Bragg gratings, etc. Of particular interest is component technology designed for Tm fibers.

DESCRIPTION: As high power fiber laser research and development continues to evolve, the US Army Space and Missile Defense command is interested in innovative technologies that will continue to advance the state-of-the-art in 1kW class solid state eye-safer fiber laser devices. The goal of this SBIR project is to develop fiber laser component technology that supports the desire for an all-fiber, eye-safer fiber laser that is rugged, has high efficiency, and is beam combinable. This topic seeks proposals for the demonstration of innovative component technologies which would enable increased performance of all-fiber high power solid state lasers. One example of component technology is for all-fiber power combiners for high power fiber lasers. An all fiber combiner is critical to eliminate free space optics to get pump light from the pump source into the fiber gain medium. The key is to produce components to support the all-fiber high power laser design that work well together. It is envisioned that technologies investigated and developed under this SBIR topic will be inserted into the Space and Missile Defense Technical Centers advance fiber laser development program.

PHASE I: Conduct research, analysis, and studies on the selected component technology and develop measures of performance enhancement and document results in a final report. The phase I effort should include modeling and simulation results supporting performance claims. The effort may also produce a preliminary design and a draft testing methodology to demonstrate the enhancement during the phase II effort.

PHASE II: During Phase II, a testable component breadboard will be designed and built based on the phase I preliminary design and analysis to conduct laboratory proof of principal testing. A test plan should be developed to test the device to stated performance objectives. Identify areas for performance enhancement and fabrication cost reduction. The data, reports, and breadboard hardware should be delivered to the government upon the completion of the phase II effort.

PHASE III: It is envisioned that a phase III for this topic would be part of the US Army Space and Missile Defense Technical Centers advanced fiber laser development program. The phase three effort would be to partner with an eye-safer fiber laser supplier and integrator to build, demonstrate, and deliver a high power, beam combinable, all fiber laser with no free space optics. A high-power, high-efficiency solid state eye-safer fiber laser has the capability of adding tremendous value to land and air directed energy platforms for both attack and protection. High energy solid state fiber lasers are also sources of material processing in the automotive, aircraft, and other large manufacturing industries. The risk of non-combatant collateral damage is always a concern for Army weapon systems. A high power eye-safer fiber laser decreases the potential for collateral damage to the retina of eyes.

REFERENCES:
1. W. Koechner, "Solid-State Laser Engineering fifth revised and updated edition" Springer-Verlag, 1999.

2. Electro-Optics Handbook, RCA Solid State Division, Lancaster PA, 1974.

3. Annual Directed Energy Symposium Proceedings available at:
http://www.deps.org/DEPSpages/forms/merchandise.html

KEYWORDS: Eye-Safer Solid State Fiber Laser, Fiber Isolators, Fiber Combiners, Bragg Gratings, Fiber Couplers.

A08-138 TITLE: Advanced Ferroelectric Materials for Explosive Pulsed Power for Missiles and Munitions

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The objective of this effort is to develop new ferroelectric materials with enhanced energy storage, voltage hold-off, mechanical, and ferroelectric properties for use in explosive driven pulsed power devices to be used in payloads for missiles and gun launched projectiles. Since the production of these new materials is related to their development, another objective is to develop the manufacturing and poling process required to produce large numbers of ferroelectric elements having different geometrical shapes.

DESCRIPTION: Ferroelectric materials are used in a number of military and commercial applications including sonars, actuators, capacitors, MEMS power supplies, and pulsed power. Of particular interest is their use in explosive pulsed power units (ferroelectric generators) and capacitors for directed energy munitions. Ferroelectric Generators (FEGs)have proven to be very compact inexpensive reliable power sources. Recent research has established that new ferroelectric materials, PZT 95/5 being the current state-of-the-art material, can enhance the electrical output of these generators by storing more energy per unit volume and/or by reducing electrical breakdown and fracturing. It has also been demonstrated that these generators can be made very small and still function effectively and reproducibily. There are two ways to enhance their performance: power conditioning and better ferroelectric materials. Thus, the focus of this effort is to develop new ferroelectric materials with increased energy storage density; enhanced electrical, mechanical, and shock properties; and reduced loss mechanisms, such as fracturing and leakage current. Since the development of these new materials is related to how they are produced, another objective is to develop and automate the manufacturing and poling processes required to produce elements with different geometrical shapes in large numbers. In order to be considered for this effort, the bidding firm must show that they are capable of performing proof-of-principle experiments involving explosives.

PHASE I: The objective of Phase I is to design and develop new ferroelectric materials with higher energy storage density and reduced losses than current state-of-the-art ferroelectric materials such as PZT95/5. Proof-of-principle demonstrations will be conducted 1) to verify that the these new ferroelectric materials exhibit enhanced energy storage, voltage hold-off, temperature stability, mechanical properties, and/or other ferroelectric characteristics than PZT 95/5, 2) to assess their ability to function properly in FEGs that have a diameter ranging from 25 to 40 mm, and 3) to assess their ability to maintain these properties in high g-force environments.

PHASE II: Design, build, and test FEGs based on these new materials, verify their enhanced performance parameters, and verify that they can meet the size requirements of a platform with a diameter as small as one inch. Develop application specific ferroelectric elements, scale-up material fabrication processes to meet the need for multiple device prototyping efforts, and refine materials to meet military environmental requirements. Other issues that should be addressed in Phase II are hardening the technology to survive high g-force launches, developing methods to reduce or eliminate surface arcing, and designing processes for mass production.

PHASE III: The explosive pulsed technologies developed under this effort could be applicable to multiple military and commercial applications requiring pulsed power. Some of these applications include water purification units, nondestructive testing systems, portable lightning simulators, expendable X-ray sources, and oil and mineral exploration. The ferroelectric materials developed under this effort could find use in a number of other applications such as high energy density capacitors, actuators, sonars, MEMS devices, and sensors. Since several government labs and prime contractors are developing advanced munitions, the contractor will need to have developed a business plan for working with these agencies and companies.

REFERENCES:
1. L. Altgilbers, M. Brown, I. Grishnaev, B. Novac, S. Tkach, Y. Tkach, Magnetocumulative Generators, Springer-Verlag, New York (1999).

2. P.W. Cooper, Explosive Engineering, Wiley-VCH,, Inc., New York (1996).

3. L. Altgilbers, "Recent Advances in Explosive Pulsed Power", Journal of Electromagnetic Phenomena, 3(4(12)), pp. 497 – 520 (2003).

4. R.E. Setchell, S.T. Montgomery, L.C. Chhabildas, and M.D. Furnish, "The effects of Shock Stress and Field Strength on Shock-Induced Depoling of Normally Poled PZT 95/5", Shock Compression of Condensed Matter – 1999, AIP Conference Proceedings CP505, American Institute of Physics, New York, pp. 979 – 982 (2000).

5. Setchell, R. E., Chhabildas, L. C., Furnish, M. D., Montgomery, S. T., and Holman, G. T., "Dynamic Electromechanical Characterization of the Ferroelectric Ceramic PZT 950," in Shock Compression of Condensed Matter - 1997, edited by S. C. Schmidt et al., AIP Conference Proceedings 429, New York, pp. 781-784 (1998).

KEYWORDS: Ferroelectrics, explosive pulsed power, ferroelectric generators, piezoelectric, manufacturing processes, poling processes, ceramics.

A08-139 TITLE: <u>Vertical Cavity Surface-Emitting Laser (VCSEL) pumps for Reduced Eye Hazard Wavelength High Energy Fiber Lasers</u>

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To research and develop Vertical External Cavity Surface-Emitting Laser (VCSEL) array pumps for reduced eye hazard wavelength Er or Tm fiber lasers. The goal is to design, build and test a VCSEL array that surpass traditional edge emitting diode array performance for pumping fiber lasers in the areas of higher efficiency, lower production costs, higher brightness, and better thermal properties.

DESCRIPTION: While it has been determined that high energy lasers can provide a tremendous benefit to the Army for area protection against rockets, artillery, and mortars (RAM) and other potential threats, there is concern about current Nd:YAG based high energy laser systems potentially causing collateral eye damage due to scatter off of target surfaces. In addition, the efficiencies of slab based solid state lasers make it desirable to explore the possibilities of reduced eye hazard fiber based high power lasers. This SBIR topic focuses on development of the VCSEL pump array for pumping an Er or Tm fiber laser. Early research investment in laser technology that supports higher efficiencies, more compact, reduced eye hazard wavelength, higher power, and lower cost is critical. The purpose of this SBIR is to investigate and demonstrate through laboratory experiments and demonstration, modeling and simulation, and building a breadboard VCSEL pump array in phase II, the potential of high brightness, and cost savings of using VCSEL technology for fiber laser pumping. The use of VCSEL technology for fiber laser pump source has many benefits. For field applications, it is important to note that VCSEL emitters have demonstrated high temperature operation and can be cooled at coolant flow rates that are much lower than traditional edge emitting diode arrays. It is anticipated that VCSEL pump arrays would tremendously reduce the size and weight for a fiber based laser system. The fabrication methods of the VCSEL arrays are appropriate for lowering the ultimate cost of the most expensive component for diode-pumped fiber lasers, the diode arrays, thus providing a long term cost advantage.

PHASE I: Conduct research, analysis, and studies on the selected VCSEL pump array architecture and develop measures of performance and document results in a final report. Provide analysis supporting the claimed VCSEL array performance. Identify requirements and performance metrics required for VCSEL pumping of a fiber laser. The phase I effort should include modeling and simulation results supporting performance claims. The effort should also produce a preliminary concept for VCSEL array proposed to be built during the phase II effort.

PHASE II: The Phase II effort should consist of, completing the breadboard VCSEL array design, building VCSEL array(s), and testing against the performance metrics identified in phase I. Added validation of the VCLES pump concept could be to actually perform an experiment demonstrating the performance by pumping a reduced eye hazard fiber laser (Er or Tm). The data, reports, and tested VCSEL array hardware will be delivered to the government upon the completion of the phase II effort.

PHASE III: If the phase II program is successful, the direct application to the developed VCSEL technology will be to insert it into the high power laser development program that is be managed by the US Army Space and Missile Defense Technical Center. In addition, the VCSEL technology can be used to replace many diode array pumped laser devices to reduce size, weight, and cost. There are many potential applications of a reduced eye hazard wavelength high energy laser. Commercial and Military applications include laser remote sensing, laser communication, material processing, and remote target destruction. Industrial high-power applications of high-power solid-state lasers include welding, drilling, cutting, marking, and micro-processing. High energy DoD laser weapons offer benefits of graduated lethality, rapid deployment to counter time-sensitive targets, and the ability to deliver significant force either at great distance or to nearby threats with high accuracy for minimal collateral damage. Laser weapons for combat range from very high power devices for air defense to detect, track, and destroy incoming rockets, artillery, and mortars to modest power devices to reduce the usefulness of enemy electro-optic sensors. Building and testing a scalable reduce eye hazard wavelength high energy laser breadboard device using the demonstrated VCSEL technology would be a phase III effort.

REFERENCES:
1. W. Koechner, "Solid-State Laser Engineering," Springer-Verlag.

2. D. Garbuzov and M. Dubinskii, “110 W Pulsed Power From Resonantly Diode-Pumped 1.6um Er:YAG Laser”, Applied Phycs Letters, 19 September 2005.

3. J. S. Sanghera, V. Q. Nguyen, P. C. Puresa, R. E. Miklos, F. H. Kung, and I. D. Aggarwal, “Fabrication of Long Lengths of Low-Loss IR Transmitting As40S(60-X)SeX Glass Fibers,” Journal of Lightwave Technology, Vol 14, No. 5, May 1996.

4. Annual Directed Energy Symposium Proceedings available at: http://www.deps.org/DEPSpages/forms/merchandise.html.

5. Electro-Optics Handbook, RCA Solid State Division, Lancaster PA, 1974

KEYWORDS: Reduce Eye Hazard Laser Pumps, Vertical Cavity Surface-Emitting Laser (VCSEL), High Energy Fiber Laser, Erbium, Thulium

A08-140 TITLE: Lightweight Electro-Optical/Infrared Payload

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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OBJECTIVE: Develop lightweight nano/microsatellite electro-optical/infrared sensor payload.

DESCRIPTION: The Operationally Responsive Space (ORS) program has been developed to meet the space-related urgent needs of the warfighter in a timely manner. The ORS operational concept calls for ORS satellites to augment or reconstitute existing “big space” systems. However, to be operationally responsive, i.e., timely, ORS space systems must be launched on relatively small launch vehicles with limited payload weights. With current technologies, smaller ORS-class satellites necessarily require smaller electro-optical/infrared (EO/IR) sensor packages which often translate into lower capabilities than their “big space” counterparts. Additionally, smaller ORS-class launch vehicles are limited to placing payloads into low earth orbit (LEO) or lower highly elliptical orbit (HEO). With current technology, LEO ORS-type satellite EO/IR sensor packages could provide adequate performance/resolution, but the persistence over a theater is poor due to short dwell times. HEO (e.g., 500 x 4000 km) with its higher apogee provides longer dwell times but relatively poor sensor resolution. Alternatively, high altitude unmanned aerial systems (balloon, airship, or winged aircraft) could provide in-theater sensor persistence for the warfighter typically not available with satellite sensors.

