ARMY
SBIR 07.2 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 (12 April – 13 May 2007), contact the Topic Authors listed for each topic in the Solicitation. To obtain answers to technical questions during the formal Solicitation period (14 May – 13 June 2007), 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
sbira@belvoir.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 **Science Applications International Corporation (SAIC), Azimuth, Inc., and The Mitre Corporation** who will provide Advisory and Assistance Services to the Army, providing technical analysis in the evaluation of proposals submitted against Army topic numbers: **A07-142 (SAIC and Azimuth, Inc.,), A07-179 (The Mitre Corporation) and A07-180 (The Mitre Corporation)**.

Individuals from **SAIC, Azimuth, Inc., and The Mitre Corporation** 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 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.

Army Phase I proposals have a 20-page limit (excluding the Cost Proposal and the Company Commercialization Report).

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

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

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

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

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

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

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

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

Phase I Key Dates

07.2 Solicitation Pre-release	12 April – 13 May 2007
07.2 Solicitation Opens	14 May – 13 June 2007
Phase I Evaluations	June – August 2007
Phase I Selections	August 2007
Phase I Awards	October 2007*

**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 Phase I award recipient is invited to propose for Phase II. Invitations are generally issued three to 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 commercializaing 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.

COMMERCIALIZATION PILOT PROGRAM (CPP)

In FY07, the Army will initiate a CPP with a focused set of SBIR projects. The objective of the effort is 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. Specific guidelines, policies, and procedures for participation in the CPP and for the award of expanded RDTE activities will be released when available.

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 https://www.armysbir.com/. **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 07.2 Topic Index

Participating Organizations	PC	Phone
Aviation and Missile RD&E Center (Aviation)	**PJ Jackson**	**(757) 878-5400**

A07-001	Small UAV High-speed Obstacle and Collision Avoidance
A07-002	Novel Passive Technologies for Improved Helicopter Rotor Performance
A07-003	Environmental Sensor for Autonomous UAVS
A07-004	Variable Turbine Technologies for Improved Part Power Performance
A07-005	Automated 1/rev Rotor Vibration Control
A07-006	Advanced Active Vibration Control of Helicopters
A07-007	Innovative Rotor Blade Anti-Icing/De-Icing Technologies
A07-008	Smart Autonomous Miniaturized Contamination Condition Sensor with Embedded Prognostics
A07-009	Field Repair of Localized Damage on Dynamic Rotorcraft Components
A07-010	Computational Fluid Dynamics Co-processing for Unsteady Visualization
A07-011	Robust, Real-time Clearance Measurement Technologies for High Temperature Turbine Applications
A07-012	Incorporating Effective Cooling into Ceramic/Ceramic Matrix Composite (CMC) Turbine Blades and Nozzles
A07-013	Dynamic Blade Shapes for Improved Helicopter Rotor Aeromechanics

Aviation and Missile RD&E Center (Missile)	**Otho Thomas**	**(256) 842-9227**

A07-014	Precision Optics Manufacturing of Large Hemispherical Domes
A07-015	Nanomaterial Improvements for Reserve Power Systems
A07-016	Manufacturing Issues for Multimode Seeker Domes
A07-017	Applying Technologies for Managing the Parallel Test Problem
A07-018	Perpetual Learning and Knowledge Mining for Automatic Target Recognition (ATR)
A07-019	Techniques for Comparison of Actual Target Signatures to Rendered or Synthetically Generated Models
A07-020	Virtual Sensor Wiring Harness for Hazardous Environments
A07-021	High-Speed Non-Intrusive Measurement Techniques for the Visualization of Droplet Clouds
A07-022	Automated Risk Assessment Tool to Optimize Missile System Affordability Management
A07-023	Embedded Vibration Monitoring and Real-Time Data Analysis and Reduction
A07-024	High Strength, High Modulus Nano-Composite Missile Structures
A07-025	Nano-composite for Impact Mitigation in Composite Missile Systems
A07-026	Cheap Miniaturized Intelligent Wireless Missile Sensor Platform
A07-027	Development of a Fuel Gel Formulation Using Nano-sized Particulates for Tactical Bipropulsion Systems
A07-028	Secure, Lightweight, Tamper Proof, Cable Technology
A07-029	Missile/UAV Dispense Interference Modeling
A07-030	Wide Waveband, Large Aperture, Trichroic Beamcombiner

Armament RD&E Center (ARDEC)	**Carol L'Hommedieu**	**(973) 724-4029**

A07-031	Boron Nanotubes for Ultra High Strength Light Weight Composites
A07-032	Multi-Agent Based Small Unit Effects Planning and Collaborative Engagement with Unmanned Systems
A07-033	Miniaturized, Low-cost Processing and Software/Hardware Component Technology for Near Real-time Structure Mapping for Urban Combat Special Operations
A07-034	Harvesting Energy for Wireless Sensor Networks
A07-035	Miniaturized Electrical Initiation Systems for Miniature Thermal Batteries
A07-036	Novel Gun Hardened Low-Drift High-Resolution Miniature Angular Acceleration Sensor
A07-037	Miniature Steerable Laser Range Finder for Small Arms Airburst Ammunition Systems
A07-038	Novel High Control-Authority Impulse Based Micro-Actuation Technologies for Steering Guided Munitions

A07-039	Probabilistic Physics-based design of Composite (and Novel) Materials & Structures for pre-defined Hi-Reliability and Life Expectancy
A07-040	High-flux electronically generated thermal neutron source for radiographic applications
A07-041	An Algorithm for Obtaining Bearing Information from a Single Triaxial Seismic Sensor
A07-042	Visible to Short Wavelength Infrared Hyperscope for Armaments
A07-043	Compact HF Antenna
A07-044	SUAV/SUGV Based Automated Geo-location and Hand-off
A07-045	High-throughput Metal Forming of Micro-components with Nano-scale Tolerances
A07-046	Precision Guided Aerial Delivery of Intelligent Ground Based Munitions and Sensors
A07-047	RESS (Rapid Expansion Supercritical Solution) Technology to Disperse Carbon Nanotubes into Selected Polymeric Matrices

Army Research Institute (ARI) **Dr. Peter Legree (703) 602-7936**
Doug Dressel (703) 602-7927

A07-048	Simulated Job Performance Assessment
A07-049	Modeling and Assessing Performance of Complex Organizations
A07-050	Measuring Learning and Development in Cross-Cultural Competence

Army Research Laboratory (ARL) **John Goon (301) 394-4288**

A07-051	Short-Range Detection of Radio Transceivers for Physical Security
A07-052	An Assessment Methodology for Effects Based Operations
A07-053	Information Technology Assistant for the soldier using flexible displays
A07-054	Highly Scalable Spectrally-Narrowed Surface-Emitting Arrays for Eye-Safe Lasers
A07-055	Rapid Recharge, High Voltage Li-Ion Battery Chemistry
A07-056	Widely-Tunable Quantum Cascade Laser Technology for Spectroscopic Sensing and Optical Communication Applications
A07-057	Automatic recognition of handwritten Arabic script documents
A07-058	Polymer Electrolyte Membrane (PEM) with Acid-Base Pairing for Direct Methanol Fuel Cells (DMFC)
A07-059	Passive Detection of Acoustic Signatures via Glint Modulation
A07-060	Behind Armor Debris (BAD) Data Collection Tool
A07-061	Ultra-Dense Nano-Device Platforms for Memory Intensive Military Applications
A07-062	High-Speed Chemometrics and Data Fusion of Orthogonal Detection Sensors
A07-063	Processes for Metal Matrix Composites
A07-064	Ultra-High Strength and High-hardness Nano-Aluminum Composites
A07-065	Warhead Adaptive Materials (WAM) for Military Operations in Urban Terrain (MOUT)
A07-066	Development of continuous in-line manufacturing process for application of multi-component semi-permeable textile coating
A07-067	Processing of Bulk Nano-Magnesium Alloy and Composites
A07-068	Antimicrobial Coatings for Military Textiles
A07-069	DNA-based barcoding for identification of Army materiel
A07-070	Stochastic Programming of Computer Agents and System of Systems Designs
A07-071	Development of Innovative Fusion Algorithms for Color Night Vision
A07-072	Development of a Naphthalene Exposure Dosimeter
A07-073	Logistical Decision Support and Planning in a Counterinsurgency Environment
A07-074	Bio-Inspired Approaches to Secure Scalable Networking
A07-075	Very Small, Heavy-Fuel Engine (VSHF) Concepts
A07-076	Generalizable Linked User Evaluation of Operational Neuro-cognition and Performance (GLUE-ON)

Army Test & Evaluation Command (ATEC) **Curtis Cohen (410) 278-1376**

A07-077	Near-real-time Biological Field Sampling System-Miniature Mass Spectrometry
A07-078	Real-Time Scalable Emulation of Communication Networks

Communication-Electronics RD&E Center (CERDEC) **Suzanne Weeks (732) 427-3275**

A07-079	Dual Band Infrared Coatings

A07-080	Ultra-High Temporal Resolution Laser Radar (LADAR) Receiver
A07-081	Persistent Surveillance in an Urban Environment
A07-082	Direct Patterning of Emitters for Micro-Displays
A07-083	Micro Patterned Electrically Variable Attenuation Filter
A07-084	Sensors, Signal and Image Processing for Threat Warning
A07-085	Improved Far-Target Location Accuracy for Man-portable Systems Through Application of GPS, Gyroscope, and Magnetometer Technologies
A07-086	Wideband Filter Networks for Joint Tactical Radio System (JTRS) Size, Weight, and Power (SWAP) Reduction
A07-087	Innovative Electronics Components and Circuit Designs for UHF RF Diplexer
A07-088	Improved Fault Management/Correlation for Tactical Networks
A07-089	Low Power High Performance Signal Processor for Joint Tactical Radio System (JTRS)
A07-090	High Efficiency, Low Power, Low Noise Amplifiers for SATCOM
A07-091	Enhancements for Military Ground Based GPS Receivers in Urban Environments
A07-092	Advancement of State of the Art Fuel Cell Technologies through Innovative Component Development
A07-093	Economical Power Source for Dismounted Soldier and Unattended Ground Sensor Missions
A07-094	Framework for Mobile Services
A07-095	Optical Character Recognition for Arabic Ruq
A07-096	Applied Innovative Nano-Materials Technology for High Energy Rechargeable Batteries, for Soldier Systems for Extended Missions in Combat Environments
A07-097	Multi-fuel Burner for Stirling Engine based on Innovative Component Development
A07-098	High Performance Uncooled Focal Plane Arrays
A07-099	Commercial Wireless Denial of Service (DoS) Mitigation Techniques
A07-100	Mobility to 802.16j - Mobile Multi-hop Relay Base Stations
A07-101	Low Profile Smart Multiple Beam Forming Antenna for KU-Band
A07-102	Cross-Layer Architectures, Semantics and Strategies (CLASS)
A07-103	Intelligent Software Agents for Autonomous Intelligence, Surveillance, and Reconnaissance (ISR) Analysis
A07-104	Low-Cost Tactical/Logistic Vehicle Real-Time Route Planning
A07-105	Connectivity, Continuity, and Data Initialization for BC Services
A07-106	Optimized Fusion Techniques for Signals Intelligence Collection Management
A07-107	Non Cooperative Combat Identification
A07-108	Human Intelligence (HUMINT) Soft-Target Identification and Tracking
A07-109	Blue Force Communications Compatible Antenna System
A07-110	Worldwide Interoperability for Microwave Access (WiMAX) Network Detector and Traffic Analyzer
A07-111	Countermeasures for Laser Activated Devices
A07-112	Activity Behavior Modeling Toolkit (ABMT) for Non-Traditional OPFOR (Opposing Forces)
A07-113	Innovative Electronic Counter-Counter Measure Techniques
A07-114	Low-Cost, Multi-Channel Arbitrary Waveform Generator
A07-115	W-Band Circular Electrically Scanned Array
A07-116	Smart Interviewing Tool
A07-117	Standoff Explosives Detection
A07-118	Visible and Near Infra-Red (VNIR) – Short Wavelength Infrared (SWIR) Hyperspectral Sensor
A07-119	Shortwave Infrared Solid State Silicon-Germanium Imaging Camera Development
A07-120	Body Wearable Diversity Antenna Systems for Increased Antenna Performance

Edgewood Chemical Biological Center (ECBC) **Ron Hinkle** **(410) 436-2031**

A07-121	Fabrication of Highly Conductive High Aspect Ratio Nanoflakes for Infrared Obscurant Applications

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

A07-122	Enhanced Standoff Detection of Personnel Intrusions using Seismic Sensors
A07-123	Novel Representations of Elevation Data
A07-124	Geospatial Database Generation Agents

A07-125	Passive Imaging Millimeter Wave Polarimeter System
A07-126	Optimal Intervisibility Site Selection
A07-127	Spatio-temporal data modeling
A07-128	Functionalization of Carbon Nanotubes into Materials with High Compressive Strengths
A07-129	Next Generation Urban Encroachment Models
A07-130	Microcontainment System for Photolytically Induced Delivery of Biocide Against Biological Agents
A07-131	Spatio-Temporal Evidential Reasoning
A07-132	Automated Condition Based Maintenance