ORS satellites are necessarily small satellites. Some boosters under consideration for future use as responsive launchers may only lift satellites weighing 10kg (22 lbs) or less (i.e., nanosatellites). Furthermore, high atmospheric altitude systems are often limited to very light sensor payloads. One key area of need for both operationally responsive space and high altitude systems is high resolution, low weight, EO/IR sensor payloads with as much capability in a 10kg package as is technologically possible for a relatively low cost. The ideal responsive EO/IR payload would be certified for use in either a high atmospheric altitude or orbital environment with little or no modification. The payload should be commandable by operational forces in theater and provide near real time tactical imagery for targets within its footprint.

Researchers into lightweight EO/IR payload innovations should take several issues under consideration, including:
• Sensor weight light enough to be part of an overall satellite or high altitude payload with a total weight of 10kg (22 lbs), if possible.
• Militarily significant EO/IR payload resolutions (<1.5 m GSD).
• Sensor repointing ability and geolocation accuracy of ground targets.
• Compatibility with planned ORS standard satellite buses.
• Technological risk and reliability.
• Deployabilty/functionality/performance in regimes from high atmospheric altitudes at 20,000 m (65,000 ft) to a HEO apogee of 4000+ km (2500+ mi).
• The LEO/HEO space environment, including effects of atomic oxygen, radiation and solar wind.
• An on-orbit design life of 1-3+ years.
• Shelf life.

PHASE I: Conduct feasibility studies, technical analysis and simulation, and small scale proof of concept demonstrations of proposed lightweight EO/IR sensor payload innovations. Develop an initial conceptual approach to incorporating sensor packages onto a common ORS satellite bus design using the ORS Payload Developers Guide and including system estimates for mass, power requirements, and duty cycles.

PHASE II: Implement technology assessed in Phase I effort. The Phase II effort should include initial lightweight EO/IR sensor payload designs, mock-ups, and, if possible, a launch-ready prototype ready to integrate into an ORS satellite bus. Initial technical feasibility shall be demonstrated, including a demonstration of key sensor phenomena. The goal should be Technology Readiness Level 4, with component and/or breadboard verification in laboratory environment.

PHASE III: The contractor shall finalize technology development of the proposed lightweight EO/IR sensor payload and begin commercialization of the product. In addition to military intelligence, surveillance and reconnaissance (ISR) missions, commercial civilian applications for a lightweight EO/IR sensor payload could include space-based remote sensing (satellite imagery and weather sensing) and high altitude aerial photography. Phase III should solidly validate the notion of lightweight EO/IR sensor payloads with a low level of technological risk. The goal for full commercialization should ideally be Technology Readiness Level 9, with the actual system proven through successful mission operations. Specifically, Phase III should ultimately produce payloads suitable for both high altitude and nanosatellite or light microsatellite applications, i.e., with a weight of only tens of kilograms, yet having sensor capabilities comparable with large satellites weighing thousands of kilograms. The contractor must also consider manufacturing processes in accordance with the president's Executive Order on "Encouraging Innovation in Manufacturing" to insure that the lightweight systems developed under this SBIR can be readily manufactured and packaged for high altitude use or launch into orbit.

While initial (Phase I and II) sponsorship and funding may come from Army Space and Missile Defense Command, during Phase III that support could conceivably transition or expand to the appropriate division of the Army Program Executive Office for Missiles and Space (PEO M&S) upon full rate production and deployment. PEO M&S could maintain a stockpile of lightweight EO/IR sensors ready to mate to either an orbital or high altitude sensor platform. Orbital versions launched responsively could meet urgent warfighter needs under DoD's Operationally Responsive Space enterprise. Simultaneously, commercial versions of the sensor could be produced, but they would be subject to national security limitations on imagery resolution, currently set at 0.5 meter (19.5 inch) ground resolution distance. Commercial remote sensing companies such as GeoEye, Inc. could start a line of lightweight on-orbit EO/IR sensors/satellites for sale of complete units to universities or other interested customers. They could also provide additional imaging services to paying customers, including the national security community.

PRIVATE SECTOR COMMERCIAL POTENTIAL: There is a perceived potential for commercialization of this technology. The primary customer for the proposed technology will initially be the Department of Defense, but there could also be other applications in the areas of commercial space-based remote sensing (satellite imagery and weather sensing) and high altitude aerial photography.

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1. US Naval Research Laboratory and John Hopkins University Applied Physics Laboratory, "ORS Payload Developers Guide", Feb 2007, (ORSBS-003, NCST-IDS-SB001).

2. The University of Mississippi School of Law, National Center for Remote Sensing, Air, and Space Law. "CURRENT EVENT: GeoEye Conttract with ITT Begins Phased Procurement of the GeoEye-2 Satellite". 26 Oct 2007. http://rescommunis.wordpress.com/2007/10/.

KEYWORDS: nanosat, microsat, electro-optical, infrared, imagery, detection, classification, geolocation, intelligence preparation of the battlefield, responsive space, high altitude, near space.

A08-141 TITLE: Lightweight High Altitude/On-Orbit Reprogrammable Two-Way Communications Payload

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Develop a tactical nano/microsatellite on-orbit/high altitude reprogrammable two-way communications payload.

DESCRIPTION: The Operationally Responsive Space (ORS) program was developed to meet the urgent needs of the warfighter in a timely manner. The ORS operational concept calls for nano/microsat class satellites to augment or reconstitute existing "big space" systems. However, to be operationally responsive, ORS space systems must be launched on short notice on small launch vehicles with limited payload weights. Smaller ORS-class launch vehicles are limited to placing payloads into low earth orbit (LEO) or lower highly elliptical orbits (HEO). To be useful, persistence over a theater is required. LEO applications would require multiple satellites due to short dwell times. Low HEO (e.g., 500 x 4000km) with its higher apogee provides longer dwell times but requires more power and larger antennae. Alternatively, high altitude unmanned aerial systems (balloon, airship, or winged aircraft) could provide in-theater persistence for the warfighter typically not available with one of a kind on-orbit systems.

Using current technology, a LEO ORS-class nano/microsat communications system could provide communications capabilities within a tactical area of interest providing dedicated communications support to forces in the field. A key area of need is a tactically responsive, two-way communications payload capable of hosting various military waveforms and converting between waveforms on the receive and transmit channels. For example, the identified payload should be able to receive SINCGARS and convert on-board to Link 16 or another common DoD communications waveform on the transmit side, allowing units with different communications equipment to communicate effectively. Additionally, the system should have the capability to be reconfigured or reprogrammed remotely while on-orbit. The payload should be designed for use in either a high atmospheric altitude or orbital environment with little or no modification.

Researchers of micro/nanosat communications payload innovations should take several issues into consideration including: functionality in both high altitude and orbital environments; compatibility with planned ORS standard satellite buses; technological risk and reliability; performance at high atmospheric altitudes from 20,000m (65,000 ft) to a HEO apogee of 4000+ km (2500+ mi); the space environment, an on-orbit design life of 1-3+ years; and shelf life. Payload should be sized for hosting on a nano-sat class or small micro-sat class (1 – 25 kg) space vehicle. A potential benchmark would be a system capable of being hosted on the academia/industry derived three-cube cubesat standard design.

PHASE I: Conduct feasibility studies and technical analysis of proposed lightweight communications payload innovations. Develop an initial conceptual approach to incorporating packages onto a common ORS satellite bus design, if appropriate, using the ORS Payload Developers Guide. Deliverable White Paper should include system estimates for mass, power requirements, and duty cycles. Technology assessment effort should achieve Technology Readiness Level 2.

PHASE II: Implement technology assessed in Phase I effort. Phase II effort should include initial digital radio payload designs, mock-ups, and small scale proof of concept prototyping and demonstration. Initial technical feasibility shall be demonstrated, including a demonstration of remote reprogramming function. Deliverables:
1. System mockup.
2. Demonstration of key reprogrammable technology.
3. Technical report summarizing the findings.

Technology development in Phase II should achieve Technology Readiness Level 4.

PHASE III: If demonstrated successfully, there is significant potential for DOD interest in this system. Potential Army customers include PEO Missiles and Space and the Army Space Center of Excellence, PEO Warfighter Information Network-Tactical (WIN-T), and potentially PEO Aviation. Additionally, a dedicated two-way communications capability for forces on the move, or geographically separated land component forces may see significant interest from the USMC.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Orbital and high-altitude software defined radios (SDR) offer the potential for significant cost savings to many commercial markets including telecommunications, broadcasting, and consumer electronics. SDRs also provide for enhanced interoperability and spectrum reuse for International and Homeland Security applications. New component technologies and radio infrastructures are needed to extend the programmable capabilities.

REFERENCES:
1. ORS Payload Developers Guide, Feb 2007. http://projects.nrl.navy.mil/standardbus/index.php

2. Navy SBIR for Land Mobile Software Defined Radio(Extensive reference list included).
http://www.navysbir.com/n08_1/N081-087.htm

3. A Look At Software Radios: Are They Fact Or Fiction?
http://electronicdesign.com/Articles/Print.cfm?AD=1&ArticleID=7536

KEYWORDS: Nanosat, microsat, responsive space, reprogrammable, radio, communications, high altitude, near space.

A08-142 TITLE: Automated Generation of Underground Structures

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

OBJECTIVE: Design and develop a software capability to automatically generate underground structures that include as a minimum subway systems, sewers, and utility lines. The developed capability must model, create, and visually represent real-world situations and environments in an immersive training construct. The aim is to support both visual (three dimensional graphics representation) and semi-automated forces (war games and automated simulations) in Modeling and Simulation applications. Current technology is very stagnant in employing methods for modeling and visualization of underground structures including the effects of surface topography and subsurface terrestrial features in a virtual and Semi Automated Forces` (SAF) environment. The preferred SAF for modeling is the OOS. This technology is needed to support Command staff, simulation developers and field operator teams to construct and visualize underground terrain, assets, and infrastructure in combination with spatial data in order to more effectively plan, rehearse, and execute military mission for troops, and other battle assessment issues.

DESCRIPTION: The Army current and future force will require rapid response and dissemination of information to Soldiers in a variety of methods, running the spectrum from those with high bandwidth access to those forward deployed in hostile environments. Common to all Soldiers everywhere is the need for top-quality training materials, and just-in-time mission planning, and rehearsal tools. The characteristics and dimensions underground structures and voids can change dramatically over time in the event of natural or induced man-made events. Automated urban terrain generation tools have matured over the last few years to the point where fairly realistic dense urban areas can be generated from Geographic Information Systems (GIS) source data with some human intervention. However, very little attention has been paid to automatic generation of underground structures such as subways, sewers, utilities and basements that include all the artifacts necessary to build three dimensional representations supporting the objectives of virtual and constructive modeling simulation domains. This effort shall exploit technological breakthroughs in 3D modeling tools used for generating urban buildings and artifacts both in the commercial (games, digital drafting and industrial design) and government (Military Application and Homeland Defense) sectors and consider it for the generation of underground structures. This capability will benefit simulations that require highly realistic, comprehensive, and functional urban models.

PHASE I: Develop a software concept design for a tool that supports automated extraction of underground features from source data, underground structure generation, and creation of underground interior and exterior features to include transportation networks associated with the modeling of the structures themselves. The software concept design should lead to the development of a software tool that efficiently captures urban features, performs data attribution, and interfaces with multiple application formats for modeling and simulation applications. Investigate the capabilities of the existing algorithms available for underground modeling and how to incorporate this need into simulation systems such as the Army OneSaf Objective System. The analysis needs to provide a recommended solution.

PHASE II: Design and develop the solution from the Phase I analysis. Demonstrate the capabilities using an Army application. The Army application could range from terrain visualization, Geospatial Information Systems, Constructive simulation and mission planning capabilities to live simulations. Develop a prototype software tool that implements an end-to-end underground structure creation capability. The end-to-end capability should include identification of underground features from GIS data, creation of underground features with connections between above ground and underground features, assignment of data attribution to structural elements and design of transportation networks associated with the modeling of the structures themselves. Develop data exporters for visual formats to include both image generators and gaming environments, and virtual and constructive simulation formats. Provide a detailed demonstration of the resultant capability (prototype) as it applies to the OneSAF Objective System (OOS) Program and other simulation environments.

PHASE III: Demonstrate applicability of this device to related markets such as home land defense, search and rescue, and emergency management. Enhance the prototype underground structure creation capability to make it suitable for transition to both military and commercial applications. Military applications may include rapid construction of underground facilities to support training and mission rehearsal. Commercial applications may include construction of underground facilities for city planning, homeland defense, and emergency response training simulations.

REFERENCES:

1. Beer, G. (2006). Virtual Training. Second International Symposium.

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3. Morin, M., Jenvald, J., Crissey, M. (2002). Using Simulation, Modeling and Visualization to Prepare First Responders for Homeland Defense. The Interservice/Industry Training, Simulation & Education Conference.

4. Policastro, A.J., and Gordon, S.P. (1999). The use of technology in preparing subway systems for chemical/biological terrorism, Commuter In the proceedings of the Rail/Rapid Transit Conference, American Public Transportation Association, Toronto, Canada, May 22-27, 1999.

5. Suzuki, T.; Okazaki, S. Comparison of visual search and pedestrian movements in way-finding at virtual and real subway stations. Journal of Architecture, Planning & Environmental Engineering, no. 555, pp. 199-205. May 2002.

6. Thomas, G. & Donikian, S. (2000). Modeling virtual cities dedicated to behavioral animation. Computer Graphics Forum.

7. Griffiths, J.B., The theory of classical dynamics. 1985. Cambridge University Press, Cambridge.

KEYWORDS: Keywords: Underground, simulation, automated, subways, sewer systems.

A08-143 TITLE: Modeling Of The Impact Response Of Multifunctional Composite Armor

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 3.5.b.(7) of the solicitation.

OBJECTIVE: To develop an accurate and efficient method/tool to characterize both the structural and ballistic response of multifunctional composite armor. This tool should be capable of predicting the type, severity and extent of damage caused by various ballistic and air blast threats, in addition to assessing the structural performance of the multifunctional composite armor in both its original and damaged states. Computational efficiency must be sufficient to allow use as a design tool in addition to providing accurate post-design performance assessment and troubleshooting.

DESCRIPTION: As part of the ongoing effort to increase the mobility and speed of deployment of our armed forces, methods are needed to reduce the weight of combat vehicles without compromising their structural integrity or ballistic resistance. One approach to solving this problem is the development of lightweight, multifunctional, composite armor systems that serve both a protective role and a primary structural support role. Design of such multifunctional composite material systems is especially challenging since structural composites and ballistic composites typically have different performance requirements (e.g., strength and stiffness vs. energy absorption). The design of such systems is currently impaired by the lack of computational tools that can accurately characterize the structural and ballistic response of thick, highly diverse, laminates composed of fiber-reinforced composite laminae, ceramic tiles, rubber, adhesives and possibly metallic foams. Conventional equivalent-single-layer laminate elements are often inadequate for representing the structural response of such laminates which tend to exhibit extreme discrete layer effects. Accurate simulation of such systems requires very efficient methods of representing multiscale constitutive behavior1-2 and adaptive kinematics3-5 in order to effectively serve in both the design phase and post-design performance assessment.

PHASE I: The objective is to develop and demonstrate a working version of numerical modeling tools that will permit accurate and timely simulation of damage evolution in multifunctional composite armor under highly transient blast/impact conditions. In addition, the numerical modeling tools should provide an accurate and timely assessment of the post-damage structural response of the multifunctional composite armor. These modeling capabilities are intended to be used both during the design of multifunctional composite armor concepts and during post-design performance assessment and troubleshooting.

Based on this scope, the requirements that should be met by the prototype numerical modeling tools include the following:

1. The numerical modeling tools should include both explicit and implicit finite element implementations in order to efficiently model both ballistic response and structural response of the multifunctional composite armor.
2. Without sacrificing accuracy, the numerical modeling tools should be highly efficient, delivering solutions in significantly less time than can currently be achieved with commercial finite element codes using current industry standard methods.
3. The numerical modeling tools should include tools that greatly simplify the processes of creating new models and modifying existing models.
4. The numerical modeling tools should efficiently incorporate a theoretically sound, physics-based damage/failure model whose coefficients can be easily determined using commonly available material test data.
5. The numerical modeling tools should include procedures for efficiently incorporating damage states (as determined from an explicit finite element solution) into the input model used to compute the structural response of the damaged composite armor (in an implicit finite element solution).

The numerical modeling tools should be developed to run on a desktop PC under Windows operating system and should permit a timely solution for problems up to 1 million degrees of freedom, providing accurate ply level stress fields where necessary for the prediction of material damage evolution and failure. Success of the Phase I effort will be determined by demonstrating that the working prototype codes satisfy the previously stated requirements. Efficiency of the code should be demonstrated via appropriate performance metrics, including, but not limited to run time, memory usage and model size. Accuracy of the new method should be judged by comparison to very highly refined, conventional 3-D finite element solutions of appropriate problems, with the emphasis on demonstrating that the new modeling framework is capable of achieving the same level of accuracy with a significant decrease in problem size and run time.

PHASE II: Pending a positive outcome in Phase I, the basic modeling methodology can be considered ready for a Phase II effort, where the contractor shall extend the Phase I methodology to the full capability of a productive tool. The new tool shall be capable of predicting the type, severity and extent of damage caused by various ballistic and air blast events, in addition to predicting the structural response of the damaged multifunctional composite armor.

This work might include, but not be limited to the following:

1. Further refinement and enhancement of the numerical modeling tools for single-processor computing environments.
2. Development of a parallel processor version of the numerical modeling tools.

3. Iterative testing and enhancement of the material damage/failure model under quasistatic and highly transient conditions.
4. Rigorous verification and validation, including comparison with experimental results.

PHASE III: The creation of this tool will have a broad range of commercial applications. Not only will it directly impact structural modeling capabilities, it will also be applicable to civilian defense issues and automotive safety issues. Commercial applications can range form the aircraft industry to the auto and shipping industry. Military application of the tools will facilitate the design of light weight Tactical Vehicles, enhancing their mobility, agility and survivability, thus increasing the mobility and speed of deployment of our armed forces.

REFERENCES:
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5. Robbins, D.H., Jr., and Reddy, J.N., (2008) "Adaptive Hierarchical Kinematics in Modeling Progressive Damage and Global Failure in Fiber-reinforced Composite Laminates," Journal of Composite Materials, 42:143-172.

KEYWORDS: Method/Tool, Characterization of the Structural and Ballistic Response, Impact response Prediction, Performance Assessment,Commercial & Military Applications.

A08-144 TITLE: Non-Destructive Evaluation (NDE) for Ground Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles, 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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a hand-held, data acquisition system for microwave inspection of ground vehicles with non-metallic armor. Currently, there is no fielded technology to acquire data to evaluate damage to armor panels on ground vehicles in the field. Armor panels may consist of many, non-metallic materials, and to date microwaves have proved most promising to non-destructively evaluate damage to panels. However, there is no simple, hand-held, data acquisition tool specific to performing inspection of ground vehicle armor panels.

DESCRIPTION: Robust (ruggedized), wireless, hand-held scanner to interrogate multiple, non-metallic material panels which include ceramics while hung on vehicles. Data acquired will enable user to easily determine if there is damage to the panel.

PHASE I: Demonstrate a technology to non-destructively evaluate at least four multiple material, non-metallic panels that include ceramics: one panel each with no and known damage and at least two others with unknown damage, and compare with the best available industrial x-ray data of the damaged panels. The demonstration will be judged successful if the proposed technology identifies all the features in the x-ray and at least one additional feature not shown in any of the x-rays. Design a robust (ruggedized), wireless, hand-held scanner that incorporates the demonstrated technology and enables the user to easily and with fidelity determine if there is damage to the panel and to store the data. Conduct a cost-benefit analysis to determine if there are any life-cycle savings when using the demonstrated technology in test, fielding, and/or refurbishing ground vehicles.

PHASE II: Optimize the robust (ruggedized), wireless, hand-held scanner design and build six proto-types to use in data collection through test, fielding, and/or refurbishing vehicles. Collect and analyze data to incorporate any design changes or improvements to the scanner design as well as update the cost-benefit analysis. Develop a performance specification to enable the Army to competitively procure scanners for data acquisition, storage, and analysis where there is a demonstrated savings in testing, fielding, and/or refurbishing of ground vehicles.

PHASE III: Microwave scanning systems for damage are currently used in the nuclear and energy delivery industries, but scanners have multiple, bulk components and are not optimized for vehicle armor panels. Aircraft as well as the nuclear and energy delivery industries will benefit from a hand-held (miniaturized) data collection system.

REFERENCES:

1. "APPARATUS AND METHOD FOR NONDESTRUCTIVE TESTING OF DIELECTRIC MATERIALS", U.S. Patent 6,359,446, MAR. 19.2002;
2. "Innovative Technique for Inspection of Polyethylene Piping Base material and Welds and Non-Metallic Pipe Repair", Robert J. Stakenborghs, ASME Publication PVP2006-ICPVT11-93795, Proceedings ASME PVP 2006/ICPVT-11, July 2006;
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4. "Microwave NDE Technique - Testing of FRP and PE Piping - Examples", R.J. Stakenborghs, Inspectioneering Journal, Mar/Apr 2005, Volume 11, Issue 2 ;
5. "Microwave NDE Method - Application Examples", R.J. Stakenborghs, Inspectioneering Journal, May/June 2005, Volume 11, Issue 3.

KEYWORDS: Non-destructive evaluation (NDE), microwave or millimeter wave, data acquisition, miniaturization, composites, ceramic, manufacturing process, process improvement.

A08-145 TITLE: Semi-Autonomous Unmanned Vehicle Control

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop a vision-based control system for unmanned ground vehicles (UGV's) that enables semi-autonomous operation in GPS-denied areas.

DESCRIPTION: Current fielded UGV systems are teleoperated and generally require at least one full-time operator and many times require two or more operators. This research is to investigate and develop a system whereby a user could potentially control multiple robots or could perform other tasks while directing a single vehicle. We are looking for approaches for exercising control both leading the vehicle and following the vehicle. It is expected that by increasing the autonomy of the vehicle, the burden on the communications system may also be reduced. For example, lower resolution and lower frame rate video may be adequate for successful operation.

We are especially interested in bio-inspired vision systems, which draw inspiration from the capabilities of biological systems to understand and operate within their environment. The preferred sensor is a single camera. Biological systems can navigate with one eye and do not required dense or precise three-dimensional data. In fact, most range sensors, such as stereovision systems and scanning lasers, have only a limited range, whereas biological systems can estimate the distance to objects miles away. They can also estimate distance to nearby objects and navigate safely around them or interact with them. Estimates for range can be found, for example, by using structure from motion, depth from focus, or an acquired understanding of the structure of the world. The relative position and motion of landmarks can also provide information on passage through the environment. Vision algorithms also go beyond three-dimensional surface structure and can infer properties beneath terrain or behind the surface of objects. Image segmentation is an important capability for vision systems and can be based on color, texture, edges, shading, motion, or range.

The concept for directing the vehicle from behind is to use a touch screen as the user interface (although a joystick or mouse could also be used). The display would show the current field-of-view seen by the robot. The user would simply touch the screen, indicating where in the scene they want the robot to go, and the robot would autonomously drive to that location. As the vehicle is driving, the user can either perform other tasks or monitor the progress of the vehicle and make course or goal changes. The advantage is that the human operator chooses a suitable goal for the robot, resulting in a path that avoids difficult obstacles, thus eliminating some of the more difficult barriers to full autonomy. This capability would be part of an overall operator control unit that would allow direct teleoperation when required.

The concept for directing the vehicle from the front is for the vehicle to recognize and autonomously follow the operator at some time or distance offset. The robot follows the same path as that of the user, allowing the vehicle to benefit from the user’s intelligence and path planning skills and thereby minimizing the demands on autonomy. The system should be capable of recognizing gestures for commands such as stop, go, faster, slower, closer, further, etc.

The system needs to be reasonably rugged, run in real-time, be compact and standardized enough to be placed on existing platforms. The system should be able to detect and avoid obvious obstacles. Platforms under consideration are as small as 20 Kg. Concepts will be compared on the effectiveness of vehicle control, burden on the user and vehicle, system capability, cost and ruggedness.

PHASE I: The first phase consists of developing the system design, investigating signal/image/video processing techniques and control mechanisms, and showing feasibility on sample data. Documentation of design tradeoffs and feasibility analysis shall be required in the final report.

PHASE II: The second phase consists of a full implementation of the system. At the end of the contract, the prototype system shall be integrated with a robotic vehicle and successful operation shall be demonstrated in an outdoor obstacle course. Deliverables shall include the prototype system and a final report, which shall contain documentation of all activities in this project and a user's guide and technical specifications for the prototype system.

PHASE III: Commercial applications for this vision-based control system include many UGV applications, such as security and inspection, hazardous waste monitoring, and planetary exploration. Military applications include robotic mule, scout vehicles, security and inspection. The likely path for commercialization is by licensing the technology to one of the large robotics firms.

REFERENCES:
1. “Depth Estimation from Image Structure”.
http://cvcl.mit.edu/Papers/Torralba-Oliva02.pdf

2. “IROS 2002 Workshop on Visual Servoing”.
http://www.robot.uji.es/EURON/visualservoing/workshop/

3. “A mobile robot employing insect strategies for navigation”.
http://www.mip.sdu.dk/~david/AM04/_I_Articles/21_lambrinos99mobile.pdf

4. “Monitoring Human Activity”.
http://mha.cs.umn.edu/

5. “People Tracking for Visual Surveillance”.
http://www.siebel-research.de/people_tracking/

KEYWORDS: Robotics, vision, visual servoing, pedestrian tracking, navigation, bio-inspired.

A08-146 TITLE: Rapid Field Test Method(s) to Measure Additives in Military Fuel

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop a portable instrument or method for the rapid measurement of corrosion inhibitor/lubricity improver in military fuel.

DESCRIPTION: Develop an innovative solution for the rapid measurement of corrosion inhibitor/lubricity improver additive concentrations in military fuels. Analysis of fuel additive concentrations is critical to the Army for ensuring the proper additive levels during fuel distribution and in the additive injection processes.