JPEO Joint Tactical Radio Systems (JPEO JTRS) — **Grace Xiang (732) 427-0284**; **Brian Crawford (732) 427-3163**

A07-133	Bandwidth Management in QoS Environments Using Wireless Network State Information
A07-134	Small Aperture X-Band Antenna (SAXBA)

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

A07-135	MEMS Enhanced Laser Spectrometer for Ultra-sensitive Toxic Chemical Detection
A07-136	Technology for Detection of Chemicals in Extreme Environmental Conditions

Single Integrated Air Picture Joint Programs Office — **Windy Joy Majumdar (703) 602-6441 (ext. 253)**; **Christine Lee (703) 602-6441 (ext. 278)**

A07-137	Passive Angle Tracking in a Distributed Sensor Environment
A07-138	Characterizing Errors in Measurements Manually Extracted from Radar Video for use in Composite Tracking Processes

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

A07-139	Portable Digital Field Panoramic x-ray
A07-140	Maintain Dexterity During Cold-Weather Operations
A07-141	Human Hydration Status Monitor
A07-142	Development of Improved Therapeutics for Local and Systemic Inflammation
A07-143	Healthcare Interface Engine To Support Health Level Seven (HL-7), Version 3.0 Data Standard
A07-144	Automated Identification Technology System (AIT) to Identify, Track and Monitor the Condition of Medical Supply Items from Point of Origin to End User
A07-145	A Compact, Rugged, Mobile Automated Identification Technology Integrated Warehouse Scanning System for use in a Military Deployed Environment
A07-146	An Advanced Medical Robotic System Augmenting Healthcare Capabilities
A07-147	Rapid Production System for High Affinity Reagents Recognizing Protein Biomarkers
A07-148	Integrated Clinical Environment Manager
A07-149	Multiplexed Assay for the Detection of Wound-related Pathogens
A07-150	A Multiplexed Assay for the Detection of Pathogens of Military Importance in Sand Flies
A07-151	Personal Insect Repellent Device
A07-152	Field-deployable source of Carbon Dioxide for use in Vector Surveillance
A07-153	A Point-of-Care Assay for the Detection of Spotted-fever group and Typhus group Rickettsia
A07-154	Therapeutic/Prophylactic Use of Human Hyperimmune Polyclonal Antibodies for Neutralizing Staphylococcal and Streptococcal Exotoxins
A07-155	Enhanced Camouflage System Materials for Protection Against Arthropod-Borne Disease

Natick Soldier RD&E Center (NSRDEC) — **Dr. Gerald Raisanen (508) 233-4223**

A07-156	Strain Measurement System for Parachute Canopies
A07-157	Smart Small Arm Protective Inserts
A07-158	Constructive Simulation Representation of Ground Soldier
A07-159	Modeling Encumbrance Effects of Ground Soldier Systems on Soldier Performance
A07-160	Temperature Controlled Enhanced Human Remains Transfer Case
A07-161	Novel Interactive Insignia for Combat Uniforms
A07-162	Sub80 Container for Semi-perishable Rations
A07-163	Off-Grid Pallet Chilling for Bottled Water

A07-164	Lightweight, low-cost armor panels for installation in soft-walled shelters
A07-165	Flameless Personal Water Heater Using Battlefield Fuel (JP-8)
A07-166	Night Vision Enhancement Technology for Paratrooper Eye Protection Goggles
A07-167	Waste Management System for Chemical/Biological Protective Garments
A07-168	Development of Nuclear Protective Materials for Incorporation into Military Protective Clothing and Equipment

PEO Ammunition — **Robin Gullifer (973) 724-7817**; **Jessica Woo (973) 724-4908**; **Silva Manjikian (973) 724-9432**

A07-169	A High Speed Towed Magnetic Array for In-Road Detection of Improvised Explosive Devices Employing Optimized Magnetic Map Differencing
A07-170	Innovative Propulsion Methods for Small Arms Projectiles

PEO Aviation — **Rusty Weiger (256) 313-3398**

A07-171	Advanced Torque Measurement Systems for Main and Tail Rotors
A07-172	Small Light-Weight Precision Localization and Geo-registration System

PEO Command, Control & Communications Tactical — **Grace Xiang (732) 427-0284**; **Brian Crawford (732) 427-3163**

A07-173	Tactical Intra-Vehicle Information Bus (TIVIB) for command and control applications
A07-174	Materials for Combustion Enhancement in a 100 kW Power Unit

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

A07-175	Control Strategies for Advanced Military Diesel Engines
A07-176	Advanced System Level Durability Analysis, Prediction and Optimization

PEO Ground Combat Systems — **Jim Mainero (586) 574-8646**; **Martin Novak (586) 574-8730**

A07-177	Development of Reactive Reflector Technology for Vehicle and Crew Protection from Blast of Landmine and Improvised Explosive Device (IED)
A07-178	Multi-mechanism, Mine Blast Protection

PEO Intelligence, Electronic Warfare & Sensors — **John SantaPietro (732) 578-6437**; **Rich Czernik (732) 578-6335**; **Debbie Pederson (732) 578-6473**

A07-179	Intelligence, Surveillance & Reconnaissance (ISR) Net-Centric Workflow
A07-180	Radar on a Chip

PEO Missiles & Space — **James Jordan (256) 313-3525**; **George Burruss (256) 313-3523**; **Robin Campbell (256) 313-3412**

A07-181	Miniaturized North Finding Module

PEO Soldier — **King Dixon (703) 704-3309**; **Jason Regnier (703) 704-1469**

A07-182	Modeling and Simulation Method to Analyze the Aerodynamic Performance of Paratroopers in Military Free fall Operations
A07-183	Accessory Rail Communication and Power Transfer

PEO Simulation, Training, & Instrumentation — **Paul Smith (407) 384-3826**

A07-184	High Speed Wireless 3-D Video Transmission to Support Virtual Dismounted Training
A07-185	Battlefield Effects for Live Embedded Training

PM Future Combat Systems Brigade Combat Team — **Frank Duriancik (703) 676-0030**

A07-186	Non-Destructive Evaluation (NDE) and Testing of Ceramic Armor

Space and Missile Defense Command (SMDC)		**Dimitrios Lianos**	**(256) 955-3223**
A07-187	Phase Transition Explosive Driven Pulsed Power Generators		
A07-188	Power Conditioning for Explosive Pulsed Power for Missiles and Munitions		
A07-189	Characterization of Cloud and Storm Ice/Hail/Graupel Concentrations and Its Impact on High Speed Missile System Performance		
A07-190	Reduced Eye Hazard Wavelength High Energy Laser Technology		
A07-191	Photonic Crystal Development for High Power Lasers		

Simulation and Training Technology Center (STTC)		**Thao Pham**	**(407) 384-5460**
A07-192	Embedded Virtual Driver Training Technologies		
A07-193	Battlespace Target Presentation in the Live Training Environment		
A07-194	Modeling Human Interfaces and Behaviors in Dismounted Soldier Training Environments		
A07-195	High Fidelity Visual Representation of Crowds		

Tank Automotive RD&E Center (TARDEC)		**Jim Mainero**	**(586) 574-8646**
		Martin Novak	**(586) 574-8730**
A07-196	Situational Awareness and localization through Road Signage Recognition for unmanned systems		
A07-197	Modeling, Simulation, and Design Optimization of Nanocomposites for Applications in Army		
A07-198	Reconfigurable Structures for Future Force/Future Combat System (FF/FCS) and Joint Force Bridging Applications		
A07-199	Advanced Electromechanical Track Tensioner		
A07-200	Vehicle Based Exportable Power		
A07-201	Tracers in Armor Ceramics		
A07-202	Advanced Technologies to Improve Fire Resistant Fuels		
A07-203	Rapid Field Test Method(s) to Measure Additive Concentrations in Military Fuel		
A07-204	Develop Aluminum Metal Matrix Components (Al MMC) and Manufacturing Applications for both Military and Commercial Vehicles		
A07-205	Accelerated corrosion simulation and Modeling		
A07-206	Detection of Magnetic Signatures of Ground Vehicles Using Spin Wave Generation in Magnetic Films		
A07-207	Development of an Advanced Heat Exchanger		
A07-208	Development of small fuel efficient multi-fuel capability engine		
A07-209	Designed-by- Reliability Zero-Maintenance Air Filtration System		
A07-210	Control of High Speed Unmanned Vehicles		
A07-211	Autonomous, Real-time, 3D Change Detection System		
A07-212	Application of Spot Cooling Technologies for the Thermal Management at the Source		
A07-213	Non Focal Plane Laser Protection Technologies		
A07-214	Innovative Simulation and Analysis Tool for Vehicle Thermal Management		
A07-215	Develop Smart Material Technology for improved Protection of Vehicles		
A07-216	Determination of Human Injury Mechanism, Mechanical Response and Tolerance for Improved Virtual and Physical Biomechanical Test Devices for Vehicle Crashworthiness Applications in Rollover Crash Scenarios		
A07-217	Self Contained Two-Phase Thermal Management System		
A07-218	Nano-material Conducting Wires With Enhanced Electric/Thermal Conductivity and Mechanical Strength		

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 3.4 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 (including attachments, appendices, or references, but excluding the Cost Proposal and Company Commercialization Report) will not be considered for review or award.

____ 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 Cost Proposal form on the Submission site has been filled in electronically. The total cost should match the amount on the cover pages.

____ 6. If applicable, the Bio Hazard Material level has been identified in the technical proposal.

____ 7. If applicable, plan for research involving animal or human subjects, or requiring access to government resources of any kind.

____ 8. 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.

____ 9. 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 07.2 Topic Descriptions

A07-001 TITLE: Small UAV High-speed Obstacle and Collision Avoidance

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

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

OBJECTIVE: Develop low size, weight, and power obstacle and collision detection system for small UAVs that allows flight at speeds near maximum maneuvering speeds for the platform as it navigates in complex environments performing obstacle avoidance.

DESCRIPTION: One of the biggest challenges for autonomous UAVs is the ability to ably and safely navigate in complex environments such as inhabited urban areas and mountainous regions or in the vicinity of other aircraft. Current technologies limit the velocities at which UAVs can travel in such complex environments. A slow UAV is not a very survivable UAV. Current technologies also are too large and require more power than typically allowable on small UAVs. These factors limit the potential that exists for using small UAVs at their most appropriate best: agile maneuvering in complex environments.

This effort will investigate and advance the ability of current and developmental technology to permit small UAVs (rotary wing or fixed wing) to detect obstacles and other moving aircraft while navigating in complex terrain without having to reduce flight speeds to accommodate detection system latencies. The challenge is for the sensor systems as well as detection and processing algorithms to support navigation in the vicinity of obstacles at platform speeds as dictated by the mission similar to what would have been permissible in the absence of obstacles.

The proposed system could use GPS position information, terrain data to identify areas of probable obstacles complemented by use real-time higher resolution visual (Electro-Optical/Infra-Red, LADAR, Synthetic Aperture Radar, etc.) and non-visual (RF, Acoustic, etc) data to detect stationary as well as moving obstacles in its path. The stationary and moving obstacle detection method must support route deconfliction with other non-cooperative manned and unmanned aircraft traveling at speeds in the same order of magnitude as the host UAV. An approach that integrates the detection system to a near-horizon route planning approach that would enable it to execute the avoidance maneuver autonomously would be highly desirable, although it is not a requirement of this solicitation.

The design space for this concept is focused primarily on small rotary wing platforms although it does not exclude fixed wing applications. The nominal range of operations would allow flight speeds of 50mph at altitudes ranging from nap-of-the-earth to 10,000ft. The payload capacity of the platform may be assumed to range from as small as 2 lbs to about 30 lbs for a larger platform. The power available may be assumed to be in the range of 10’s of watts; 100W would be considered higher than desired.

The key technical challenges that will be the focus of this effort include: 1. Low cost, low weight and low power sensor systems to detect moving and stationary obstacles. 2. Low latency data processing to enable flight at or near maximum maneuver speeds platform is capable of in executing required mission.

PHASE I: Through Trade Studies identify appropriate sensor and software algorithmic technology that can be used/developed and integrated on small UAVs that will permit high speed obstacle avoidance in a complex environment without limiting platform maneuvering speeds. Conduct proof of concept assessment of any critical technologies.

PHASE II: Using simulation and other test facilities continue to develop and refine obstacle detection approach. 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 a core need for the Army's FCS (Future Combat Systems) goals and similar related defense systems. The lower size end of the spectrum is expected to be dominated by rotary wing UAVs used in urban and nap-of-the-earth operations. At the higher size end of the scale, the application envisioned is for see-and-avoid flight capability in civilian or restricted airspace for small fixed wing UAVs as well as fully autonomous military operations in complex terrain such as higher elevation mountainous terrain. The transition to these applications will be paced by the extent to which the technology miniaturizes in terms of size, weight and power, supports high speed maneuvering by reducing processing latencies, and conforms to interoperability standards and airspace management needs consistent with the wider aviation community practices. This technology has potential commercial applications in the areas of intelligent transportation, disaster relief, and homeland security. Beyond these it could enable a vast assortment of new and unanticipated applications in both the commercial and military domains.