The Army would like to develop a light weight portable instrument or simple field method for the determination corrosion inhibitor/lubricity improver additive concentrations in military fuels. The total weight for the solution will be under 15 pounds. The threshold ability of the instrument/method is being able to detect corrosion inhibitor/lubricity improver (0 – 81 ppm) [1]. Additional objective detection goals for the instrumentation/methodology include static dissipater (quantity to be able to provide a measurable conductivity between 0 – 1050 picosiemens per meter), and fuel system icing inhibitor additives (0 – 2250 ppm) [2-4], thermal stability improver (0 – 450 ppm), antioxidants (0 – 36 ppm), metal deactivator (0 – 8.7 ppm) [2-3], and ignition improver additives (quantity to be able to provide a measurable ignition quality cetane number greater than 63 or cetane index greater than 65) [5]. The Army's goal is to use the device for testing fuel samples and/or monitoring fuels for correct additive levels to ensure the proper function of fuels.

PHASE I: Develop an approach for the design of a portable analytical instrument(s) that is capable of analyzing fuels to determine the concentration of fuel additives. Conduct proof of principle experiments supporting the concept and providing evidence of the feasibility of the approach.

PHASE II: Develop, build, and evaluate a prototype portable analytical instrument(s) that is capable of analyzing fuels to determine the concentration of fuel additives. The prototype shall be delivered to the government.

PHASE III: Technology developed under this SBIR could have a significant impact on military fuel distribution and field additive injection processes, the intended transition path is into the Army's Petroleum Test Kit or alternatively the Petroleum Quality Analysis System. The developed technology may also find application in the commercial aviation industry or in commercial fuel analysis.

REFERENCES:

1. Military Performance Specification MIL-PRF-25017G, "Inhibitor, Corrosion/Lubricity Improver, Fuel Soluble," 15 December 2004.

2. Military Specification MIL-DTL-83133E, "Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8), NATO F-35, and JP-8+100," 1 April 1999.

3. ASTM D 1655-06 "Standard Specification for Aviation Turbine Fuels".

4. ASTM D 975-04 "Standard Specification for Diesel Fuel Oils".

5. Military Specification MIL-DTL-16884L, "Detail Specification, Fuel, Naval Distillate," 23 October 2006.

KEYWORDS: Additives, JP-8, Diesel, Fuel, Fuel Additives, Instrument, corrosion inhibitor, lubricity improver.

A08-147 TITLE: Automated Algorithm Generator for Ground Vehicle Diagnostics/Prognostics

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: The end product will be a comprehensive library of light-weight, diagnostic and prognostic algorithms and corresponding server based tool set to enable autonomous algorithm generation and unsupervised maintenance of the vehicle-side algorithms. These algorithms are based on the analysis of vehicle data sets and corresponding enterprise-level data sets. The vehicle-side algorithms will analyze current status of bus parameters as well as have linkage to the server side tool set over a network (when in range) to provide algorithm attenuation as new fleetwide trends and/or anomolies are discovered on systems and components across a fleet of vehicles.

DESCRIPTION: Condition Based Maintenance (CBM) requires embedded diagnostics and prognostic algorithms to determine current health status of systems and subsystems. The formulation of models and diagnostic/prognostics algorithms becomes a challenge when dealing with a vast number of Army ground vehicle platforms because they vary widely in their capabilities, characteristics, and functionality. The challenge for this effort will be formulating a software framework to perform autonomous algorithm generation from the server tools and the ability to maintain the algorithm remotely. The Automated Algorithm Generator (A2G) must also consider algorithm attenuation based on fleet-wide statistics and trending of data sets on the server system. This will require the development of the framework, vehicle/component models, and server-side/platform-side tools to properly generate the diagnostics/prognostics algorithms hosted on the vehicle. Artificial Intelligence practices for developing and enabling self-learning diagnostic/prognostic algorithms should be considered.

PHASE I: Phase I will result in delivery of a detailed software requirements specification (SRS) with use cases, list of COTS available tools, and a DODAF Operational View - 1 (OV-1 / Operational Concept Graphic). Platform diagnostic/prognostic algorithm run-time should be minimized as much as possible, with linear (O(n)) run-time as the objective. Open standards and interfaces shall be utilized/specified in the report.

PHASE II: Phase II will use the phase I SRS/OV-1 results to develop the specified software system to be demonstrated on a bench-level system running simulated vehicle data bus parameters, diagnostic/prognostic algorithms, and server-side algorithm generating tool set. The A2G bench-level system must successfully demonstrate the generation of diagnostic and prognostic algorithms utilizing comprehensive data sets of real-world vehicle data from J1939/J1708/J1850 type data buses. The system must successfully manage the maintenance of the algorithms as new trends, anomalies, and/or business rules are discovered on systems and subsystems. False alarms in the generated diagnostic/prognostic algorithms shall be minimized as much as possible.

PHASE III: The A2G system can be applied to both commercial and military vehicle systems. For the military this could be applied towards PM Heavy Brigade Combat Team vehicles (i.e. FMTV, HEMTT, Abrams, Bradley) vehicle diagnostics/prognostics for vehicle health management. For the commercial sector, this could be applied to a number of commercial long-haul trucking fleets such as Penske, Schneider, and Freightliner for fleet-wide diagnostics/prognostics. Phase III demonstration of this technology would use a commercial or military fleet to demonstrate the A2G diagnostics/prognostics system across a fleet of vehicles utilizing larger and more comprehensive data sets to prove out the technology on a larger scale.

REFERENCES:
1. On-line Intelligent Self-Diagnostic Monitoring System. http://www.pnl.gov/energy/eed/etd/pdfs/pnnl-14304.pdf

2. Prognostic Enhancements to Diagnostic Systems (PEDS) Applied to Shipboard Power Generation Systems. http://stinet.dtic.mil/oai/oaierb=getRecord&metadataPrefix=html&identifier=ADA455198

KEYWORDS: CBM, Diagnostics, Prognostics, Code Generation, Algorithm Generation.

A08-148 TITLE: Distributed Services Framework for Mobile Ad-hoc Networks

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: The objective of this effort is to develop and demonstrate a detailed distributed services framework (DSF) for mobile ad-hoc networks (MANETs). To define the DSF, the research will establish approaches to systems engineering documentation, workflows, specifications, and lightweight server software components that minimize computing platform resources. This framework shall focus specifically on the methods of service discovery and service access over MANETs.

DESCRIPTION: The increase of mobile devices and the maturation of wirelessly connected devices provide a motivation for pervasive device researchers to provide a service-oriented, distributed architecture for the hosting, advertising, discovery, and invoking of services across MANETs. Current Army MANETs face performance limitations resulting from mobile devices having power and Central Processing Unit (CPU) constraints to limited bandwidth in the wireless network. Service oriented devices are designed to share capabilities while minimizing the amount of functionality a single host needs to possess. This is effective in ad-hoc networks because storage space and computing resources on an individual hosts is limited. Therefore, with a large number of hosts each with small code fragments can contribute to a distributed computing capability as a whole. There is a high technical risk in this area since existing commercial-off-the-shelf (COTS) service discovery protocols and delivery mechanisms fall short of accommodating the complexities of the ad-hoc environment. The difficulties of implementing a service oriented framework in ad-hoc networks is hosting, advertising, discovering, and invoking of services. Service Discovery in hybrid mobile ad-hoc networks is another challenge due to the absence of centralized intelligence (server) within in the network. This project will focus on developing a framework for service discovery across MANETs to enable resource sharing on resource constrained mobile devices.

The DSF must be designed using an open architecture and provide interoperability between different systems (i.e. Windows and Linux based) and programming languages for integration between different applications on different platforms.

PHASE I: Phase I will consist of a concept of operations (CONOPS) for a proposed framework to outline the operation of secure service oriented devices connected in an ad-hoc network arrangement. A systems engineering approach shall be used to accommodate the several devices, distributed software applications, and data passage requirements. The phase I report shall outline the CONOPS, DoDAF Operational View 1 (OV-1), and a detailed framework design document.

PHASE II: An implementable architecture shall be developed, demonstrated, and validated using the OV-1 and framework design results of phase I incorporating service oriented devices. This distributed architecture shall incorporate methods for distributed hosting, discovery, description, and invocation of services across the MANET. Required phase II deliverables will include a prototype demonstration that shall have several mobile devices hosting various services with other devices on the MANET discovering and invoking these services.

PHASE III: The DSF for MANETs can be used for commercial and military applications. For the military, this framework can be applied towards in MANETs across convoy formations. Services running on the DSF could range from diagnostic/prognostic services, communications (voice/data), authentication services and other condition based maintenance services. Target fleets could range from tactical wheeled vehicles to combat vehicles. For the commercial sector, applications could range from distributed service framework for MANETs to support mobile vehicle networks, network enabled appliances, or production/manufacturing equipment.

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KEYWORDS: Develop, demonstrate, prototype demonstration, limitations, technical risk, design.

A08-149 TITLE: Sensors for Vehicle Health Monitoring

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: The objective of this effort will be to design, build, and demonstrate a bench level prototype sensor system (5 sensors with sensor fusion algorithms) with the ability to determine the state of health, predict component and system failures, and measure the following:
- measure foreign inorganic materials in vehicle fluids
- capture extreme shock events
- capture a wide range of load events
- measure pressure, acceleration, torque, and liquid quality
- detect cracks in powertrain, chassis, and suspension components

DESCRIPTION: Effective and efficient platform health monitoring requires data that is readily available on the vehicle databus as well as the integration of additional sensors to gather data that isn't readily available. The Army would like to embed sensors to provide the data to effectively monitor and predict failures in high payoff areas, and to capture information about the usage of the vehicle to accurately determine the state of health of vehicle systems and components.

Sensor fusion algorithms will be created to make more accurate system level determinations based on the data derived from these individual sensors. Under this effort, work will be done in the five technical areas described above.

The individual sensor should not be larger than .75" x .75", and not weigh more than 100 g. The typical sensor should be powered by the vehicle battery (without impacting any other vehicle component) and not draw more than 10 mA.

PHASE I: Proof of principle assessment of high-payoff sensors (both COTS and new sensor designs) for military vehicles to meet the above objectives, including recommendations for possible military vehicle mounting locations of the sensors.
- Definition of the data types and data parameters that will be available from the working sensors and planned data analysis to determine diagnostics and planned prognostics on the measured vehicle components, sub-systems, and systems.

PHASE II: Phase II shall result in the design, build, and demonstration of a bench level prototype of a sensor system, and the working software to rationalize the data coming from the sensors, perform sensor fusion, and display useful engineering data concerning the health of the vehicle components, sub-systems, or systems. The SAE

J1939, J1708, and MIL-STD-1553 databuses will also be investigated to ensure that all sensor data can be transmitted through these databuses. Also, an integration plan shall be developed for a representative HBCT platform (Abrams, Bradley, HEMTT, FMTV).

PHASE III: Phase III shall result in military testing of the sensor system to pass MIL-STD-461E and MIL-STD-810F. The tested sensors and integration plan developed in Phase II shall be used to install and integrate the sensors in a vehicle. The sensor system is a dual use system because it is directly applicable to the commercial automotive world.

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1. Acoustic Emission Sensors - http://www.pacndt.com/index.aspx?go=products&focus=Sensors.htm.

2. Acoustic Wave Technology Sensors - http://www.sensorsmag.com/articles/1000/68/main.shtml.

KEYWORDS: CBM, Condition Based Maintenance, Sensors, SAW, Surface Acoustic Wave, AE, Acoustic Emission, Shock, Wideband Accelerometer, Inorganic, Wear Metals, Sensor Fusion.

A08-150 TITLE: Smart Sensor Network for Platform Structural Health Monitoring

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 3.5.b.(7) of the solicitation.

OBJECTIVE: The objective will be to design and develop a smart sensor network that can monitor the condition of structural components on Army vehicles and bridging platforms. The network will be self sustained with the ability to send data to a Controller Area Network (CAN) vehicle bus or external PC.

DESCRIPTION: Platform structural health monitoring requires detailed information be collected during the usage of a particular vehicle. This becomes a challenge when dealing with all Army mobile and non-mobile platforms because they vary widely in their capabilities and functionality. Some platforms carry parameters over an already existing CAN bus, while others have no onboard network or even a power source. An additional challenge will be meeting very tight cost restraints regarding the expense of the sensors and communication infrastructure. Some concepts include IEEE 1451 smart transducer architectures, energy scavenging, and wireless communication to overcome some of the integration challenges. The sensors shall also need to be intelligent enough to reduce time history data into meaningful data parameters on the fly to minimize bandwidth usage especially on connected networks. Some examples of the structures that require monitoring on vehicles are the vehicle frame, hinges, joints, rivets, bolts, welds, as well as fasteners for add-on armor, suspension components, and the drive shaft. Structures that require monitoring on bridge platforms include hinges, joints, rivets, bolts, welds, as well as support wires and trusses.

PHASE I: Phase I shall be a study of the Army vehicle bus systems CAN, J1708, J1850, J1939, and others as available, wireless interfaces to these busses, and computer connections followed by an evaluation of relevant sensor types and parameters required to monitor the structural health of Army vehicle and bridging systems. Phase I shall also include a study of how the sensor network can be retrofitted to existing Army platforms or embedded in new ones. This study will include the size, weight and power limits of these sensors on vehicle and bridge platforms and will highlight any differences and similarities. A plan to acquire or generate power on both powered vehicle and un-powered bridge systems will also be required. Finally, the study will include computing requirements required for the sensor network and develop a total cost comparison between network design alternatives. The results of the study will be detailed in a final report.