REFERENCES: 1) Visual Servoing for Tracking Features in Urban
Areas Using an Autonomous Helicopter, http://cres.usc.edu/pubdb_html/files_upload/474.pdf
2) Aerial Robots: Airframes, Sensing and Navigation, Paul Y. Oh, Drexel University – Mechanical Engineering - http://www.wtec.org/robotics/us_workshop/June22/Aerial-robots-paul-oh.pdf

KEYWORDS: UAV, Unmanned Aerial Vehicles, Autonomous, Navigation, Obstacle Avoidance, Visual Odometry, Algorithms, GPS, Global Positioning System, Obstacle Avoidance, Algorithms, deconfliction.

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A07-002 TITLE: Novel Passive Technologies for Improved Helicopter Rotor Performance

TECHNOLOGY AREAS: Air Platform

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

OBJECTIVE: Develop innovative passive rotor blade technologies that improve helicopter rotor performance, reduce rotor vibration levels, and reduce rotor noise signatures.

DESCRIPTION: Recent work in advanced rotor blade development has been focused on on-blade active controls such as trailing edge flaps and active twist blades. Current active rotor actuators lack the authority to realize the full potential of smart rotor controls. Research in innovative passive technologies has the potential to augment the aero performance of future passive/active hybrid rotors, thus reducing the authority requirements of the active blade actuators. There are no known current applications of passive technologies to purposefully help the limited authority (stroke and force) of active rotor actuators. Potential passive technologies include, but are not limited to, aeroelastically tailored rotor blades to exploit couplings available with composite materials, advanced blade planforms and or tip shapes, and advanced airfoils such as slotted or multi-element.

PHASE I: Demonstrate the feasibility of an innovative passive technology through bench top tests that are representative of typical rotor blade loading conditions. Analytical or computational models (new model development is not required), such as any comprehensive code (for example CAMRAD, Comprehensive Analysis and Modeling of Rotor Aerodynamics and Dynamics, Reference 1), or any simple blade element momentum code, could be used to address how the proposed passive technology affects the following quantifiable performance metrics: hover efficiency, forward flight efficiency, maximum blade loading, rotor vibration level, and rotor noise level.

PHASE II: Demonstrations of appropriately scaled passive rotor blade prototypes should be conducted in Phase II to show the improved aero performance of the proposed passive technology. Among the issues to be investigated for the passive technologies concepts proposed are cost, aeromechanical stability, reliability, reparability, maintainability, producibility, fatigue life, added weight, and compatibility with and performance augmentation to active rotor designs. Typical Army operating environmental conditions such as a wide temperature range, icing, rain and sand should be considered for the proposed passive rotor blade concept. The scalability (helicopter size classes from light utility/scout to heavy lift) of any proposed solution should be considered, as well as its potential to be retrofitted to current Army rotary-wing platforms.

PHASE III: This phase should complete the passive technology development. System integration, wind tunnel testing, and flight tests should be conducted to demonstrate the potential applications of the passive technology approach to all manned and unmanned rotorcraft, including commercial helicopters. The passive technology developed will have applications to both existing DoD and civilian rotorcraft. If successful, further refinement and full-scale demonstration of a passively augmented active rotor system will take place through transition into an Army Platform Technology 6.3 program for which there is sufficient funding beginning in FY08, and continuing through the POM. After thorough refinement and testing the new system would transition into operational use by implementing the technology onto the AH-64 and UH-60 platforms, as well as onto other legacy and future rotorcraft platforms.

REFERENCES: 1. Johnson, W., "Development of a Comprehensive Analysis for Rotorcraft: I-Rotor Model and Wake Analysis", Vertica, Vol.5(2), 1981, pp.90-130.
2. Bao, J., Nagaraj, VT, Chopra, I. and Bernhard, A., “Development of a Low Vibration Mach Scale Rotor with Composite Couplings”, 58th American Helicopter Society Forum, Montreal, Canada, June 2002.
3. Lake, R.C., Nixon, M.W., Wilbur, M.L., Singleton, J.D., and Mirick, P.H., “A Demonstration of Passive Blade Twist Control Using Extension Twist Coupling”, NASA Tech Memo 107642/USAAVSCOM Tech Report 92-B-010, June 1992.
4. Nixon, M.W., Piatak, D.J., Corso, L.M., and Popelka, D.A., “Aeroelastic Tailoring for Stability Augmentation and Performance Enhancement of Tiltrotor Aircraft”, 55h American Helicopter Society Forum, Montreal, Canada, May 1999.
5. Narramore, J.C., “Slotted Rotor Configuration for Improved Tiltrotor Performance”, American Helicopter Society 4th Decennial Specialist Conference on Aeromechanics, San Francisco, CA, January 2004.
6. Sekula, M.K., Wilbur, M.L., and Yeager, W.T., “A Parametric Study of the Structural Design for an Advanced Active Twist Rotor”, 61st American Helicopter Society Forum, Grapevine, TC, June 2005.
7. Sekula, M.K., Wilbur, M.L., and Yeager, W.T., “Aerodynamic Design Study of an Advanced Active Twist Rotor”, 4th American Helicopter Society Specialists Conference on Aeromechanics, San Francisco, CA, January 2004.

KEYWORDS: passive technology, advanced rotor blades, composite materials

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A07-003 TITLE: Environmental Sensor for Autonomous UAVS

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop a suite of micro/small sensors to measure weather and environment conditions to support optimal sensor utilization and enhanced navigation on autonomous small UAVs.

DESCRIPTION: One of the keys to making UAVs and various other robotics platforms more autonomous is to make them more aware of the environment they operate in. The ability for autonomous UAVs to plan optimum utilization of their sensors for surveillance and recon missions in adverse weather conditions is dependent on how well the system can characterize dust, fog, haze, local obscurants, and rain and communicate that to the planning system in real-time and in a manner useful to the autonomy system. If possible the system needs to characterize and potentially map environmental condition directionally to where the sensor can characterize the regional fluctuations. Current weather monitoring technology is limited to large meteorological weather UAVs and to fixed-ground operation for obscurants and general weather conditions for using a variety of radar and optical sensors.

This effort would build upon and expand the functionality of the autonomous UAV behaviors developed under the Army's Unmanned Autonomous Collaborative Operations (UACO) Program. One of the contractors, under their own funds integrated into Part 1 of their UACO software, a constraints-based system that calculates optimum sensor range and settings based on environmental conditions and operational requirements. The system is designed to modify a UAV’s route and sensor control parameters to keep the same sensor probability of detection, contrast level, footprint size, and/or coverage rates, etc. when the visibility changes due to haze or fog and lighting conditions. The development of a sensor to measure and parameterize weather in the local vicinity of a UAV would enable an autonomous UAV to react in real-time to changing weather conditions.

This effort will focus on developing a small light weight sensor system with the ability to measure and analyze environmental conditions. Initially the purpose will be to develop a system to determine weather related effects impacting EO/IR sensor utilization and target recognitions systems. As a minimum, the following basic weather effects should include: ambient light levels, atmospheric visibility, and relevant information as to the type (rain, dust, fog, smoke, etc.) and nature (density) of atmospheric obscurants. If possible the ability for the system to map weather in 3D and track changing weather conditions with sufficient detail that automated planners can route around adverse weather. Additionally, the offeror needs to identify key technologies that ultimately might go into a more generalized weather /environmental monitoring system to support wider UAV, manned aviation, and battlespace planning needs. The sensor system needs to be able to work day and night as well as in adverse weather. Also, the ability to feed weather monitoring systems like the Army’s Integrated Meteorological System (IMETS) throughout the battlespace can have significant advantages in all planning systems. Key to making this type of sensor systems practical for the various UAV applications is to keep its weight, size, and power to only a fraction the basic sensor package. What this means is that the system on a Raven size UAV may be limited to a few ounces at most while a large UAV (Hunter, Fire Scout) might be able to carry a sensor system over 10 pounds. Needless to say the capabilities and range of environmental parameters will vary depending on the application vehicle. For this effort, a sensor system that can detect the basic weather effects listed above and that minimizes size, weight, and power is the highest priority and a system applicable to smallest UAVs is desirable.

PHASE I: Develop a core concept to measure weather and environmental conditions impacting the effectiveness of EO/IR sensors and conduct proof of technology demonstration as needed. Conduct a trade study to identify which sensor technologies are most applicable to small UAV systems as far as size, power, weight, and packaging to perform sensing and analysis in real-time of the environment as it impacts sensing, flight dynamics, and navigation functions.

PHASE II: Select the sensor(s) that was identified in phase 1 trade study and conduct any proof of principle tests needed to determine the full suite of weather sensors. Develop and integrate sensors and weather analysis software in a bread board prototype system. Conduct testing to validate the prototype environmental sensing system’s ability to measure changing weather conditions and appropriately characterize them in a manner meaningful for the on-board planning system.

PHASE III: This system should give the UAV additional all weather capabilities and enhance their autonomy. This system could be incorporated into a wide variety of applications to current and future Army UAVs, to include Raven, Shadow and most FCS vehicles. This technology would have application to any intelligent UAVs where weather can significantly impact the outcome of the sensor utilization or flight path planning. Applications include anywhere a UAV might be used to automatically detect specific vehicles or people for security purposes, such as police, homeland security, and any recreational event over unprepared sites (i.e. where it has no inherent surveillance capability). It also would have application to activities where varying weather conditions are important to monitor such as fighting forest fires or crop dusting fields. Beyond these it could enable a vast assortment of new and unanticipated applications in both the commercial and military domains.

REFERENCES: 1) AF Studies: New World Vistas; Sensor Volume; 5.0 Illustrative Sensor System Concepts pg59-, 1997; <http://www.au.af.mil/au/awc/awcgate/vistas/sench5.pdf>
2) Odom, Maj Earl "Duke", USAF, "Future Missions for Unmanned Aerial Vehicles, Exploring Outside the Box"; 3 June 02, Aerospace Power Journal, http://www.airpower.au.af.mil/airchronicles/apj/apj02/sum02/phisum02.html>
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5) Sudhakar Y. Reddy, Kenneth W. Fertig, David J. McCormick, "Constrained Exploration of Trade Spaces," SMCIT2006, Pasadena, CA, 2006, also available at, http://www.teledyne-si.com/designsheet/.

KEYWORDS: UAV, Autonomous, Navigation, Weather, environmental monitoring, Algorithms, perception, planning, obscurants, optimization

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A07-004 TITLE: Variable Turbine Technologies for Improved Part Power Performance

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: The Program Objective is to develop and validate, via test, variable turbine technologies (includes fluidic or mechanical devices/concepts) for improved part power turboshaft engine performance.

DESCRIPTION: Advanced turboshaft engines are required to support Army Future Force Rotorcraft (Apache, Black Hawk, ARH, Future Combat System UAVS, etc.). It is anticipated that this will involve new centerline engines with a 20-35% reduction in specific fuel consumption (SFC), a 50-80% improvement in shaft horsepower to weight, and a 35-50% reduction in production cost. These turboshaft engine goals are acknowledged to be highly aggressive. To achieve them will require technology leaps. Another very important aspect of these turboshaft engines is that excellent part power performance is required where significant time at cruise (part power) conditions is typically required and where time-on-station and range requirements will be stringent. Reduced specific fuel consumption at cruise and loiter conditions is especially crucial with the ongoing directives to reduce the required fuel on the battlefield. The objective of this topic is the development and validation of variable turbine component technologies that are innovative, unique and offer significant performance payoff at part power. The major component sections of a turbine engine consist of the compressor, combustor, turbine, mechanical systems, and controls/accessories. This topic is directed at only those technologies that are physically part of the turbine section of a turboshaft engine. Such technologies could involve advanced flow control concepts, advanced clearance control concepts, novel mechanical devices, or any other turbine component technology that has potential to significantly improve part power specific fuel consumption. This will result in advanced objective force rotorcraft that can operate economically over a large power range for both cruise and full power conditions.

PHASE I: Establish the feasibility of proposed technology to improve part power performance (i.e., specific fuel consumption) of advanced turboshaft engines.

PHASE II: Further develop and validate the technology through design, fabrication and testing on representative turboshaft engine components.

PHASE III: Commercialize the technology through integrating the developed system into multiple engine manufacturers' military engine development efforts to improve turbine engine efficiency at part/cruise power and reduce fuel consumption. Also integrate into engine manufacturer's future turbine engines to reduce specific fuel consumption by 20-35%, improve shaft horsepower to weight by 50-80% and reduce production costs by 35-50% 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 one of Utility Helicopter Project Office's top two SBIR endorsements and is needed to lead to an improved engine to support UH-60M Block-2 and meet Future Combat System (FCS) external lift requirements.

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2) Culley, Dennis E., "Variable Frequency Diverter Actuation for Flow Control," AIAA–2006–3034 (NASA/TM—2006-214396), 3rd Flow Control Conference, San Francisco, California, June 5–8, 2006

KEYWORDS: Gas Turbine Engine, Turboshaft Engines, Turbine, Part Power Performance, Unmanned Aerial Vehicles, Rotorcraft

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A07-005 TITLE: Automated 1/rev Rotor Vibration Control

TECHNOLOGY AREAS: Air Platform

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

OBJECTIVE: Develop a system that can automatically adjust rotor mass balance and blade track equivalent to adjustments currently made with balance weights, pitchlink adjustment and tracking tabs bending for helicopter rotors.

DESCRIPTION: Significant maintainance activity is required to ensure acceptable 1/rev vibration levels from main and tail rotors. These flight and ground based maintainance activities translates into significant cost and downtime for the helicopter operator. Cost has been somewhat mitigated with the use of on-board systems with computerized diagnostic algorithms. These algorithms yield rotor tuning adjustments derived from measured fuselage vibration and blade track data to reduce vibration to an acceptable minimum. The result is better ride comfort which translates into minimized pilot fatigue, and better helicopter and helicopter component life. The rotor tuning adjustments that are typically used are blade pitchlink length adjustment, blade trailing edge tab angle adjustment, and overall rotor weight balance adjustment. These adjustments are manually interpreted and implemented by maintainers in a relatively inefficient way that is time consuming and sometimes prone to error. Methods of implementing rotor tuning adjustments in an automated manner are sought.

Recent efforts to develop active on-blade control have provided interesting actuator and control mechanisms. Typically these systems have been selected for high frequency requirements to improve performance, vibration and acoustic helicopter rotor characteristics. These efforts have non-the-less provided technology that may be benificial or directly applicable to the control of 1/rev vibration. Ultimately an overall system is desired that would enable relation of the results of the computerized diagnostic algorithm to the automated rotor adjustment implementation system in an automated way such that the changes are made in a quick, efficient, accurate, repeatable, and error free manner.

PHASE I: The proposer should design a system for reducing 1/rev vibration equivalent to adjustments currently made with balance weights, pitchlink adjustment and tracking tabs bending for helicopter rotors. Bench testing of proposed actuators is recommended.

PHASE II: The proposer should build a proof of concept system and demonstrate automated track and balance adjustments in a wind tunnel, whirl stand or lab environment.

PHASE III: Further develop the system as a desired product. The vision is an automated system with sufficient authority to dramatically reduce the track and balance maintenance activities. Application potential for UH-60, AH-64, CH-47, other DoD rotorcraft,and commercial helicopters. Transition path potential may include helicopter manufacturers, DoD Program Managers, or other interested parties.

REFERENCES: 1) R. J. van der Harten, "Operational Viewpoint on Control of One-Per_Rev-Vibrations," NASA SP-352, Rotorcraft Dynamics, Feb 1974, pp
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2) M. Revor and E. Bechhoefer, "Rotor Track and Balance Cost Benefit Analysis and Impact on Operational Availability," AHS International 60th Annual Forum and Technology Display, Baltimore, Maryland, June 2004.
http://www.vtol.org/index.html

KEYWORDS: rotor track and balance, 1/rev vibration

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A07-006 TITLE: Advanced Active Vibration Control of Helicopters

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop effective control algorithms for Active Vibration Control (AVC) systems, especially for reduced helicopter vibration during maneuver transients and gust disturbances. Apply modern adaptive control design concepts to improve the effectiveness and robustness of AVC. Reduced rotorcraft vibration improves crew comfort, reduces pilot fatigue, and increases the life of electronic components.

DESCRIPTION: Active Vibration Control (AVC) is currently used to reduce helicopter vibration, using a number of fixed-system, narrow band force generators to reduce the acceleration measured at multiple locations in the aircraft fuselage. These systems currently use adaptive, frequency-domain, plant model based (T-matrix) controls, a form of minimum variance controls applied to disturbance rejection. The present systems are effective at reducing vibration in steady-state flight conditions, provide appropriate adaptation for aircraft configuration changes (e.g. weight, center of gravity, and rotor speed), and can adapt to varying flight conditions (especially flight speed). Current algorithms, however, fail to adequately suppress transient vibration, particularly during low speed approaches, Nap Of the Earth (NOE) flying, flare to hover, and some Navy vertical replenishment (VERTREP) maneuvers.

It is believed that existing adaptive plant model based methods do not have sufficient control authority and bandwidth to adequately reduce transient vibration. In particular, the present control algorithms have excessively low gains to avoid instabilities caused by plant model errors and signal processing time lags.

Advanced AVC control algorithms are needed for improved reduction of transient vibration. A controller is sought that uses classical or modern control theory, either in the frequency- or the time-domain. Particular emphasis is needed on the effective reduction of narrow band, random disturbances, with a bandwidth of 1 Hz. Methods must allow larger gains for increased effectiveness, especially for disturbance rejection, while also providing increased robustness to modeling errors and guaranteeing stability. Improved models of the pilot, environment, and helicopter may be developed, especially those which provide predictive capabilities to reduce control delay. Improved pilot command and helicopter response measurements may also be considered. Any selected method must be computationally efficient, with a minimum control update rate of once per rotor revolution.

Reduced rotorcraft vibration improves crew comfort, reduces pilot fatigue, and increases the life of electronic components. Advanced control algorithms are needed to improve the effectiveness of AVC, especially in transient flight conditions. If this project is successful, the resulting control algorithms will likely be incorporated into future military and civilian rotorcraft.

PHASE I: Develop a few multi-input, multi-output control algorithms, appropriate to the needs of AVC. Develop a simplified rotorcraft model, which captures key aspects of transient flight. Perform preliminary optimization of the new control algorithms, and compare their performance against that of traditional plant model based controls. Suggest promising control algorithms for future study. The key metric for evaluation is the ability of the controller to suppress vibration during transient maneuvers where the bandwidth of the random disturbance is 1 Hz.

PHASE II: Develop one or two control algorithms in full detail. Develop a full-fidelity, validated, comprehensive rotorcraft model for the prediction of helicopter transient flight, including gusts and maneuvers. Ensure that proper modeling is included for the entire control system, accounting for issues such as computational processing delays, actuation delays, plant modeling errors, and noise. Fully optimize each control algorithm, and compare its performance against adaptive, plant model based controls. Add additional control algorithm features as needed to provide the needed effectiveness, robustness, and stability. Recommend an advanced control algorithm, including its baseline parameters, and quantify its performance.

PHASE III: Work with one or more helicopter prime manufacturers, and/or military acquisition program (PM/PEO), to identify system integration and certification issues particular to certain helicopters or programs. Develop the system to address integration and certification issues common to many aircraft. Provide system demonstrations for aircraft not modeled in Phase II. If this project is successful, the resulting control algorithms will likely be incorporated into future military and civilian rotorcraft. If the resulting control algorithms are sufficiently innovative, they may be applicable to a wide variety of other systems, both military and commercial.

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KEYWORDS: helicopter, rotor, rotorcraft, active vibration control, higher harmonic control (HHC), T-matrix, classical control theory, modern control theory, feedback control, robust, stability, comprehensive analysis, flight control simulation, fuselage, algorithm, maneuver, transient, vertical replenishment (VERTREP).

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A07-007 TITLE: Innovative Rotor Blade Anti-Icing/De-Icing Technologies

TECHNOLOGY AREAS: Air Platform

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

OBJECTIVE: To develop a practical and innovative alternative to existing electrothermal rotor blade de-icing systems to enhance the capability to operate in adverse icing conditions. This effort should focus on non-electrothermal anti-icing/de-icing technologies that prevent/eradicate the formation of ice on the rotor blade and avoid the problems of the current electrothermal de-icing systems.

DESCRIPTION: Icing conditions limit the environment in which rotorcraft can operate. Only two Army rotorcraft are equipped with de-icing systems to remove ice from the rotor blades: the UH-60 Black Hawk and AH-64A Apache. The de-icing systems on these aircraft are electrothermal, where blade leading edges are heated by wires embedded in the leading edge composite under the titanium wear strip. Wires burn out, and if controllers fail, leading edges can overheat, causing damage to composites and blade delamination. Leading edge damage from excessive heat has been a problem for the Apache AH-64A (see Reference 1). Because of its unreliability and demanding power requirements, the system is typically never used and, in some cases, is permanently disabled. In addition, the Operator's Manual for the UH-60 Black Hawk states that blade de-ice operation with erosion strips installed may cause blade damage. At present, icing causes mission delays during ground de-icing of aircraft and mission cancellations and abortions because of forecasts or actual in-flight icing. The common notion, however, is that icing is “not a problem” for Army aviators because they generally “do not fly in icing,” even though Army Safety Office data reveals that it occurs remarkably often and is the likely cause of millions of dollars in damage and loss of life (see Reference 1).

The objective of this effort is to develop a practical and innovative alternative to existing electrothermal rotor blade de-icing systems to enhance the capability to operate in adverse icing conditions. Other non-electrothermal methods have been used or tested, and while effective, each has had their own share of limitations. For instance, the Pneumatic Boot, similar to that found on some fixed-wing aircraft, requires a high increase in torque in order to function. The Fluid Anti-icing system is limited by the amount of fluid that the rotorcraft is able to carry, resulting in very short operational time. However, there are other promising technologies that could lead to potential non-electrothermal solutions. For example, electro-impulse de-icing requires only a small amount of power and uses a magnetic field to create repulsive forces and expel the ice. Another example is electro-vibratory de-icing, which also requires only a small amount of power in order to shake the blade at its natural frequency, causing the ice to detach. A final example is a high frequency microwave de-icing system, in which energy is radiated from inside the blade to the ice on the outside. These examples are given to illustrate possible promising solutions and are not intended to limit other innovative methods.

This effort should focus on non-electrothermal anti-icing/de-icing echnologies that prevent/eradicate the formation of ice on the rotor blade and avoid the problems of the current electrothermal de-icing systems, as well as overcoming deficiencies in other existing non-electrothermal systems. Any resulting system must be fully integrated within the rotor blade and must be able to function under rotorcraft flight conditions. Among the issues to be considered and investigated for the non-electrothermal anti-icing/de-icing concepts proposed are: weight, required power, effects on rotor performance, cost, maintainability, reliability, and ease of integration into legacy and future rotorcraft designs. If anti-icing coatings are proposed, the ability to withstand sand and rain erosion should also be addressed. The Army desires an alternative system that can meet the goal of reducing failures of current electrothermal de-icing systems by 80%.

PHASE I: Develop non-electrothermal rotorcraft anti-icing/de-icing technology concepts. Conduct proof-of-concept testing in order to demonstrate feasibility.

PHASE II: Non-electrothermal anti-icing/de-icing technology concepts will be advanced from lab components to a representative prototype system configuration, including appropriate considerations for limiting weight, space, and power requirements. The non-electrothermal anti-icing/de-icing technology should be demonstrated in a relevant ambient environment, such as an icing tunnel or any other appropriate laboratory conditions, preferably on an applicable rotorcraft structure. A prototype system should also be tested in order to demonstrate functionality under typical helicopter dynamic loads.

PHASE III: This phase should complete non-electrothermal anti-icing/de-icing technology system development and integration to demonstrate the potential applications to all rotorcraft, both military and commercial, manned and unmanned. The end-state of the research should provide a matured system that can transition into an Army Platform Technology 6.3 program. It is expected that the 6.3 program will consist of technology concept definition, technology development, and technology demonstration that will include a full-scale system demonstration on a currently fielded rotorcraft platform, such as Blackhawk or Apache, in the flight environment. De-ice/anti-ice capability would likely be demonstrated by a component test in an icing tunnel. Successful completion of the full-scale demo and icing tunnel tests will characterize key performance demands of the system, and will enable the technology implementation of the system into the Army's fielded rotorcraft fleet.

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2. The Icing Branch at NASA Glenn Research Center. Documents, presentations, images, and videos available at: http://icebox-esn.grc.nasa.gov/ext/resources/resources.html

3. Jeck, Richard K. "Snow and Ice Particle Sizes and Mass Concentrations at Altitudes up to 9 km (30,000 ft)." DOT/FAA/AR-97/66. August 1998. Report available at: http://aar400.tc.faa.gov/acc/accompdocs/97-66.pdf

KEYWORDS: anti-icing, de-icing, rotor, blade, icing

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A07-008 TITLE: Smart Autonomous Miniaturized Contamination Condition Sensor with Embedded Prognostics

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Design, build and demonstrate an autonomous miniaturized contamination sensor system with built-in prognostic capability, applicable to rotary and fixed wing platforms to improve unit's operation downtime.