PHASE II: Phase II will use the phase I results to develop an acceptable prototype sensor network as chosen by the government. This prototype network shall be demonstrated on both an Army vehicle system and on a bridging system. The demonstration shall include simulated structural degradation and show how the network responds. It shall also show how the network communicates with an attached network or computer. The prototype shall be self sustaining on the platform for which it is implemented on and capable of running for extended periods with minimal maintenance. Minimal maintenance means that components shall not require replacement more frequently than regular system maintenance intervals. The network shall also be reconfigurable in software and in hardware to support varying numbers of sensors and new sensor data reduction algorithms. The resulting deliverable to the government will be the prototype sensor network system capable of monitoring at least six of the structural parameters described in the description that is compatible with both bridge and vehicle platforms. A final report detailing the algorithms, source code, and configuration required to develop and imlement the prototype will also be a required deliverable.

PHASE III: Phase III will work with PEO-CS/CSS to potentially deploy several sensor networks on bridges and up-armored tactical vehicles. A demonstration with several networks running continually will aid the Army in evaluating its use to optimize maintenance tasks with the resulting engineering and logistic information. The proposed research will also provide a suitable foundation for monitoring the health of public infrastructure such as roads, bridges, and public transportation vehicles like buses and subway cars.

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1. D. Adams, J. Gothamy, P. Decker, D. Lamb, "Analysis of Passive Vibration Measurement and Data Interrogation Issues in Health Monitoring of a HMMWV Using a Dynamic Simulation Model ." SAE World Congress 2008, Publication # 2007-08MV-4.
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http://www.intelligent-systems.info/papers/avlb.PDF

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KEYWORDS: CBM, Condition Based Maintenance, Sensors, Health, Vehicle, Maintenance, Prognostics, Bridging, Structural.

A08-151 TITLE: <u>Realistic High Fidelity Dynamic Terrain Representation</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Research the latest state of the art technology (both hardware and software) in computer graphics to aid in the development of technology required to implement realistic, high-fidelity dynamic terrain into a visual simulation environment to improve the realism of the soldier-machine/terrain interface, thereby improving the reliability of modeling and simulation and enhancing the accuracy of the model's predictions.

DESCRIPTION: Various visual simulation technologies are capable of rendering large outdoor environments, complete with buildings, roads, moving models and accurate geographical features, at interactive frame rates. However, the moving models represented in such environments are typically reactive instead of interactive, meaning they tend to react to the terrain instead of interacting with the terrain, thus lacking the ability to reasonably alter the terrain at run-time (e.g. by explosions, tire-tracks, or earth-moving equipment). Near term advances in graphics hardware shader units (specifically, a new tessellation unit, due out mid 2008) will make generation of such effects more practical. With modern engineering vehicles such as the Mine Resistant Ambush Protected (MRAP) family of vehicles, there will be a growing need to update terrain representations to be able to leverage these advances to represent dynamic interactions in a visually plausible way. In order for the system to be useful, changes in the terrain must be controlled through the vehicle dynamics (in the instance of a vehicle affecting the terrain) or through a terrain server (for effects not caused by a controlled vehicle, such as explosions, modifications made by entities in a remote simulation, weather effects, etc.) and updates to the terrain must be exchanged with the image generator. Hence, the modifications to the terrain must be both visually reproduced in an accurate and acceptable manner, but must also be integrated with the terrain itself to provide the surface that the dynamic models are traversing. To date, there are no known image generators that will accomplish this task. It will be incumbent upon the offeror to perform research into this field to develop an acceptable solution that is both innovative and state-of-the-art.

To support research and training the system must integrate in additional features such as basic lighting/texturing, multiple dynamic vehicle/character models, animations, polygonal switches, infrared/night-vision representation, advanced lighting techniques (shadows), an appication programming interface (API) and support for distributed interactive simulation (DIS) or high-level architecture (HLA).

A demonstratable visual simulation package should be in the form of a PC based image generator, using the latest in graphics technology hardware coupled with state-of-the-art software developed under this SBIR. Terrain alteration should be accomplished via the API using a combination of advanced shading/lighting techniques and terrain manipulation itself. The resultant terrain must be able to interact with vehicle models (i.e. - an MRAP driving over a crater should feel the terrain distortions attributable to the blast).

PHASE I: Determine technical feasibility and develop approaches for how newly available graphics technologies can provide fully dynamic terrain, while preserving interactive frame rates of 30 - 60 Hz. The visual representation of the dynamic terrain should incorporate suitable lighting and shading modifications, and should be synchronous with the terrain model used for collision detection. Furthermore, the terrain system must be capable of being distributed over multiple display channels with no apparent lag for the duration of the simulation.

PHASE II: Research, design, develop, test and implement a full featured dynamic terrain algorithm. The core algorithm must be able to represent deformations at an arbitrary (user settable) resolution inside the terrain engine itself, while image generators may visualize the terrain at a reduced resolution to ensure a consistent frame rate. In addition to the core algorithm, the run-time component must be able to trigger dynamic events which modify the terrain, including explosions (with animations). An API would also be developed to allow new deforming objects to be introduced into the system.

PHASE III: This system will be useful in a wide range of simulation scenarios, including vehicle track analysis over soft terrain, combat training, and demolition/construction. With a dynamic model navigating through dynamic terrain, a more realistic driver/vehicle simulation is possible, thus providing more accurate dynamic loads, power draws and human interactions, providing more realistic simulations used for engineering analysis of any prototype vehicles/subsystems. Also, the results of this research would be directly applicable to commercial organizations (e.g. moving equipment companies) seeking a deformable terrain solution for their training and research needs.

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1. "Applying Light Mapping Techniques to Vis-Sim Databases," Michael M. Morrison, 2005 IMAGE Society Conference, July 2005, Phoenix, AZ.

2. "High-Frequency Terrain Content and Surface Interactions for Off-Road Simulations," Alexander Reid, David Gorsich, Michael Morrison, SAE Commercial Vehicle Engineering Congress & Exhibition, Oct 2004.

3. "Development of a High-Resolution Virtual Terrain to Support the Development and Testing of Intelligent Systems," Alexander Reid, 2002 NDIA 2nd Annual Intelligent Vehicle Systems Symposium, Jun 2002.

KEYWORDS: High Fidelity, Dynamic Terrain, Visual Simulation, Realistic, Image Generator, Computer Graphics, Displacement Mapping.

A08-152 TITLE: <u>Vehicle Dynamics and Motion Drive for Realtime Simulators</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: The program will investigate, develop, and refine realtime vehicle dynamics methodologies and motion software to improve fidelity of motion simulators in driving scenarios.

DESCRIPTION: The use of motion based driving simulators continues to increase throughout the world as capabilities and availability rises. Today, motion simulators are more common in Army Technical Centers, private industry, and universities. The motion simulator allows researchers to bring the test track or battlefield scenario into a laboratory setting to enable key experiments in human factors and vehicle technology. The Army uses driving simulators to determine advanced crewstation design, produce duty cyle metrics, and to identify issues with vehicle design before full scale engineering efforts. The driving simulator consists of many subsystems that synergistically operate in realtime including motion, sound, vehicle dynamics model, visual and terrain, and cab. Three key systems of interest in this topic are: vehicle dynamics model, cab - particularly the control loader system, and motion base. Many driving simulator motion bases consist of a hexapod-type design that yields 6 degrees of freedom (DOF) motion within 1 to 2 meters of travel. Washout algorithms are used in driving simulators to translate the large motions of the actual vehicle into the limited motion envelope of the motion base. The vehicle dynamics model subsystem simulates and determines the occupants 6 DOF dynamics in realtime. The cab feel system uses a combination of controls, motors, or other devices to produce steering, brake and accelerator pedal motions so the occupant can better sense the driving sensation. Shortcomings often exist with this subsystem setup because of motion simulator limitations, model assumptions, or simplifications to achieve the required realtime operation. One particular weak area in simulators that needs improvement is the perceived lateral handling of the vehicle in such maneuvers as a lane change, turn, or wind gust. Simulator occupants sometimes note that the simulator produces lateral motion and feel that is not the same as actual driving with the same scenario and manuever. The problem exists when simulating both tracked and wheeled vehicles. The desire and goal of this project is to mitigate these undesirable effects in the drving simulator. The problem can be challenging in that all subsystems affect the outcome of the driving experience. Potential solutions toward this problem could involve reviewing the components of the vehicle dynamics model (such as tires, tracks, and steering systems) and motion control subsystems (such as geometry and motion control algorithms) to determine their contributing portion towards lateral motion and vehicle handling. Solutions could also include methodologies, software, and demonstrations on a motion base simulator to enable simulation engineers to tune and optimize simulations to certain vehicle-scenario pairs. Solutions will ultimately be applicable and useful to simulation engineers of automotive and heavy vehicles - both wheeled and tracked.

PHASE I: One particular weak area in motion simulators that needs improvement is the perceived lateral handling of the vehicle in such maneuvers as a lane change, turn, or wind gust. Simulator occupants sometimes note that the simulator produces lateral motion and feel that is not the same as actual driving with the same scenario and manuever. The problem exists when simulating both tracked and wheeled vehicles. The desire and goal of this project is to mitigate these undesirable effects in the drving simulator. Identify the key components of a driving simulation that affect handling and lateral motion cues in a driving simulator. Define the key elements contributing to the problem. This could be vehicle models, data or lack of data, computing inefficiencies, motion bases and their drive algorithms, control loading and other elements. Develop an approach for solving the problem and identify initial process(es) simulation engineers can follow to improve perceived vehicle handling in motion simulators.

PHASE II: One particular weak area in motion simulators that needs improvement is the perceived lateral handling of the vehicle in such maneuvers as a lane change, turn, or wind gust. Simulator occupants sometimes note that the simulator produces lateral motion and feel that is not the same as actual driving with the same scenario and manuever. The problem exists when simulating both tracked and wheeled vehicles. The desire and goal of this project is to mitigate these undesirable effects in the drving simulator. Using the results of Phase I, develop component models within the vehicle dynamics that show improvement in the lateral stability and handling percieved by the simulator occupant. Implement results into realtime software usuable for a man-in-the-loop motion base. Include, within these results, a consideration of a variety of terrain such as paved, secondary and off-road as well as a variety of driving scenarios. Develop and tune optimum washout (motion drive) software that presents the best effort motion cue to the occupant when riding in 6 degree of freedom hexapod simulators. Test and

demonstrate the final effort using a motion base simulator (preferred) or a simulation of a motion base. Required Phase II deliverables include:
1. Software models of vehicles that run in realtime.
2. Washout motion drive software compatible with the model and simulator.
3. Instructions or user guides on how to best tune a vehicle/scenario to a motion base simulator.

PHASE III: Several significant Army programs could benefit from the use of motion base simulators for driving to include the Future Combat System and the Joint Light Tactical Vehicle programs. Hexapod simulators can be used to evaluate potential design solutions. Many domestic and international automotive companies employ hexapod motion bases for similar purposes of evaluating potential vehicle design solutions or ideas. Therefore this program can be marketed towards the automotive sector as well. Potential other industries include training (both military and commercial), safety, and medical applications.

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2. Thomas Chapron, Jean-Pierre Colinot, "The new PSA Peugeot-Citroën Advanced Driving Simulator Overall design and motion cue algorithm.", North American Drivers Simulation Conference, 2007, Iowa City, Iowa.

3. Kaleb McDowell, Victor Paul, Jillyn Alban, "Reduced Input Throw and High-speed Driving", North American Drivers Simulation Conference, 2007, Iowa City, Iowa.

KEYWORDS: Vehicle Dynamics, Motion Simulator, Motion Drive, Realtime, Hexapod.

A08-153 TITLE: Improved Thermal Management Systems using Advanced Materials and Fluids

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop and demonstrate a high heat capacity fluid and/or high performance thermal material to provide new options for military vehicle thermal management systems enabling simplified thermal designs with improved performance, significant weight savings, reduced cooling power, and/or fuel savings.

DESCRIPTION: Highly effective thermal management systems are needed in the design of military ground vehicles in order to provide reliable mobility under all vehicle operating conditions while meeting the needs of the vehicle and crew on a system level. The main function of the thermal management system is to dissipate heat at a rate equal to or greater than its generation. At a system level, the management of heat dissipation directly or indirectly affects engine performance, fuel economy, safety and reliability, engine/component life, driver comfort, and maintenance. Military ground vehicles are generating more heat than ever before due to more powerful engines, air conditioning and additional auxiliary equipment.