DESCRIPTION: The Army has on the average of 4 to 6 (UH-60 uses six, AH-64 uses four) pop-up indicators to monitor the health of filter clogging on almost all the legacy aircraft, both rotary and fixed wing. It is a key indicator of the health of the aircraft fluid, which powers flight critical items such as flight actuators and pumps, etc. These devices are not very reliable based on field checks conducted by the Army Hydraulics Integrated Product Team on various platforms. The problem is universal. The devices are easily tampered with, resulting in false alarms or no alarms to the maintainer of aircraft. If the device is inoperative, the aircraft maintainer will not be able to assess contamination levels and perform maintenance actions to prevent impending failures in time. The current purely mechanical condition indicator device is at least a 40 year old design, which uses bi-metal springs that act as detents to prevent false readings during cold start-up conditions. These bi-metallic springs have a history of becoming weak and inoperative due to high operating temperatures. This results in false alarms. This phenomenon has been confirmed on some models from field-returned units.

The current fielded sensors are sensitive to vibration and shock, which cause false alarms and result in unscheduled maintenance, which increases costs and impacts mission readiness. The sensor also has high hysteresis that may cause premature or no alarm signals, and may expose critical components to high contamination levels.

A system design containing smart MEMS technology for contamination condition sensing and self diagnostics may reduce operating costs on aircraft. Approximately 80% of pump and hydraulic component failures are due to higher contamination levels and this fact is validated by many industry experts both in aerospace and industrial markets. Army's own 2410 data indicate 59% of failures are due to leaks which generally can be attributable to high temperature and contamination. The Army spends over $71M/year on all rotary aircraft models for key critical hydraulic components (based on 2005 CCSS data for the UH-60 and AH-64 helicopters). It is conceivable that a MEMS-based prognostic device could reduce maintenance expenses 20-30% per year which translates to potential savings of over $8M/year for UH-60 and over $3M for AH-64.

Current MEMS-based technology has the potential to provide more reliable indicators on impending failures resulting in improved mission readiness and usable prognostic data. The problem is that there is not a single device readily available that is miniaturized with smart diagnostic features and battery operated, which can be used on legacy aircraft without interfering with the current wiring harnesses. The device most also add no additional burden on the pilot or maintenance mechanic. The sensor system must be able to store 1000 hours of operation data. This will to assist in developing a maintenance and repair schedule strategy based on the fluid, temperature, pressure and readings correlated to specific time stamps during aircraft operation. MEMS sensors that log pressure differentials over extended periods provide clues to the rate of degradation of filters in relation to flying environments the aircraft has been in, and rate of wear for pumps and other components. Currently, this information is not readily available to the maintainer of aircraft.

Critical parameters on hydraulic system temperatures and pressure differentials must be monitored over time and down loadable via either wireless or removable storage devices for more thorough analysis of anomalies and unusual conditions one may encounter in the battlefield.

The benefits are numerous with new miniaturized technology to address the deficiencies and capability gaps identified above. MEMS-based sensors are more reliable and compact in size and can potentially withstand harsh operating conditions and higher temperatures as opposed to conventional technology devices currently in use. One of the technology challenges and benefits associated with energy-efficient smart sensors is the ability to operate with or without power from aircraft. The proposed design must result in a removable, non-interference fit on current MIL-F-8815 filter housings makes to facilitate demonstration without interfering with the current control architecture on aircraft.

PHASE I: 1. Develop preliminary requirements for a sensor and algorithms based on bench test data and available smart sensors.

2. Investigate/develop prognostic algorithms based on bench tests and interface solutions. Refine identification of the sources of failure modes and system concepts. Develop methods for storing the sensor data and reliable data storage/recovery process.

3. Define the control panel and set points for alarm signals, i.e. red and green lights. Design and define the ability to check for the condition of the power when on the ground and unpowered.

4. Identify alternatives for power supply options that are consistent with aircraft maintenance practices and envelope constraints.
Identify additional sensor development required to measure all required relevant properties (temperature, pressure, impedance, viscosity, dielectric constant, etc.) in an integrated, reliable system.

PHASE II: 1. Refine the sensor concept and finalize sensor system practical size envelope and alternative power sources.

2. Develop installation procedures and drawings for prototype installation on Army UH-60 and AH-64 test aircraft.

3. Fabricate three prototype models to directly interchange with existing monitoring devices on UH-60 and on AH-64 using industry standard interface cavity dimensions in MIL–F-24402 or cavities in housings using MIL-F-8815/1-6 and -8 filter housings.

4. Demonstrate and refine detection and prognostic algorithms based on test data on used and new filters, forced pump degradation and other bench tests. Correlate information to pressure rise rate and develop estimates on residual filter life for UH-60 and AH-64 models.

5. Verify repeatability of the data gathering, recognition of failure modes, and alarm signals based on induced dust in bench tests using UH-60 and AH-64 filter housings and filters. (TRL 6)

6. Conduct durability/qualification tests per MIL-F-8815 and environmental tests per MIL-810F tests on at least 3 units per aircraft design to confirm the performance, reliability, and failure prevention versus the conventional sensors. Publish qualification report against current Army requirements.

7. Develop recommended specifications, system design, and drawings for the optimized smart sensor system to for both the UH-60 and AH-64 models. Develop estimated sensor system cost in military volumes of 500 and 1000, and commercial volumes of 10,000 and 50,000. Include estimated component delivery lead times and expected production timeframe.

PHASE III: 1. The ideal end-state is for demonstration on at least 3 different UH-60 and AH-64 test aircraft in an operational environment (TRL 7) to characterize and prove sensor effectiveness in realistic environments, i.e. dust, sand, high and low temperature environments for at least 6-12 months. The system would then be validated via one or several fielded units for an extended period of time (greater than 12 months), with significant feedback from the aircraft maintainers.

2. The implications of this technology are quite large and have applications in many industries. For example:

a. Aerospace: This new technology can be used on any legacy or future aircraft, and ground support equipment which uses hydraulic or lube filtration. It opens up opportunities to explore additional applications of this technology on other weapon systems.

b. Industrial/mobile/construction equipment/energy industries:
The majority of the filters used in these industries have the same pop-up type indicators as used in the military. This technology could potentially save millions in maintenance costs.

REFERENCES: 1) Test standards ISO-23369, MIL-F-8815, MIL-810-F, ISO-16889, SAE–AS- 4059
2) RSIC _SBIR search references: TR52088, TR52087, IR&D 52086, TR50279

KEYWORDS: condition based maintenance, self diagnostics, prognostics, fluid filters, data port, data acquisition, MEMS sensor, sensor fusion, information processing, contamination effects, hydraulics, MIL-F-8815, Differential pressure sensor, Pop-up failure indicators, visual failure indicators

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A07-009 TITLE: Field Repair of Localized Damage on Dynamic Rotorcraft Components.

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop a reliable field portable/deployable device to impart residual compressive stresses in surfaces of fatigue sensitive dynamic rotorcraft components in which localized mechanical and/or corrosion damage has been blended out.

DESCRIPTION: Ferrous, aluminum, titanium and nickel alloy fatigue sensitive dynamic rotorcraft components are subject to mechanical and corrosion surface damage in service. The deleterious effect of this surface damage on component fatigue life can be mitigated by imparting the components with a residual compressive stress surface layer via shot peening during manufacturing. To ensure that the level of damage accumulated in service does not become excessive, or life limiting, routine inspections are performed in the field in accordance with Technical Manuals (TM) and at overhaul facilities (known as depots) in accordance with depot maintenance work requirements (DMWR's). These documents also contain instructions for component repairs, scrapping and replacement.

Surface damage is typically repaired by blending. Visual and fluorescent penetrant inspections (FPI) are utilized to verify blending has completely removed component damage and ensure cracks are not present. Unfortunately, blending removes the of beneficial residual compressive stresses remaining in the component, immediately adjacent to the location of blending. Because residual compressive stresses can only be restored in these components through the use of depots or civilian firms with non-portable, component specific, shot peening processes, many repairs are not performed in the field.

The creation of a reliable field portable/deployable device to restore residual compressive stresses to a component's surface would enable localized damage of fatigue sensitive dynamic rotorcraft components to be repaired in the field and reduce the time, logistics and costs to transport repairable components to depots or civilian firms with non-portable, component specific, shot peening processes.

PHASE I: Design and demonstrate the feasibility of a field portable/ deployable device capable of imparting residual stresses to materials, geometries and surface finishes common to Army fatigue-sensitive dynamic rotorcraft components.
Describe (and, if possible, demonstrate) the relationship between the proposed process, common Army part microstructures, properties and performance.

Develop a system validation plan for each example application provided.
Estimate operator/device repeatability and reproducibility for a fixed set of device operating parameters.
Estimate system capabilities and compare with (portable and fixed) commercially available processes.
Estimate system acquisition, operation, maintenance and performance costs and compare with (portable and fixed) commercially available processes.

PHASE II: Demonstrate a field portable/deployable device capable of imparting localized residual compressive stresses on test coupons representative of materials, geometries, surface finishes and blending repairs common to Army fatigue-sensitive dynamic rotorcraft components.
Develop potential field repair procedures and quality control procedures (for blending and imparting localized residual compressive stresses).
Characterize the effect of the above device on the microstructure, mechanical properties and fatigue life of test coupons and retired (or scrapped) fatigue sensitive dynamic rotorcraft components to verify potential field repairs.
Measure operator repeatability and reproducibility for a fixed set of device operating parameters.
Develop and provide operator's manual and device maintenance manual.
Develop and provide a method for determining optimal use of device upon new fatigue sensitive dynamic rotorcraft component applications.
Develop and provide a method for training and qualifying operators in the proper use of the device.

PHASE III: The vision of this SBIR research is a device that will enable the warrior to repair fatigue sensitive dynamic rotorcraft components in the field in less time and at a lower cost than at the depot level. Cost and time reductions will be obtained by designing the device so that it can be handled by a single, trained and qualified operator. The device will perform reliably, safely while imparting residual compressive stresses into component surfaces in a repeatable and reproducible manner. A matrix of fatigue tests upon specimens similar in material, condition and geometry to the fatigue sensitive dynamic propulsion and structural system components of rotorcraft will be used to prove the operational capability of the device and transition it from a TRL 5 at the end of Phase II. Military applications include the fatigue sensitive dynamic components of propulsion and structural systems in fielded Chinook, Black Hawk and Apache helicopters. Commercial applications of the device would include the repair of fatigue sensitive dynamic components in civilian rotorcraft parts and the repair of new production aerospace parts (military and civilian) normally scrapped because of the cost, time, and masking penalties imposed by non-portable shot peening techniques.

REFERENCES: 1) ASM Handbook, Volume 5, Surface Engineering, Shot Peening, p. 126-135, ASM International, 1994.
2) ASM Handbook, Volume 5, Surface Engineering, Residual Effects of Finishing Methods, p. 144-151
3) ASM International, 1994.
Shot Peening, Proceeding of the 8th International Conference on Shot Peening (ICSP-8) in Garmisch-Partenkichen, Germany, 16-20 September 2002
3) Lothar Wagner, Ed., ISBN 3-527-30537-8, Wiley-Vch, 2003

KEYWORDS: Corrosion, Damage, Dynamic, Fatigue life, Mechanical, Repair, Residual stress, Rotorcraft, Blending, Pit, Pitting

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A07-010 TITLE: Computational Fluid Dynamics Co-processing for Unsteady Visualization

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop scalable, efficient parallel software to significantly reduce the online data storage and manpower post-processing requirements of unsteady computational fluid dynamics simulations using batch co-processing, data extracts, and feature detection at simulation runtime.

DESCRIPTION: Development of efficient techniques for the visualization of large computational fluid dynamics (CFD) data sets is required to keep pace with the increasing capability of modern parallel supercomputers to generate such data. State-of-the-art CFD simulations, especially for rotorcraft, are time-dependent, moving body problems. They contain millions of grid points run for thousands of time steps potentially producing hundreds of gigabytes of output. In order to understand the flow physics associated with these simulations and be able to use the results for engineering analysis, post-processing techniques and especially time-dependent visualization methods need to be significantly improved. Current visualization technology has numerous deficiencies and new co-processing strategies are necessary, as discussed by Haimes and Jordan (2001).

The next generation techniques should directly address the large-scale aspects of the data and data processing, both computation and storage, in a parallel, distributed computing environment. Research is needed to drastically reduce the amount of data that is stored from a simulation while at the same time increasing the accuracy and efficiency of analysis processing. Proposals are sought related to co-processing strategies, wherein the usual post-simulation processing of data is substantially replaced by concurrent simulation and data analysis. Such strategies will take advantage of batch co-processing (Haimes and Jordan 2001), data extracts (Globus 1992), and feature detection and extraction (Kao and Shen 1999). A flexible and efficient, commercializable, co-processing strategy may be an Application Programming Interface (API) that can be integrated with a wide range of CFD codes. Commercial and government CFD codes use various structured, unstructured, and overset gridding strategies. Simultaneous calculation and interactive viewing of the solution, i.e. interactive instead of batch co-processing, is not a prime requirement, in part due to the queue structure of many supercomputer clusters in government and industry. pV3 (Haimes 1994) is an example of a co-processing visualization system. Data extracts are a drastically reduced subset of the complete time-dependent dataset and are the information of most interest to the engineer. Extracts are often associated with stand-alone, collaborative, graphical viewing software (e.g. Ensight Reveal, Fieldview ATViewer, FAST ARCGraph). In order to be productive, the co-processing software must be able to extract data of interest, including shocks, separation regions, and vortical flows. This is in addition to standard interactive graphics visualization constructs such as cutting planes, computational surfaces, and iso-surfaces. For rotorcraft analyses, vortical flow feature extraction and particle path (streakline) integration is of frequent need for determining rotor-fuselage interactions. Obviously, the more automated this detection and extraction task the more useful it becomes while reducing the need to rerun simulations. In summary, co-processing visualization software is required to replace the current post-processing paradigm. This puts an increased burden on flow physics detection and extraction in exchange for drastically reduced data storage and manpower requirements.

PHASE I: Conduct required analysis and research on the technical areas described in the topic description. Based on the result of these analyses and research, develop and implement initial concepts in a limited demonstration of the co-visualization of a large, time-dependent simulation.

PHASE II: Refinement of Phase I visualization techniques and inclusion of a broader range of co-processing capabilities. The capabilities should be incorporated into a software product (e.g. API) that is compatible with widely used CFD codes. Extract files should be integrated with viewing software.

PHASE III: The envisioned technology transition path from research to operational capability is incorporation of the co-visualization API/library into commercial and government CFD codes and incorporation of the extract viewing technology into commercial visualization software. With the increasing size of unsteady simulations in the aerospace industry and the large number of CFD codes in use, a co-processing API and library has significant commercial viability.
DoD rotorcraft development programs frequently suffer cost and schedule setbacks caused by unforeseen aeromechanics issues which are not detected until flight test. Many of these problems can be reduced by CFD analyses with co-processing feature detection of adverse rotor-fuselage interactions. The research may be

transitioned for direct application to Joint Heavy Lift (JHL) or Joint Multi-Role (JMR) development as well as S&T 6.2 programs Lightweight Active Rotor Concepts (LARC) and Future Aeromechanics Concepts (FAC).

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2) Globus, A., "A Software Model for Visualization of Time Dependent 3-D Computational Fluid Dynamics Results," NASA Report TNT-92-031, November, 1992.
3) Haimes, R., "pV3: A Distributed System for Large-Unsteady Visualization," AIAA Paper 94-0321, Reno, NV, January 1994.
4) Kao, D., and Shen, H., “Automatic Surface Flow Feature Visualization,” AIAA Paper 1999-3287, Norfolk, VA, June 1999.

KEYWORDS: CFD, visualization, co-processing, data extracts, feature detection, graphics

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A07-011 TITLE: Robust, Real-time Clearance Measurement Technologies for High Temperature Turbine Applications

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop and validate a real-time clearance measurement system for gas turbine engines using high temperature probes capable of operating in the harsh environment of the gas generator and power turbine.

DESCRIPTION: Improving measurement systems for the blade-tip clearance in the turbine section of a gas turbine engine can improve efficiency, minimize leakage flow, and shorten engine development time. The tip-clearance varies throughout different operating conditions (start-up, idle, shut-down) because of different expansion coefficients and heating rates. Temperature and pressure conditions can cause the rotor to expand and rub the housing, resulting in damage that can potentially be catastrophic. Leakage flow is responsible for a significant percentage of overall rotor losses and can also locally increase the heat transfer. A real-time clearance measurement system can lead to turbine designs that eliminate rubbing of the housing and minimize leakage flow for maximum efficiency in the turbine section. The tip-clearance data collected from a robust, real-time clearance measurement system can provide information on the condition of the stage for maintenance and allow an active control for tip-clearance. [1]

The most widely used methods of measuring the distance between the blade tip of a turbine rotor and its housing involve inductive and capacitive sensors which result in moderate frequency response and 50μm accuracy. [2] The current methods where the probes can be flush mounted are only possible in lower temperature parts of the turbine. In the higher temperature sections, the current measurement probes require protective recess mounting points.

The goal is to develop and validate a real-time, self-calibrating clearance measurement system for gas turbine engines using high temperature probes capable of operating in the harsh environment of the gas generator and power turbine over the full range of operation. Innovation should be present in the design of the measurement system, which should be capable of operating in extreme environments up to 2000° F and insensitive to electrical disturbances. Meeting measurement goals and overcoming the additional challenges inherent with this technology insertion point are paramount. The most significant measurement goal is to measure the blade-tip clearance within

20 μm accuracy at near-real-time of 1 μs blade passage time. The measurement system must be able to recognize each blade and calculate the position of each individual blade tip. Ultimately, the measurement system must be an economical design that meets the goals required while being very robust and accurate in the early stages of the turbine.

PHASE I: Develop a design for the measurement system and present the feasibility of the design relative to achievement of topic objectives.

PHASE II: Design and develop the proposed measurement system (preferably via coordination with an engine manufacturer) and validate the performance relative to topic goals through experimentation.

PHASE III: Commercialize the technology through integrating the developed system into multiple engine manufacturers' military engine development efforts to reduce engine development cycle time and cost by enabling turbine clearances to be understood and optimized to achieve improved engine fuel efficiency and durability in a more efficient manner. Also integrate into engine manufacturer's future turbine engines to attain improved engine fuel efficiency on future advanced military or commercial engine development programs or on upgrades to current fielded systems. This will be achieved by usage in a condition based maintenance system or enabling the use of active clearance control technologies by application of this key technology. 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 one of Utility Helicopter Project Office's top two SBIR endorsements and is needed to lead to an improved engine to support UH-60M Block-2 and meet Future Combat System (FCS) external lift requirements.

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2) "Laser Doppler Velocimetry: Fiberoptic probe measures turbine tip clearance", Gail Overton, Laser Focus World, June 2006.

KEYWORDS: Tip-Clearance Measurement System, High Temperature Probes, Gas Turbine Engines, Tip-Clearance Probes, High Temperature, Clearances, Measurement

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A07-012 TITLE: Incorporating Effective Cooling into Ceramic/Ceramic Matrix Composite (CMC) Turbine Blades and Nozzles.

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: Develop and validate a manufacturing process that incorporates effective cooling schemes into Ceramic/CMC turbine blades/nozzles for increased cycle temperatures leading to improved turbine engine performance.

DESCRIPTION: Ongoing operations in adverse and challenging theaters has created a need for increased performance from turboshaft engines. This need translates into higher temperature capabilities and better horsepower-to-weight ratios. One state-of-the-art solution to these requirements is the incorporation of ceramic/Ceramic Matrix Composite (CMC) materials into the components of future turboshaft engines. ceramic/CMC components offer higher temperature capabilities as they are more resistant to the immense heat experienced in the hot sections of engines and directly contribute to higher horsepower-to-weight ratios by significantly reducing the weight. Using ceramic/CMC materials in the turbine blades and nozzles is an ideal application as this is the hottest section of engines and one of the higher part-count components. However, the capabilities of uncooled CMC technologies can only extend the capabilities of the engine and platform to a certain plateau. In an effort to further exploit the potential of ceramic/CMC technology, it is desired that effective cooling schemes be incorporated into turbine blades and nozzles. If successful, a program of this nature would even further increase the temperature capabilities and subsequently improve horsepower-to-weight ratios and specific fuel consumption in turbine engines. This presents significant challenges, however, in that ceramic/CMC material processes do not as yet lend themselves well to incorporating cavities for cooling. It is the intent of this topic to solicit an innovative approach to both incorporating effective cooling schemes into CMC blades and/or nozzles as well as definitively validating the temperature and life capabilities of those components. Innovation should be present in the process by which the cooling holes are introduced into the components whether pre- or post-processing. A successful program should demonstrate two distinct capabilities; successful manufacturing of components and the ability of those components to meet both the physical and environmental requirements of advanced turboshaft engines in the size range of 5000 to 20,000 horsepower. The manufacturing process should be well defined and demonstrate an understanding of current ceramic/CMC manufacturing processes. A component that incorporates the proposed cooling scheme should be able to withstand the physical loads (centrifugal force, bending, aerodynamic, vibratory, etc) as well as the adverse environmental effects (thermal loading, high temperature, etc.) experienced in turboshaft engines. The desired program should design and fabricate turboshaft engine compatible cooled turbine blades or nozzles using an innovative process built upon established ceramic/CMC manufacturing processes. These components should then be tested to demonstrate their ability to survive the expected turbine engine hot section stress and temperature environment. Doing so will allow those components to be included in future turboshaft engines with far improved performance capabilities which will in turn provide for greater mission capabilities in theater.

PHASE I: Develop and design an innovative approach for incorporating effective cooling schemes into CMC turbine blades and/or nozzles. Fully support the feasibility of the approach as well as describe any testing that would be necessary to validate the components ability to survive the physical and environmental demands. Effort should be coordinated with OEM to ensure interest and future support.

PHASE II: Manufacture a representative component that utilizes the approach detailed in Phase I to incorporate cooling schemes into CMC turbine blades and/or nozzles. Complete testing as described in Phase I report in order to validate approach and demonstrate potential for commercial application. Direct coordination with a major engine or airframe company during this phase is highly desirable.

PHASE III: Commercialize the effort to achieve the desired end-state of a cooled CMC component's inclusion into an advanced Science and Technology (S&T) demonstration engine platform via collaboration with an engine manufacturer. Engine manufacturers are continuously advancing technology to meet military and commercial needs. Future military programs will focus on both heavy lifting capabilities as well as furthering the family of autonomous aircraft. Commercialization should focus on this wide range of application. Commercial applications are far less specific as the market is wider. Consequently, commercialization for commercial applications should be focused on those applications fitting into the engine size range as described in the Objective. 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 has been endorsed by the Systems Engineering group of PEO Aviation and would said group would be interested in developing this technology if successful.

REFERENCES: 1) Martha H. Jaskowiak and Kevin W. Dickens. "Cooled Ceramic Matrix Composite Propulsion Structures Demonstrated". http://www.grc.nasa.gov/WWW/RT/2004/RM/RM24C-jaskowiak.html
2) J. Douglas Kiser, Dr. Ramakrishna T. Bhatt, Dr. Gregory N. Morscher, Dr. Hee Mann Yun, Dr. James A. DiCarlo, and Jeanne F. Petko. "SiC/SiC Ceramic Matrix Composites Developed for High-Temperature Space TransportationApplications". http://www.grc.nasa.gov/WWW/RT/2004/RM/RM26C-kiser.html
3) Dr. Ramakrishna T. Bhatt and Dr. James A. DiCarlo. "Method Developed for Improving the Thermomechanical Properties of Silicon Carbide Matrix Composites". http://www.grc.nasa.gov/WWW/RT/2003/5000/5130bhatt.html

KEYWORDS: Ceramic Matrix Composites, cooling schemes, turbine blades, turbine nozzles

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A07-013 TITLE: Dynamic Blade Shapes for Improved Helicopter Rotor Aeromechanics

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: Determine candidate dynamic blade shapes for improved helicopter rotor aeromechanics, especially rotor performance. Calculate the resulting rotor performance, steady and vibratory blade loads, and aeroelastic stability, for minimum actuation system weight, centrifugal force, work, and power. Develop a proof-of-concept actuation system. Solutions are sought that increase helicopter efficiency and operating envelope.

DESCRIPTION: Increased rotor performance remains an important Army objective, since it can increase maximum weight and speed while reducing rotor power for less demanding flight conditions. Unfortunately, the inherent physics of edgewise flight requires design compromises, particularly for fixed blade geometries. Fortunately, recent advances in adaptive aerodynamics and smart structures could enable advanced active rotor concepts for enhanced performance. Solutions are sought that increase helicopter efficiency and operating envelope.

In principle, active rotors which enhance performance will change the geometry of rotor parameters that have the largest effect on performance. Failing that, active rotors will modify less powerful parameters that can more easily be changed. Some parameters need to be changed at only low rates, while others need to be changed once or twice per rotor revolution, plus some higher harmonic motions at reduced amplitudes.

Potential blade morphing includes blade tip planform geometry; blade anhedral/dihedral; winglets; blade twist; and airfoil shape and size. Both compliant structures and diverse actuators may be considered, including pneumatic, hydraulic, electromechanical, and smart materials. Both real and virtual shape change concepts may be proposed. Previous research has focused on blade twist and airfoil shape, often for reduced vibration, with other geometric parameters usually being taken as fixed (non-active) design parameters. Particular emphasis is needed on new concepts which improve rotor performance.

Improved performance is sought for the entire operating envelope: reduced power (for nominal weight and speed), increased cruise speed (for nominal weight and fixed power), increased maximum speed (for fixed power and weight), and increased thrust (for fixed power).

Innovative dynamic blade shapes are sought. Emphasis should be on blade shape concepts, with actuation a secondary consideration. In particular, with respect to actuation, the emphasis should be on estimated actuation requirements for a variety of blade shape concepts. Rough estimates of actuator system properties (especially mass, centrifugal force, work, power, and volume) should be used to eliminate infeasible concepts and identify the more promising concepts. The primary goal is to approximately rank the blade shape concepts, not to optimize the actuation system for each configuration.