Current vehicle cooling systems utilize a number of heat transfer fluids to dissipate heat at a vehicle level including air, coolant, engine oil, transmission oil, fuel, and refrigerant(s). The amount of heat transfer to and from these fluids depends on the fluid’s properties, mass flow rate, and the change in temperature between the fluid and the heat transfer surface. Fluids that are used today tend to have poor heat transfer because of their relatively low physical properties such as specific heat and thermal conductivity. This topic seeks to better understand and develop more effective methods to improve a fluid’s heat transfer characteristic. Some fluids, such as nano fluids show promise to significantly increase heat transfer by dispersing nanometer-sized metallic particles in conventional heat transfer fluids such as 50/50 ethylene glycol/water mixtures and oils. Because of percolation, theories predict that particles in the shape of nanorods would exhibit better thermal properties than particles in the shape of nanospheres. In addition, "near field" radiation theoretical predictions have shown that wide band-gap semiconductors such as nitrides and carbides will provide significant improvements in thermal properties. Research to substantiate these predictions is desired including: (1) controlled shape particle dispersement in baseline fluids and/or (2) nitride and carbide dispersement in baseline fluids.

Combat and tactical vehicles experience problems arising from operation in hot ambient temperatures up to 130 degrees F while under steady state full load, full power and/or transient conditions. The Army is seeking innovative concepts which use high performance advanced materials that offer significant improvements to solve these thermal challenges. Advanced material categories of interest include: monolithic metals, highly oriented pyrolytic graphite (HOPG), and composites including carbon fiber-reinforce epoxy (C/Ep) and carbon fiber-reinforced copper (C/Cu).

Advanced fluids and materials developed under this SBIR topic must exhibit: (1) higher heat transfer characteristics, (2) higher heat energy storage capacity, (3) enhanced thermal conductivity and be (4) corrosion-resistant. The novel fluids and/or materials may require checking for stability over long periods of time and making sure fluid does not clog small passages, damage pumps, corrode aluminum or cause system degradation.

Throughout the project, the connection between testing and analytical methods through modeling and simulation will be fostered. Modeling the effects of intelligent material and thermal fluids will provide the ability of capturing the interactions associated with achieving maximum thermal properties and showing the effects of these interactions. The project focus is to develop fluids and/or materials for stable long life and compare their performance through laboratory testing. This technology will benefit new vehicle designs such as FCS and/or be spiraled into existing vehicle systems where a need exists.

Many technical challenges exist for the Manned Ground Vehicle (MGV) under the Future Combat System (FCS) Program in regards to providing adequate cooling in a high temperature environment. Heat dissipation is the key factor limiting power levels. Fluid and material solutions to these real issues are critical, as related to new vehicles such as the MGV, if the FCS program is to achieve their desired performance goals. At least one challenging area will be explored which provides the biggest value to the vehicle customer(s). The technology area (s) chosen will result in overall lighter weight/volume reductions within the propulsion compartment.

PHASE I: Phase I will result in the demonstration of a prototype material and/or fluid on a bench-level system that shows a substantial improvement in thermal conductivity compared to a currently used material and/or fluid. In addition, Phase I will demonstrate an innovative concept or method to utilize this advanced material or fluid in a military vehicle thermal management system in order to achieve significant weight and fuel savings. The thermal conductivity, heat transfer coefficient and viscosity will be measured and compared to the baseline. An examination of the effect of particle size, shape, and distribution in regards to optimization of thermal properties shall be specified in the report. Issues relating to stability of dispersed particles and material compatibility will be evaluated. A Phase II plan forward shall be provided including program goals, objectives and schedule indicating how and when objectives will be met.

PHASE II: Phase II will use the Phase I results to design/develop/fabricate/test and demonstrate the innovative concept to utilize the advanced fluid/material in a military vehicle thermal management system in order to achieve significant weight and fuel savings. Modeling and simulation will be used to show effects of the advanced concept in a military vehicle thermal management system as compared to the baseline system. Subscale testing will be conducted to validate model and select best design for full scale concept fabrication and test. The testing will be performed in a laboratory environment, conducting experiments which factor in real world conditions and cooling requirements. Calculations of fuel savings and weight reduction in a vehicle cooling system will be made to determine the percent improvement to the vehicle thermal management system. A cost estimate to integrate the solution onto the vehicle will be provided including any necessary hardware modifications.

PHASE III: Phase III will apply the developed fluid/material solution to both commercial and military vehicle systems. For the military this could be applied towards PM Heavy Brigade Combat Team vehicles as well as other current and future vehicle for improving thermal management systems. For the commercial sector, this could be applied to a number of commercial trucking fleets such as Penske, Schneider, and Freightliner. Phase III demonstrations of this technology would us a commercial or military fleet to demonstrate the increase in performance and weight savings.

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KEYWORDS: Propulsion Cooling Systems, Advanced Fluids, Advanced Materials, nano fluids, graphite foam, thermal conductivity, Modeling, Simulation, Thermal Management.

A08-154 TITLE: High Temperature Capacitors for Hybrid Electric Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop and demonstrate compact capacitors with the capability of operating reliably at temperatures exceeding 150 degrees C, for use in future compact high-temperature, high-frequency Army ground vehicle power electronics.

DESCRIPTION: Future Army vehicles require compact electrical power systems with reduced cooling requirements. To accomplish this, power converters must be compact, efficient, and capable of using high temperature coolant. High frequency operation is used to miniaturize the size of passive components. To provide this performance, future wide bandgap power converters are expected to operate at power device junction temperatures >175 degrees C, inlet coolant temperatures 90 - 120 degrees C, and frequencies > 60 kHz. This SBIR seeks an innovative solution to provide filter capacitors for use in these future wide bandgap power converters. Power conversion applications include high power motor drive inverters and high power dc-dc converters. The power levels of these converters may range from 50kW to 300kW, depending on the vehicle and application. The key technical challenge of this effort is to miniaturize the capacitors, while providing high temperature and high frequency ripple current handling capability. Efficiency, reliability and service life must be maintained. Capacitors must be suitable for use in a combat vehicle, and must be able to operate at low temperatures to -40 degrees C, without significant loss of performance or reliability.

PHASE I: Contractor shall develop an innovative design for compact capacitors capable of operating at temperatures above 150 degrees C (threshold) to 200 degrees C (objective). Capacitor design must provide for the capability to be cooled with 115 degrees C coolant, operate at voltages up to 700 Vdc, handle high frequency ripple currents up to 60 kHz, operate at low temperatures to -40C, and scale to sizes of 1000 microfarads or larger. Capacitor design must be able to handle high ripple currents. Peak currents can be >500A, depending on the application, voltage and required power. If a trade-off exists between higher operating temperature capability and smaller capacitor size, the contractor shall provide an analysis which will allow selection of the best alternative. Contractor shall perform modeling and simulation and a sound physics-based analysis to establish technical feasibility. Demonstration and testing of a prototype is strongly encouraged. Contractor must show path to commercialization, manufacturability, market penetration, lifecycle cost.

PHASE II: Contractor shall fully develop the Phase I design to provide compact high temperature capacitors that can be cooled with 115 degree C coolant, operate at voltages up to 700 Vdc, handle ripple currents up to 60 kHz, operate at -40 degree C, and scale to 1000 microfarads. Capacitor design shall be suitable for high power applications at power levels up to 300 kW, and peak currents up to 500 A. Contractor shall develop capacitor fabrication procedure. Contractor shall develop capacitor test procedures to fully test the capacitors over the full range of temperature, voltage and power level. Contractor shall implement these procedures using commercially available test equipment, or fabricate high power test circuits as required. Contractor shall fabricate prototype test capacitors and shall test these capacitors to full ratings. These prototype capacitors will be in three principle (approximate) voltage ranges, < 300V, 300 - 500V and 600 - 700V. The exact voltage values to be specified by TARDEC at the start of the Phase II. Required Phase II deliverables will include a minimum of ten 100 microfarad (approximate) capacitors rated at 700 Vdc, and ten 300 microfarad (approximately) capacitors rated at 400 Vdc, both suitable for use in 60 kHz dc-dc converters operating at 150kW at voltages of 600Vdc and 300Vdc respectively. A minimum of ten capacitors (approximately) microfarads rated at 200 Vdc, suitable for use in 60 kHz dc-dc buck converters operating on the high voltage side at 175 Vdc and 50 kW. The exact capacitance, voltage and power levels will be given at the start of Phase II. These capacitors must meet contract objectives of minimizing size while operating at high temperature > 150 degrees C (threshold) and 200 degrees C (objective). Capacitors must be capable of operating at -40 degrees C, and capable of cooling with 115 degrees C coolant.

PHASE III: Phase III effort will provide capacitor components for high power dc-dc converters and electric motor drive inverters for future hybrid electric vehicles such as the FCS or JLTV, or the hybrid electric HMMWV. Potential commercial applications include capacitor components for dc-dc converters and motor drive inverters for hybrid electric automobiles, SUV's and trucks.

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KEYWORDS: Capacitors, high temperature, passive components, volumetric efficiency, power density, power converters, inverters, dc-dc converters.

A08-155 TITLE: <u>Safe, Low-Cost Cylindrical and Prismatic Nickel-Zinc Batteries for Hybrid Vehicles</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: The objective of this work is to improve nickel-zinc battery technology to allow it to be one of the prime contenders as a safe, low-cost battery for hybrid vehicles, other high-power portable implementations and current fleet applications.

DESCRIPTION: There is a need for a safe, light, low-cost, long cycle-life battery in the 30 kWh range to be used in military hybrid vehicles and to provide high power for pulsed power applications (e.g., directed energy weapons). Conventional lead-acid batteries are heavy (30 Wh/kg) and limited in cycle life. Lithium-ion batteries (100-150 Wh/kg) present potential safety problems, particularly in large sizes, and are relatively expensive. What is needed is a battery that is lighter than the lead-acid battery, with long-life capability and relatively low cost.

A prime candidate is the nickel-zinc battery, which until recently was limited in its cycling capabilities to a few hundred cycles, but the advent of new promising technologies`(Ref. 1 and 2) puts it into the range where it could be a prime competitor for these applications.

Advantages, some of the key features that appear within reach are that it would:

1. Have an energy density in the range of 60-80 Wh/kg, which is just below the range of lithium-ion batteries using iron phosphate as the cathode. Iron phosphate has been used because it appears that batteries using it as a cathode have a significantly lower tendency to explode or burn than other lithium rechargeable batteries. This safety advantage comes at the expense of energy density. Therefore a nickel-zinc battery approaches the energy density of a Li-Ion iron phosphate battery.
2. Contain no flammable components in the electrolyte. Even though Li-ion iron phosphate batteries are apparently safer than other lithium batteries, they still contain flammable solvents, as well as a flammable Li-C anode, both of which can cause problems in the event of a mishap, especially with larger batteries.
3. Provide a low-cost system, with the relatively high energy density mentioned above.

It is estimated that the relative costs would be as follows:
- Lead-acid batteries, the most common battery used in vehicles, have an energy density in the range of 30 Wh.kg, at a price of $100-250/kWh.
- Nickel-Metal hydride batteries, commonly used in hybrid vehicles in smaller sizes, have an energy density in the range of 50-60 Wh/kg, cost in the range of $500/kWh.
- Nickel-Zinc batteries, in the range of 60-80 Wh/kg and $300-400/kWh.

Recent developments, Sub-C size cells are nearing the point where they will be used in commercial power tools, and larger batteries In the 30 Ah size range, are reported as reaching cycle lives of 800-1000 cycles.

Anticipated program, it is anticipated that this Research and Development program would focus on the key items required to improve the system to the point where it would be applicable to military hybrid vehicles. It is anticipated that this would incorporate improvements in electrolyte additives and cathode formulations. This obviously involves significant risk, since others in the past have attempted to provide long -lived batteries without success. The proposed has significant flexibility to propose various additives and electrode configurations in aiming at an acceptable product.

In summary, the nickel-zinc battery has the potential to be a low cost, safe, rechargeable battery with an energy density about twice (60-80 Wh/kg) that of the lead-acid battery (30Wh/kg). This is about the same as that of the nickel-metal hydride battery, but the coast should be about half that of the nickel-metal hydride battery, and the cooling problems on recharge should be simplified.

PHASE I: Nickel-Zinc Cell and Initial Pack Development, in this phase, which will cover a 6-month, $70K (max) effort, the contractor will develop and demonstrate prototypes, both cylindrical and prismatic, of both cells and batteries demonstrating improved cycle life. The improvements shall be in the range from 250-1000 cycles, the higher the better. Packs would be provided utilizing smaller cylindrical cells, D-size or less, to assess the performance of cells operating in series and to determine the electronic control requirements. At this stage and to keep costs at a modest level, the prototype cell assemblies shall use existing processing capabilities.

The deliverables would be cylindrical cells (6) in the 5 Ah range, and prismatic cells (4) in the 30 Ah range, along with a report covering the evaluation of the cells and cylindrical cell batteries.

PHASE II: Nickel-Zinc Pack Development, Demonstration and Validation, this phase, which will cover a 2-year, $730K (max) effort, will cover the development and demonstration of multi-cell packs of both cylindrical and prismatic cells produced on an installed pilot assembly line. This is in contrast with Phase I where the cell modifications are based the adaptation of cells produced on an existing process line. The capacities of the cylindrical cells shall be in the range of 5 Ah, and the capacities of the prismatic cells shall be in the range of 30 Ah. Appropriate electronic controls shall be incorporated into the system, based on the results from Phase I.

In order to evaluate advances for various types of hybrid vehicle applications, it is anticipated that deliverable would include batteries utilizing D-size cells with a capacity in the range of 5 Ah, and larger batteries incorporating prismatic cells with a capacity in the 30 Ah range. The goal for each of these systems would be to have a cycle life in the range of 800-1000 cycles.