Numerical calculations shall encompass rotor performance, steady and vibratory blade loads, and aeroelastic stability, based on validated analytical tools. Example tools include the comprehensive analyses RCAS and CAMRAD II.

Ultimately, the only active solutions which will be fielded are those which are superior to passive designs. Thus, active solutions must provide performance that is unattainable by passive systems, or provide the same performance for reduced weight and/or power.

PHASE I: Develop an assortment of design concepts -- dynamic blade shapes -- suitable for enhanced rotor performance. Quantify the extent to which the various concepts would affect rotor performance, and determine the actuation requirements, including force, stroke, frequency, work, and power. Recommend several concepts for future study.

Recommend a metric for ranking the design concepts in Phase II. Evaluation criteria to be considered include rotor performance, weight, centrifugal force, and power.

PHASE II: For each design concept (from Phase I), estimate the actuator system properties, including mass, centrifugal force, work, power, and volume. Rank order the design concepts. Develop additional design concepts, and revise the rank order.

For the most promising concepts, develop preliminary designs -- refined blade geometry definitions, deployment schedules (magnitude and phase of deformation, e.g.), and actuation systems -- and make high fidelity performance calculations. Refine the actuator requirements. Develop revised estimates of the actuator system properties. Rank order the preliminary designs. For at least two (2) preliminary designs, calculate detailed rotor aeromechanics, including performance, steady and vibratory blade loads, and aeroelastic stability.

Recommend at least one (1) preliminary design for further development. In particular, develop a proof-of-concept actuation system, including detail design, fabrication, and bench testing. Test methods shall approximate significant aerodynamic, inertial, and structural loads, and shall quantify actuation system performance, efficiency, and fatigue life.

The deliverables include three (3) main items: 1) a dynamic blade shape specification, 2) detailed aeromechanics predictions, and 3) a bench-qualified, prototype actuation system.

PHASE III: Present results to rotorcraft prime manufacturers to obtain feedback about the adequacy of the hardware and the predicted aeromechanics, and to receive suggestions for improvements.

Further develop and test the actuation system.

Make refined aeromechanics calculations, including both the effects of actuator properties and (fully dynamic) on-blade actuation performance.

Perform small- to moderate-scale rotor testing to verify the rotor performance predictions and the key actuation requirements.

Develop partnerships for further development, including complete aeromechanics phenomenological testing, optimized actuation hardware design and fabrication, and active rotor development and testing.

If this project is successful, and further development is also successful, the resulting dynamic blade shapes would be used in the design of a variety of future military and civilian rotorcraft. Improved rotorcraft performance reduces operating costs and increases mission effectiveness.

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1. Noonan, K.W., Althoff, S.L., Samak, D.K., and Green, M.D., "Effect of Blade Planform Variation on the Forward-Flight Performance of Small-Scale Rotors," NASA TM-4345, AVSCOM TR-92-B-005, April 1992.

2. Yeo, H., Bousman, W.G., and Johnson, W., "Performance Analysis of a Utility Helicopter with Standard and Advanced Rotors", Proceedings of the American Helicopter Society Aerodynamics, Acoustics, and Test and Evaluation Technical Specialist Meeting, San Francisco, CA, January 23-25, 2002.

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6. Nitzsche, F., Feszty, D., Waechter, D., Bianchi, E., Voutsinas, S., Gennaretti, M., Coppotelli, G., and Ghiringhelli, G.L., "The SHARCS Project: Smart Hybrid Active Rotor Control System for Noise and Vibration Attenuation of Helicopter Rotor Blades," 31st European Rotorcraft Forum, Paper No. 52, Florence, Italy, September 13-15, 2005.

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8. Karem, A.E., "Optimum Speed Rotor," U.S. Patent 6,007,298, December 28, 1999.

9. "RCAS Theory Manual, Version 2.0," United States Army Aviation and Missile Command/Aeroflightdynamics Directorate Technical Report, USAAMCOM/AFDD TR 02-A-005, US Army Aviation and Missile Command, Moffett Field, CA, June 2002.

10. Johnson, W., "Technology Drivers in the Development of CAMRAD II," American Helicopter Society Aeromechanics Specialists' Conference, San Francisco, California, January 1994.

KEYWORDS: rotor, blade, shape, deformation, geometry, morphing, nastic, structures, blended, wing, planform, anhedral, dihedral, winglets, twist, airfoil, chord, trailing-edge flap, elevon, camber, leading-edge nose droop, rotorcraft, helicopter, aeromechanics, aerodynamics, dynamics, aeroelasticity, comprehensive analysis, performance, thrust, power, speed, efficiency, vibration, vibratory, loads, aeroelastic stability, active, smart, elastic, conformal, compliant, actuator, pneumatic, hydraulic, electromechanical, higher harmonic, weight, work, power.

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A07-014 TITLE: Precision Optics Manufacturing of Large Hemispherical Domes

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 topic is to enable achievement of precision transmitted wavefronts through large aperture hemispherical domes.

DESCRIPTION: Precision strike is a cornerstone of military doctrine regarding the use of missiles. The Army, as well as other services, is developing longer range precision strike missile systems that can acquire targets at extended ranges. The seekers in these missiles require precision optics, including the dome, in order to resolve targets at range. This requirement has placed added stress on the dome as the seeker has grown larger. New multimode seekers require multilayer domes increasing the difficulty in obtaining high quality optical transmission. Meeting the demanding performance specifications placed on these domes requires careful study and control not only during the final polish, but at every step of the manufacturing process. This topic is designed to identify the manufacturing steps which introduce the largest errors in transmitted wavefront, propose and evaluate methods or techniques to minimize introduction of those errors, and evaluate deterministic finishing methods for correcting the transmitted wavefront to meet the dome specifications. The final product from Phase II will be a multilayer dome meeting a quarter wave transmitted wavefront specification over any 4" aperture in a 7" hemispherical dome.

PHASE I: Phase I will focus on an analysis of the manufacturing steps for a multilayer dome to identify those steps which have the greatest contribution on the transmitted wavefront error of the finished dome. The feasibility study will propose techniques or processes which minimize the introduction of errors into the wavefront and evaluate deterministic polishing as a means correct the dome transmitted wavefront to meet the specification. The multilayer dome is described in the reference publications.

PHASE II: Phase II will focus on implementing the recommended techniques and processes for minimizing wavefront error in the dome manufacturing process. Correcting the final concave surface of a 7" multilayer hemispherical dome to meet the 1/4 wave at 632.8 nanometers transmitted wavefront specification will also be demonstrated.

PHASE III: Phase III will focus on scaling the demonstrated processes to production quantities and rates. Multilayer domes are being considered for Army, Navy, and Air Force missile systems in development. Deterministic finishing, which is a commercial process, will be shown to be a viable manufacturing technology for large, high precision missile domes whether single or multilayer in decision. This will be an enabling technology for future systems requiring the highest quality optical systems at an affordable price. Initially, the primary beneficiary will be the Joint Common Missile. The Joint Attack Munitions Systems Program office is supportive of this technology and will be kept informed of the progress. In addition, the Joint Common Missile Prime Contractor will have access to this technology. Other beneficiaries of this technology will be the Air Force Small Diameter Bomb which also uses a tri-mode seeker.

REFERENCES: 1) "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.
2) "Materials for infrared windows and domes : Properties and performance", Daniel C. Harris, Society of Photo-optical Instrumentation Engineers, Bellingham, August 1999.

KEYWORDS: missile dome, deterministic finishing, optics manufacturing process

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A07-015 TITLE: Nanomaterial Improvements for Reserve Power Systems

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: The purpose of this proposed effort is to develop and demonstrate retrofit improvements in specific energy, specific power, and the operational (active) lifetime of reserve power systems for long term storage munitions using nanoscale technologies based on structures and coatings.

DESCRIPTION: Improvements to batteries have concentrated on primary and particularly secondary (rechargeable) batteries with some attention to some types of reserve batteries. Future mission requirements for advanced munitions with multifunctional seeker and sensor packages will increase power requirements for these systems. Additionally, increases in on-board computational capacities will allow autonomous munitions to search for targets of interest requiring longer flight times. The power sources for these munitions must provide sustained power throughout this mission lifetime. Long term reserve battery types for munitions are typically thermal reserve batteries and need to be improved to increase energy density, power density, and active lifetime to meet future needs. Nanomaterial improvements could include improvements in the electrode surface areas compatible with existing battery types. No increase in volume of the power storage unit is desired.

PHASE I: Phase one should define the detailed approach to munitions reserve type power storage improvements, develop a detailed prediction of the performance increase, perform an analysis of materials, and provide a demonstration of a critical fabrication process component or step for the application of nanomaterials in the power storage systems components.

PHASE II: Phase II goals should include identification of a munitions based reserve power storage system used by the U.S. Army for application of improvements. For this system, finalize the design from Phase I and develop a fabrication process, demonstrate, test, and characterize, the improvements. Goals should be to obtain at least a 30% increase in at least one of the parameters of specific energy, specific power, and battery lifetime. Phase II deliverables should include a prototype demonstration of an assembled unit for the above system meeting the improvement goals as described. Deliverables should also include a complete description of any fabrication and test processes, any test data and results, and a sufficient model to describe these results.

PHASE III: A Phase III application for Army missile systems could include PAC-3 system or the Joint Common Missile. Phase III should demonstrate the increased power storage system improvements in a relevant environment and provide the complete engineering and test documentation for development of manufacturing prototypes. The development of other military applications of this technology may include future urban warfare surveillance/reconnaissance unmanned aerial vehicles. Commercial applications of this technology could include the application to emergency power systems for vehicles, rescue markers for ship/aircraft rescue, facility emergency evacuation systems, and remote sensor systems with wireless communication links.

REFERENCES: 1. Proceedings of the 42nd Power Sources Conference, Philadelphia, PA, June, 2006
2. D. Linden, T. B. Reddy (eds.), Handbook of Batteries, 3rd ed., McGraw-Hill, 2002

KEYWORDS: reserve batteries, thermal batteries, nanocomposite, nano-structured surfaces, nanomaterials, electrolyte

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A07-016 TITLE: Manufacturing Issues for Multimode Seeker Domes

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 topic is to address manufacturing issues associated with multilayer domes for multimode seekers.

DESCRIPTION: Multimode seekers for missiles are becoming a reality with multiple technology development efforts underway across the services. The Army's Joint Common Missile and the Air Force Small Diameter Bomb are two potential candidates for this technology. The Army has recently demonstrated proof of principle multilayer missile domes for these seekers and is interested in continued development of the capability. While these proof of principle domes were successful, numerous technical challenges remain in scaling the processes to acheive an actual manufacturing capability. The amount of touch labor, reproducibility of the precursor materials, and repeatibility of the processes are huge obstacles to affordable manufacturing capabilities. The objective of this topic is to analyze the processes used to create the multilayer proof of principle demonstration domes, propose changes and improvements to the process that could be used to achieve production rates of 250/month, and demonstrate these processes on a small scale. As the current multilayer dome structure includes two single layer dome shells, much of this effort will also apply to monolithic dome production as well. The multilayer dome and the proof of principle demonstration is described in the reference.

PHASE I: The goal of the Phase I program is to provide a study of the manufacturing process for producing the initial dome blanks for the multilayer dome as well as the bonding process used to create the multilayer dome. This study should include documentation of the current state of the art for producing these dome blanks and the subsequent bonding. This study should then identify a path from the current state of development to full scale production, and should identify the major obstacles and issues that must be addressed in order to reach full scale production. These should include powder manufacture, forming, and heat treatment. The study should also lay out a detailed plan for demonstrating key elements of the production process in Phase II.

PHASE II: Several of the key issues/obstacles to scale up should be addressed during the Phase II program. For each of these issues/obstacles, trade studies will be conducted to determine the various options for manufacturing scale up, and pilot scale experiments should be carried out to demonstrate the feasibility of the various options. A complete process flow from precursor materials to deliverable dome will be documented. At the completion of Phase II, an outline of an optimized manufacturing process will be presented, steps initially identified as high risk will have been demonstrated, and any remaining risk quantified. Realistic production cost estimates will be included with the final report.

PHASE III: Full scale manufacturing demonstration of manufacturing process documented during the Phase II effort. The application of statistical methods to assess and improve yields shall be utilized for all aspects of dome blank manufacture. Process steps which apply to both multilayer and monolithic domes will be identified and the cost savings for monolithic domes documented. Initially, the primary beneficiary will be the Joint Common Missile. The Joint Attack Munitions Systems Program office is supportive of this technology and will be kept informed of the progress. In addition, the Joint Common Missile Prime Contractor will have access to this technology. Other beneficiaries of this technology will be the Air Force Small Diameter Bomb which also uses a tri-mode seeker. Eventually, the techniques developed in this program will be applicable to the manufacture of most ceramic infrared missile domes.