PHASE III: Nickel-Zinc Initial Commercialization, the results of the development of these two new types of batteries should enable their incorporation into two new types of systems:

Military: The larger 30 Ah cells will enable the development of safe, low-cost hybrid vehicle batteries suitable for use with electric weapons. These could be assembled into battery packs of up to 30 kWh.

Commercial: The cells in the 5 Ah capacity range should allow for the development of commercial and consumer hybrid vehicles, and in addition could be utilized in cordless power tools and garden appliances.

The goal in this phase will be to evaluate products for military and commercial applications, and to initiate the manufacturing processes to produce these products.

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2. J. Phillips, PowerGenix Sealed Rechargeable Technology for High Rate Applications”, 23rd International Battery Seminar and Exhibit, Broward County Convention Center, Florida, Mar, 13-16, 2006.

3. B. Bugnet, D. Doniat, R. Rouget, Batteries 2005, June 14-16, Paris.

4. B. Bugnet, D. Doniat, R. Rouget, “Nickel-Zinc Battery Development”, Proc. of the 40th Power Sources Conference, Cherry Hill, NJ, June 10-13, 2002.

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KEYWORDS: Batteries, nickel, zinc, hybrid, electric, power, energy.

A08-156   TITLE: Exportable Vehicle Power Using Cognitive Power Management

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop the ability to export electrical power generated on military ground vehicle platforms to support the need for electrical power in the field. It is desired to augment the existing electrical power generation capacity to both increase available electrical power and also provide a readily available and mobile source of electrical power when needed.

The end result of the Phase II effort will be the design and demonstration of an intelligent power system from ground vehicles which will supply both exportable and importable power in both a stand alone mode and with multiple vehicles linked together, i.e. a microgrid, to increase available power by operating intelligently in a collaborative environment between vehicles and/or utility gird. This will include intelligence to ensure safe connection and disconnection of the electrical systems of multiple vehicles and also synchronization of electrical power

DESCRIPTION: Using vehicular power systems to supply electrical power to fielded units will provide a highly mobile source of electrical power which may quickly respond to emergency situation and also augment the power capacity of existing electrical generation units. Linking together multiple power sources requires proper sensing and control of the status of those sources and greatly benefits from the intelligence provided by embedded processors, in particular "smart switches". Embedded processors can provide for the safe operation of switches and other controls used to connect and combine multiple power sources. Among the challenges in this area is the need to synchronize the amplitudes, phases, and frequencies of multiple AC generator units within 100 cycles or 1 second and also to quickly disconnect sources and loads from the power grid within 10 milli-seconds when unsafe conditions are detected. With multiple electrical sources the ability to optimize the efficiency of power generation becomes an option. This leads to the potential of using prior research into intelligent and cognitive power management in the application of exportable vehicle power. Ultimately, creation of an "ad-hoc microgrid" composed of several ground vehicles and electrical generation units is desired, with intelligent control to maintain stability of the microgrid and optimize the power generation from multiple sources to meet mission goals.

PHASE I: This will demonstrate the feasibility and indicate the potential benefits of an intelligent, exportable power system derived from a ground vehicle due to the collaborative efforts of multiple systems and vehicles. This phase will also focus on the feasibility of detecting and synchronizing the sources and explore potential data busses to control and synchronize sources. The applicability of SAE J1939-75 Application Layer—Generator Sets and Industrial to military vehicles will also be considered. Phase I will develop a concept for a military ground vehicle based power interface that will permit both power export and import. In power export mode this power interface will automatically detect and synchronize to an existing AC or DC power system and allow for variable user defined limits to the percentage of overall power contribution of the vehicle. In power import mode the vehicle power system would automatically detect and accept power from a grid system, for example to be used to recharge batteries and/or operation of on-board vehicular systems.

PHASE II: This will result in an in-vehicle (and/or lab environment) implementation of the approach developed in Phase I. This effort includes development of hardware and software, primarily the "smart switches, which include a communications interface (CAN or Ethernet for example) and the software to control and manage the power control units (PCUs) or "smart switches". The demonstration will integrate a vehicular power system with an external military APU and/or DC power system. The demonstration will include both power export and import. For both power export and import the amount of power transferred will be able to dynamically adjust according to vehicular power management control system commands and will automatically sense and disengage power sources once faults are detected - such as overload and overvoltage. Extensions to the existing Power Management API to facilitate export power will be suggested. This work will build on previous SBIR efforts, specifically the Advanced Electrical Power Architecture (AEPA) SBIR as well as the cognitive power management control strategy optimization development performed in conjunction with University of Michigan - Dearborn. Additionally, cognitive power management applied to exportable power augments work performed for both the Power and Thermal Management Technologies ATO and the Non-primary Power Systems ATO. This ability to export power from on-board vehicle electrical systems, including any vehicular Auxiliary Power Units (APUs), can expand the range of applications for products developed by both of these ATOs to off-vehicle and vehicle - grid electrical systems.

PHASE III: Technology will be transitioned to vehicle system and subsystem manufacturers for inclusion in their upgraded vehicles. The technology will be available as an option item in the vehicles, mainly to those ones likely to operate in a fleet environment. Under a collaborative environment with a fleet of multiple vehicles, it is possible to have a more optimized and compact electrical system in each vehicle, so that all the electrical power needs for the whole system of vehicles together can be fulfilled without excessive overcapacity in each. A potential commercial application of the technology will be in the latest hybrid electric vehicles, particularly in the area of "plug-in hybrids", where recharging "off the grid" is desired and promises to further increase the overall efficiency of hybrid vehicles. and also regular IC engine based vehicles, where the vehicle power can be used for household electrical needs during utility power failure conditions. Potential commercial applications include the construction industry, which often requires various forms of electrical power at remote job sites, and also recreational vehicles for use at remote camp sites.

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2. Kueck,J. D., Staunton,R.H., Labinov, S. D., and Kirby, B.J., "Microgrid Energy Management System", ORNL/TM-2002/242, January 29, 2003, Prepared by OAK RIDGE NATIONAL LABORATORY.

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KEYWORDS: Exportable power, power management, cognitive power management, power optimization, vehicular micro-grid, hybrid electric vehicle.

A08-157 TITLE: Real-time In-line Water Quality Monitoring

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors, Electronics

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Provide the tactical water purification system operators (92W) a real time in-line diagnostic tool to verify treatment process operation, removal of contaminants, and optimize performance.

DESCRIPTION: Military tactical water purification systems must currently rely on periodic sampling and water quality analysis using the water quality analysis set purification (WQAS-P) to verify proper operation of the equipment and verify water quality to ensure soldier safety. The water quality parameters monitored are pH, temperature, turbidity, total dissolved solids, and free chlorine residual (these are common place and easily monitored by commercially available meters). Its principal components are a case, water quality meters, and calibration standards. The WQAS-P is only used to sample water periodically creating a high probability that short term or pulsed deliberate or incidental water contamination or threat agents will not be identified putting soldier safety at risk. Additionally, upsets in equipment operation will likely not be identified until after water is issued and soldier's heath is put at risk.

To overcome this problem in-line, continuous water monitoring technology capable of measuring pH, temperature, turbidity, total dissolved solids (TDS) and free residual chlorine needs to be developed on a single platform such as a chip. Other parameters of interest include total organic carbon, calcium, alkalinity, LSI, oxidation-reduction potential, particle count and distribution, and microbial contamination. During phase II extend platform to include additional parameters needed to verify two of the following processes: microfiltration, coagulation, anti-scalant effectiveness, or granular activated carbon. The platform developed should have a measurement range for each parameter equivalent to commercially available equipment currently used by the water industry. Accuracy of each parameter should be evaluated by comparing the results to analysis by the appropriate reference method from Standard Methods for the Examination of Water and Wastewater, 20th Edition. The percent difference should be less then 5%. Each parameter shall be tested in varying types of water with a relative standard deviation of less then 3%. The sensor for these multiple analytes should be housed within a single platform no larger than one cubic foot. The sensor platform should be self calibrating with duration of at least one month before recalibration is needed. The sensor should be capable of infrared communication with a data logging device.

The data logging device should be no larger than the size of a PDA. The data logging device should allow for further analysis of data such as determining % rejection and scaling potential. Other information should be able to be recorded such as date, time, place, sensor, system being used. This information will provide a real time accountability of water quality on the battlefield.

This request is NOT looking for proposals that integrate various commercial items with minor modifications to meet the above requirements. The proposals should identify cutting edge research that allows for the consolidation of the parameters identified above on a single platform such as a chip.

PHASE I: Demonstrate concept feasibility by designing, building, and testing one breadboard system in a laboratory environment for the detection of pH, temperature, turbidity, TDS, and free residual chlorine.

PHASE II: Develop, build, and evaluate field prototype for in-line monitoring device in field environment through third party testing. Deliver and demo device in-line with a military mobile water treatment system.

PHASE III: PM Petroleum and Water Systems can integrate the technology developed under this SBIR into the mobile water treatment systems, storage, and distribution systems to ensure water quality is not compromised. Water utilities could insert the technology developed under this SBIR throughout public water distribution system providing a real time accountability of water quality up to when the consumer drinks the water from the tap.

REFERENCES:
1. U.S. Army Center For Health Promotion and Preventive Medicine (CHPPM), http://usachppm.apgea.army.mil/.

2. U.S. Environmental Protection Agency (EPA), http://www.epa.gov/water.

KEYWORDS: Water, quality, real time, in-line, treatment process, contaminants, data logging.

A08-158 TITLE: Measuring Fuel Quantity in Bulk Containers

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: To develop an instrument or method to accurately measure the volume of fuel or water in a collapsible fabric storage tank of variable size and shape.

DESCRIPTION: On the battlefield, the Army relies heavily on collapsible fabric storage tanks for temporary storage of fuel and water. These tanks range in size from 3000 gallons to 210,000 gallons. The use of these fabric tanks poses several technical difficulties when accounting for the volume of fuel the Army uses, due to the problems in accurately measuring volume in a container of variable size and shape.

The current method for tracking the volume of fuel in these tanks is to measure it as they are filled or emptied via flow meters. However, flow meters are fairly inaccurate, and are only able to measure the tank volume to within an estimated ± 6-10% accuracy, assuming that the meters are reset on a daily basis. If the meters are not reset regularly, the accuracy is worse than that, due to the cumulative error. Additionally, even if current techniques could precisely gauge the volume during filling, the tanks are fabric and therefore semi permeable, with the result that fuel can be lost to diffusion through the walls of the tanks. This diffusion process, along with evaporation through the tank’s venting system, makes it even more important to have a method to accurately measure the volume contained in the tank, as that volume is not constant even when no fuel has been pumped in or out.

To this end, the Army desires a long term technological solution to the problem of accurately measuring the volume of fuel in a collapsible fabric storage tank. Currently, a short term solution is being developed which involves measuring the height of the tank and estimating its volume based on this height. However, this method is projected to achieve a ± 5% volume accuracy at best, due to a variety of limitations.

The proposed long term solution to this problem will need to overcome these limitations, including:
1. The exact size, geometry, and construction material of a tank varies with manufacturer and tank.
2. The tank may expand or contract with changes in temperature.
3. The ground the tank is deployed on is not necessarily uniform, affecting the shape of the tank. Even when a tank is setup on initially flat terrain, the weight of the tank can cause the ground to deform, changing its shape and internal volume.

Finally, safety considerations should be taken into account in the proposed solution to this problem. Fairly obviously, the proposed solution will need to be used in or near petroleum fuels and their vapors. Therefore, any solution must be able to be safely operated in a Class I, Division I Hazardous Location as defined by the National Electric Code (NFPA 70). Additionally, collapsible fabric tanks are erected inside large berms in order to capture the fuel in the event that a tank bursts. Such an event would pose a significant danger to anyone standing inside the berms. Consequently, an ideal solution should not require the Soldier to spend any time inside the berms while a tank is full. With water tanks, compliance with NSF 61 must be considered in any design solution.

PHASE I: Develop a technique to measure the volume of fuel in a collapsible fabric tank. Particular focus should be paid to the level of precision of the measurement. An accuracy of ± 2-3% volume is the minimum threshold accuracy desired. Demonstrate the effectiveness of the proposed technique.

PHASE II: Design, construct, and test a prototype device for the measurement of fuel in a collapsible fabric tank. Testing and demonstration for this phase may be done with water. This device will be delivered to the Army.

PHASE III: Technology developed in this topic could greatly enhance the Army's ability to track and account for its fuel use. Additionally, it may prove useful in any other industry where there is a need to measure the volume of fluids in irregularly shaped containers.

REFERENCES:

1. Military Performance Specification MIL-PRF-32233, "TANKS, COLLAPSIBLE, 3,000, 10,000, 20,000, 50,000, & 210,000 U.S. GALLONS, FUEL," 8 December 2006.

2. Technical Manual TM 10-4930-239-12&P, "Fuel System Supply Point Model Lab 6891," 31 March 1993.

3. Technical Manual TM 10-5430-242-12&P, "TANK, FABRIC, COLLAPSIBLE, FUEL STORAGE," January 2002.

4. NFPA 70, "National Electric Code," 2008 Edition.

5. NSF/ANSI 61-2007a, "Drinking Water System Components – Health Effects," 18 July 2007.

KEYWORDS: Collapsible fabric tank, fuel, storage, accuracy, measurement, volume.

A08-159 TITLE: <u>Advanced Additives to Improve Fire Resistant Fuels (FRF)</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Utilize advanced associative polymer technologies capable of retarding flame propogation when JP-8 and diesel fuels are ignited from an incendiary threat. The formulation must have minimal impacts on engine performance and the logistic fuel supply chain.

DESCRIPTION: The U.S. Army has successfully formulated a JP-8 and diesel fuel capable of self extinguishing after ignition from an incendiary threat. The fuel formulation, termed fire-resistant fuels (FRF), is essentially a water-in-fuel emulsion. Previous ballistic experiments have shown that FRF formulation can be dramatically improved when fuel misting is prevented during the initial stages of a fuel fire. The U.S. Army is interested in developing a custom anti-fuel misting additive for JP-8 and diesel fuel. The additive formulation shall be highly stable and have minimal effects on fuel properties, toxicity, engine performance, and the logistic supply chain. The formulation must be shear-stable and not loose their capability when fuel is re-circulated in diesel engines.

PHASE I: Research current and concept technologies and evaluate their potential to provide anti-misting properties in fuel. Model or perform a pilot demonstration of the most promising approaches. These results will lead to an approach and procedure to follow under Phase II.

PHASE II: Formulate a JP-8 and diesel based FRF (water-in-fuel emulsion to be provided) with anti-misting additve developed in Phase I. Perform bench-scale flame onset and propagation testing to determine efficacy of the proposed FRF formulation. Measure physical and chemical properties of the fuel (per MIL-DTL-83133 and ASTM D975), and determine the performance boundary conditions for a wide range of operating environments (particularly fuel temperature). Validate the proposed anti-misting additive formulation will not negatively impact engine performance and durability, and is non-toxic. Finally, perform a midlevel-scale demonstration of the anti-misting addtive technology (The definitive test for fuel self-extinguishment is an incendiary ballistics test).

PHASE III: Anti-misting additive can substantially improve the fire-resistance of JP-8 and diesel fuel, and could potentially be utilized by military ground vehicles to minimize the occurrence and damage caused by fuel fires. Anti-misting additives could potentially reduce the logistical footprint of suppling FRF technology by reducing the volume of water emulsified in FRF formulations, enabling the military to more easily implement this technology in field applications. A product successfully developed under Phase II could potentially be integrated into the fuel logistic system by the U.S. Army's Product Manager, Petroleum and Water Systems (PM PAWS) pending a Combined Arms Support Command (CASCOM) capabilities-based analysis. Furthermore, technologies that may decrease flame propogation properties of a fuel or prevent fuel misting could potentially be adopted by military / commercial ground vehicle and aircraft fire suppression systems as well as the racing automotive industry. Organizations including the Fire Research Division of National Institute of Standards and Technology (NIST), U.S. Army Research Lab (ARL), U.S. Naval Research Lab (NRL), and U.S. Air Force Research Lab (AFRL) which have ongoing fire suppression programs and commerical chemical industry could both potentially leverage an advancement in associative polymer additive technology developed under this research effort.

REFERENCES:
1. Wright, B.R. and Kanakia M.D. (1987) Final Review of U.S. Army Fire Resistant Fuel Program. Interim Report BFLRF No. 244.

2. National Materials Advisory Board (1997) Aviation Fuels With Improved Fire Safety: A Proceedings. National Academy Press.

3. Klueg, E.P. (1985) Antimisting Fuel Technology for Transport Category Aircraft. SAE 851886. Department of Transpiration. Federal Aviation Administration.

4. Wright, B.R. and Kanakia, M.D. (1985) Investigation of Diesel Fuel Fire Vulnerability Parameters in Armored Personnel Carriers Due to Ballistic Penetration. Interim Report AFLRF No. 194.

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KEYWORDS: Anti-Misting Additive, Fire Supression, Flame Propogation, Fuel Fire, Fire Resistant Fuel, JP-8, Diesel Fuel.

A08-160 TITLE: Intelligent Multi-modal Ground Robotic Mobility

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

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

OBJECTIVE: We seek to design, develop, and demonstrate an ultra-mobile unmanned vehicle platform with adaptable on-the-fly locomotion articulation. This platform will support operations in battle-torn urban areas, while improving the current state-of-the-art in robotic vehicle mobility. The robot will be capable of sensing the operational terrain and morph between two mobility configurations, providing either continuous contact or discrete contact locomotion modalities (e.g., tracks and legs or wheels and legs). The robotic platform will be large enough to lift & carry payloads & accomplish manipulation tasks (e.g., opening doors, lifting objects) requiring human strength or greater, but small enough to go in locations a human could traverse.

DESCRIPTION: The Army has a critical need for high performance robotic mobility platforms that can quickly and efficiently traverse challenging terrain, particularly those that would be encountered in a wartime urban environment. Such vehicles would have continuous contact and discrete contact locomotion modalities (e.g., tracks and legs or wheels and legs) and would have the intelligence to automatically select and operate in the mode most suitable and efficient for the current situation. A key feature of such robotic vehicles would be articulated suspension mechanisms that are actively controlled depending on the operational environment. This would allow for active control of ground interaction characteristics depending on the general type of terrain (paved, mud, sand, concrete debris, staircases (internal, as well as non-backed external types), etc.). It would also allow positioning of wheels or tracks to roll or step over large obstacles, and to support basic climbing capability over obstacles of 30”-36” height. To be relevant and effective, these vehicles would have speeds of 15-20 mph (maximum) and continuous operational speeds of 7-10 mph in order to maneuver with infantry units. The vehicles must be able to perform soldier support maneuvers, while lifting and carrying a payload of 300 to 400 pounds, in a stable, mobility position.

In order for such a vehicle to be operated quickly and efficiently, the operator should have to specify a desired velocity vector, and the vehicle should automatically determine all control actions that most closely achieve this, including locomotion mode, wheels/tracks/legs placements and trajectories, and control actions that maintain dynamic stability. The operator should not be required to specify details of how the vehicle traverses the terrain, nor should the operator be required to control individual joints in linkages, or determine optimal wheel or track placements.

PHASE I: Develop a proof of concept articulated suspension prototype. As part of the development, models for key components, a full robotic vehicle design and simulation capabilities shall be delivered to validate the overall design. The platform design should possess the following for relevancy: The robot design shall feature a multi-modal articulated, controlled suspension that would allow traversal of challenging terrain. The platform should have manipulators and be large enough to lift/carry relevant payloads (300 to 400 pounds) as well as accomplish other manipulation tasks (e.g., opening doors, clearing debris) requiring human strength or greater. The platform should also be small enough to traverse in a typical urban environment that a human would traverse (fit through doors & traverse through indoor hallways & staircases that have 90 degree bends.) The platform should possess the capability to quickly & reliably produce & update terrain elevation maps for terrain in immediate vicinity of robotic platform to provide for the intelligent multi-modal locomotion and generation of terrain navigation plans. (Vision/sensing systems and local navigation systems that take terrain elevation maps & desired velocity vectors as inputs could provide for this). Platform should possess whole-body maneuver & balance control systems capable of executing navigation plans in presence of significant disturbances (e.g., balance).

PHASE II: Using the Phase I design requirements and technical documentation, the contractor shall fully develop, fabricate and deliver a prototype of the robotic vehicle. The developed robot shall provide a highly maneuverable robotic mobility platform with adaptable on-the-fly locomotion modalities to support operations in battle-torn urban areas. The robot shall be capable of sensing the operational terrain and morph between two mobility configurations. The robotic platform shall be large enough and equipped with manipulators to enable the robot to lift & carry payloads of 300 to 400 pounds & accomplish other manipulation tasks (e.g., opening doors, removing light debris from robot path, stabilizing the robot under extreme mobility conditions) that would require human strength or greater. Once constructed, the contractor shall provide manpower and materials support to a performance validation test that will be conducted to test the developed robot against the requirements in a military MOUT facility.

PHASE III: The results from this effort will not only provide soldiers with platforms that increase their mobility and payload transport capability, but will also enhance interrogations with a small footprint. This robot will increase soldier survivability by providing & maintaining safe stand-off distances in MOUT operations. Such a robotic platform has many potential commercial applications. The first responder community could utilize this robotic platform for urban search and rescue missions, which might require personnel extraction or operations in hazardous areas. Such a mobility platform could be used for hospice care of the sick and elderly. Construction equipment manufacturers may also be interested, specifically in mining type applications where tight access corridors are the only routes to extract heavy material. The off-road ATV community is another candidate that may seek to benefit from the development of this technology. The articulation mechanisms and technologies developed under this effort could also be commercialized into smaller platforms such as toys.

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2. Multi-Modal Locomotion Robotic Platform Using Leg-Track-Wheel Articulations.
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KEYWORDS: Articulated suspension, intelligent robotic mobility modality, inherent stable mobility, articulation, tracks, wheels, legs, manipulators, intelligent locomotion, multimodal locomotion, unmanned ground vehicle, mobility.

A08-161 TITLE: Tactical Vehicle Underbody Blast Energy Absorber Kit

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 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop blast attenuation kits and / or integrated vehicle components that would be applied to light tactical vehicles - such as the HMMWV or its replacement vehicle(s) - at a surface density less than 20 pound mass per square foot, based on the surface area of the bottom of the vehicle, and that would reduce the amount of blast energy transmitted to the crew compartment of tactical vehicles by at least 30 percent.

DESCRIPTION: During armed conflicts, casualties are often attributable to vehicle-landmine accidents and mine blast protection features are thus a desirable functionality for vehicles serving in such situations. Various solutions to this problem currently exist and are well known. Materials or structures are sought that offer exceptional levels of blast protection but that, at the same time, contribute less weight per vehicle and require less space in order to accomplish the blast energy absorbing function. It would not, within the context of this SBIR, be appropriate to propose and develop solutions that primarily involve making thicker layers of armor; this has already been done. The intent here is to introduce design approaches that utilize more innovative geometries and, possibly, materials in order to, at a surface density less than 20 pound mass per square foot based on the surface area of the bottom of the vehicle, reduce the level of blast impact energy transmitted to the crew compartment of tactical vehicles by at least 30 percent. This improved performance will be measured in terms of experimentally and/or computationally determined reduction of blast-induced displacements and accelerations of the vehicle bottom and of the vehicle floor panels as compared to the performance of a baseline tactical vehicle hull design that does not include the blast mitigation kit.

PHASE I: The state of the art with regard to vehicle underbody blast mitigation is well understood; a mere review and the development of and supply by the SBIR contractor of a new catalogue of currently available solutions will not be sufficient. For the purposes of this SBIR project, if the proposed energy management solutions are comprised of a passive device, for example, a geometric structure comprised of an innovative material, then a credible demonstration of the efficacy of the design as well as an estimate of manufacturing and application cost shall be furnished for one or more new, unique, relatively unknown, and innovative candidate blast energy absorber technologies. In the event that the proposed solutions are of an active type and would involve actuation as the result of, for example, signals from a sensor or system of sensors then the deliverables shall include evidence that the proposed device would exhibit acceptable levels of energy attenuation, perhaps via simulation, and that control algorithms and device response would be sufficiently robust to offer protection during blast incidents but, at the same time, would not be prone to false triggering due to non-blast related mission events.

The successful contractor would, by virtue of an understanding of the structural and kinematic responses of the vehicle to mine blast excitation, develop a blast attenuation package that would significantly reduce the amount of blast energy transmitted to the crew compartments of light tactical vehicles such as HMMWV, future replacements for the HMMWV, etc., as measured by means of experimentally and/or computationally determined reduction of displacements and accelerations of the inner surface of the vehicle bottom and of the vehicle floor panels as compared to the performance of the baseline tactical vehicle hull design without the blast mitigation kit.

PHASE II: Develop, build, and evaluate - in terms of reduction of underbody and floor displacements and accelerations - the performance of, a field prototype kit for a specific light tactical vehicle such as the HMMWV, a future replacement vehicle for the HMMWV, etc. The performance of the kit would be such that, at a surface density less than 20 pound mass per square foot, based on the surface area of the bottom of the vehicle, blast energy transmitted to the crew compartment of the baseline light tactical vehicle would be reduced by at least 30 percent.

PHASE III: Dual use applications. There is currently a lot of interest on the part of vehicle integrators, their suppliers, other researchers, and within the Department of Defense (DoD) with respect to the development of light weight solutions to the blast mitigation problem. It is therefore expected that the successful development of this type of lightweight underbody blast energy absorber system would engender commercial interest on the part of vehicle integrators and associated contractors to the DoD. It is expected that vehicle integrators and others would want to apply such a technology to various classes of combat vehicles, to protected commercial vehicles for very important persons (VIPs), to route clearance vehicles such as the so-called MRAP vehicles, and to other commercial vehicles and structures that require hardening against blast threats.

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KEYWORDS: Energy management, Energy absorber, Impact attenuation, Survivability, Blast protection, Blast, Mine blast, Armor, Tactical vehicle, Blast mitigation, manufacturing technology, light tactical vehicle, MRAP, route clearance vehicle, HMMWV.