REFERENCES: 1) "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.
2) "Materials for infrared windows and domes : Properties and performance", Daniel C. Harris, Society of Photo-optical Instrumentation Engineers, Bellingham, August 1999.

KEYWORDS: multimode dome, manufacturing process, process control, optics manufacturing

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A07-017 TITLE: Applying Technologies for Managing the Parallel Test Problem

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: Enable advanced conceptual visualization and employment of applications that can, but do not currently simultaneously access asynchronous, and independently available systems resources. The products would lower overall systems costs and availability via reduced throughput burden.

DESCRIPTION: Test systems technologies are moving toward electronic rendering and sampling capabilities that can be invoked concurrently. The concurrency will allow testing to be performed more closely to operational levels and provide decreased test times. Although most test systems do have some instrumentation that might be invoked concurrently, there is little or no support to administer the parallel capability in software. Future systems, with much denser and more parallel hardware will need technologies for dealing with concurrency or the facilities will not be utilized to their fullest extent. This topic is focused on solutions for managing and visualizing concurrency in software and solutions that ease programmer burdens when dealing with concurrent requirements.

Test developers at all levels are looking for ways to decrease test times, allowing more platform throughput and more efficient use of test assets. Various incarnations of virtual instrumentation are in existence and new solutions are being produced. Most of the existing virtual instrumentation hardware provides functionality on a per channel basis that exceeds the traditional single instrument functionality concept. Perhaps the ultimate innovation will be hardware that provides all required capabilities on a per pin basis to the Units Under Test (UUT). Even though advances in hardware are providing many opportunities for parallel test, most test systems have always had the hardware capability to perform parallel testing at some level. The parallel capabilities, although constrained far more than the full bandwidth behind each pin concept, are provided when more than one instrumentation bus is present and also when instruments can be set up and triggered simultaneously or in response to one another. Generally though, the actual use of the parallelism provided by the hardware in these systems is only utilized on a very limited basis because the software does not support the concurrency.

New software technologies and concepts need to be applied to achieve the maximum throughput and efficiencies that modern test systems can provide. Also, the application of modern tools being recently advanced may hold some of the keys to addressing problems and challenges that enabling test concurrency pose. There is currently no way to visualize concurrency and that creates challenges for test developers who might need to wrestle with developing parallel applications. Also, the primitive elements needed to invoke concurrency in an explicit way that allows the developer to document in code that concurrency should exist has not been provided. This SBIR solicits innovative approaches to enabling test concurrency from a software development perspective.

PHASE I: Investigate and define a means of conceiving, viewing and applying asynchronous test requirements that facilitates simplified developer assimilation of concurrency issues. The research intent is to discover approaches and then determine feasibility of actually producing a demonstration and eventual product that embodies the enhanced capabilities. The study shall result in a roadmap for how any research products, findings or technologies should be applied along with a prototype implementation plan for physically demonstrating them.

PHASE II: Tasking will be to actually implement and demonstrate a prototype development toolset. The demonstration would obviate the prospective technology’s ability to allow users a comprehensive efficient means of conceiving and deploying test applications that take advantage of asynchronously and independently deployable hardware resources. The results might be in the form of products, standards, interfaces or concepts that are eventually saleable, standardized or published.

PHASE III: Tasking will be to finalize products into saleable packaging, push any standards into committees, finalize and publish, develop any documents, books, whitepapers, etc. These products will initially be directly applicable to Automatic Test Systems and deployed on the Integrated Family of Test Equipment family of test systems; IFTE is a series of test systems used off-system for testing electronic and electro-optic weapons devices, including missile systems, vehicles, aircraft and more. Other systems that employ parallel resources with asynchronous availability that could employ their usage to increase throughput and enhance performance are also targets. Some of these include data acquisition systems, health maintenance systems, surveillance systems, communications systems and others.

REFERENCES: 1) Performance Improvements and Multiprocessing Intel Architecture Workstations: Multithreaded Applications. http:www.intel.com/business computing/wrkstn/multi/ (Nov. 1999).
2) Brown, S. Changing The Automatic Test Paradigm Through Concurrent Measurement and Test Development. Wiley- ATC proceedings (2003)

KEYWORDS: concurrency, parallel, test, software, distributed

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A07-018 TITLE: Perpetual Learning and Knowledge Mining for Automatic Target Recognition (ATR)

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: The intent of this effort is to develop a method for selecting sparse, operationally viable, representative sets of target and clutter samples from both previously collected and/or operationally gathered data or image sequences as they become available. These representative sets are for the purpose of creating and updating robust operational knowledge bases for automatic target recognition. The desired knowledge base creation method should be synergistic with and demonstrated in conjunction with a specific ATR system approach.

DESCRIPTION: The initial knowledge base should make use of all available data samples for each target type to allow bootstrapping of an automatic target recognition system knowledge base while insuring optimal discrimination of and incorporation of new target and clutter samples, when they are made available. Optimality in this context is with respect to ATR performance and pragmatic storage requirements of the knowledge base itself. Perpetual learning implies the process of incorporating new information/samples such that prior knowledge is not diluted, destroyed, or compromised in any way while retaining non-redundant information. Determination of how to incorporate any new or current samples should be implicit in the knowledge base creation and updating method. The initial bootstrapping process can be implemented as an off-line non-real time data mining of the a priori data samples. Subsequent updating of the knowledge base, however, requires at least a close to real time implementation. The real time ATR is limited by both computational throughput and storage capacity, hence the emphasis on optimal storage of the knowledge base while the ATR approach must consider the dynamic operational environment.

In the training process, representative target and clutter samples are typically extracted from the sequences of infrared imagery. In typical air-to-ground ATR applications, especially with missile-based platforms, autonomous methods are required to accurately discriminate the desired tactical targets from background clutter. For any given sequence, we desire samples to train the ATR classifier by exploiting information from the image regions containing only background clutter or undesired objects and from the image region encompassing the targets of interest. The quantity of available clutter data can be significantly larger than that of the target data leading to a potential training data imbalance, but note only specific scenario relevant clutter impacts ATR performance. Additionally, many of the clutter samples may contain redundant information about the background terrain and if every sample were used in the training phase the computational demand could be untenable. Many techniques, parametric and non-parametric, have been applied to pare down the clutter samples to a representative training subset. Intuitively one may desire to select clutter samples that are most target-like, especially for a specific engagement scenario, since these will define the decision boundary in the classifier's decision space; this methodology may not succeed for many classifier architectures. The clutter distribution is likely to be multi-modal and highly variable; we desire investigation of parametric and/or non-parametric techniques to provide both accurate and robust representations of such distributions to be added to the synergistic knowledge base over time as newer data is provided.

Variations in environmental and background terrain can induce significant mismatch between the statistical distributions of features derived from infrared image sequences, and more importantly, between training imagery and imagery observed operationally in fielded systems. When new imagery is observed, we desire a methodology to autonomously learn whether the data is redundant or whether it provides new information to enable efficient and effective knowledge-base expansion and to implement that expansion optimally.

PHASE I: The results of this phase I effort is delivered code illustrating creation of sample knowledge bases showing creation and testing using the developed and applied mining and learning techniques.

PHASE II: The results of the phase II effort is code demonstrating the incorporation of all known target set signatures and the creation of operational knowledge bases with seperate cases showing unconventional or new target knowledge base incorporation and learning. Delivery of code and the created knowledge base showing learning of newer data

PHASE III: Work will be oriented towards technology transition to weapon and/or surveillance system acquisition programs of record (FCS, Longbow/Apache, NLOS-LS, JCM, etc.) and/or commercialization. Specific assessment of real time timelines and architectures for individual military and commercial system applications will provide for synergistic and architecturally extensible instantiations in both military and commercial systems. Applicability toward commercial security and surveillance applications will be included. The software will be implemented with flexible databases ideally allowing the products of this SBIR research to be inserted into multiple weapon, fire control, and surveillance systems.

REFERENCES: 1) DACS - Data & Analysis Center for Software - DACS - Software... Data Mining, Data Warehousing and Knowledge Discovery : Education and Training An Introduction to Data Mining: A Tutorial - Outline: Overview of data ... Data Mining Site - Pilot Software offers data mining tools and training in their use. This site also provides a video overviewing data mining. http://dacs.dtic.mil/databases/url/key.php?keycode=222:226

KEYWORDS: Perpetual learning, knowledge mining, automatic target recognition, ATR

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A07-019 TITLE: Techniques for Comparison of Actual Target Signatures to Rendered or Synthetically Generated Models

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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OBJECTIVE: Identify and develop techniques to quantitatively compare synthetic models with data collected during field tests. Establish an acceptable level of agreement between synthetic models and field test data.

DESCRIPTION: Performance analyses utilizing field test data are completed on many different types of sensors, such as high range resolution radar data, imaging infrared data, and synthetic aperture radar data. Digital and hardware in the loop simulations are developed to predict sensor performance and offset field test costs. These sophisticated simulations rely on synthetically generated target and clutter models to replicate real world environments. To date, numerous statistical models have been used for comparison of real versus synthetic models. The results from utilizing these techniques have provided a limited understanding of the quality of the synthetically generated model and its “good enough” criteria. Improving model verification capability has long been sought after.

PHASE I: Identify and/or define mathematical techniques to compare synthetically rendered target and clutter models to actual field test data. Develop a method or methods to determine the degree to which the synthetic models match the real world. Mathematical techniques selected or developed should be robust across frequency bands (Infrared, Radio Frequency, etc.). It is desired to have the applied techniques applicable to any frequency band. Existing synthetically rendered models and field test data will be provided. The proposed methods must exceed current generic statistical practices. A feasibility concept study verifying performance of the method(s) is required.

PHASE II: Model and verify/validate methods identified and/or defined in phase 1. Demonstrate performance of the method(s) to compare synthetic models with field test data. Additional enhancements to improve the performance of the techniques studied in phase 1 may be investigated. Data sets of synthetic models and field test events may include mid wave IR, Ka and W band frequencies. Technical reports and briefings are required.

PHASE III: Utilize the techniques and models developed in phase II to characterize and assess quantitatively the comparison of synthetic models to field test data. These methods are applicable to all sensor programs utilizing simulations for performance predictions including NLOS-LS, Small Diameter Bomb, and Joint Common Missile. Commercial applications including collision avoidance systems and automated control systems could capitalize on this effort to enhance their simulation capabilities

REFERENCES: Douglas, Mitchell. "An Assessment on Modeling and Simulation of Infrared Sensor Systems." DMSTTIAC-TA-97-02 (DMSTTIACTA9702)

KEYWORDS: model verification, model validation, imaging infrared, millimeterwave, radar, synthetic aperture radar, mid wave IR, digital simulation, synthetic models

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A07-020 TITLE: Virtual Sensor Wiring Harness for Hazardous Environments

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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OBJECTIVE: Develop and demonstrate a means of exchanging information between remote embedded sensors and an embedded datalogging unit wirelessly in an explosive hazard environment.

DESCRIPTION: Energetic chemical systems, electronic systems, and mechanical systems degrade over time based on the temperatures and vibration environments to which they are exposed. Other environments (humidity, chemical) degrade other systems in various ways. It is critical to long-term system reliability that such factors be monitored within the systems on a continual basis.
Monitoring within enclosed embedded systems, particularly munitions, presents unique challenges. In particular, it is highly desirable to not add to the wiring burden within the system. Second, for munitions specifically, inter-device communication must be accomplished in such as way to not risk unintentional initiation of electro-explosive devices. The purpose of this task is to develop a means of communication between sensors within an embedded system that is wireless, ultra-low power, and safe to use within an explosive environment.

PHASE I: Identify concepts and methods of safely exchanging sensor information within an embedded, potentially explosive environment. Sufficient analysis shall be performed so as to determine the feasibility of any selected approach. Any communications scheme developed shall be capable of operating within the environment of, and within the materials typically found in, a missile system. To scope the system development, the following parameters shall be considered. The maximum communication range shall be no less than 5 meters, and the minimum communication range shall be no more than 5 centimeters. Up to 100 sensors shall be capable of operating safely within 5 meters of each other. The system shall comply with the safety requirements as described in Reference 1, below. Consideration will be given to the power requirements of any system to be evaluated, with a life of 10+ years on a single set of batteries being a goal.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over extended operating conditions. If a radio frequency (RF) solution is chosen, international licensing requirements shall be considered during frequency selection and system. Also, the contractor shall address minimizing the size of any system components, with < 1 cu. in. being the desired goal for any sensor unit, and < 4 cu. in. being the desired goal for any datalogging unit. Additionally, for communication outside the system, it is highly desirable that the datalogging unit be compatible with a standard such as ISO/IEC 18000 described in Reference 3 or the Remote Readiness Asset Prognostics/Diagnostics System (RRAPDS) Communication Protocol as described in Reference 3.

PHASE III: The final outcome of this work will be a methodology for incorporating low-power sensors into munitions and retrieving data from them in an inherently HERO-safe wireless manner. By having such a communication technique available, it will be possible to instrument areas of a missile that cannot currently be practically instrumented (i.e.within a rocket motor case). Additionally, it will be possible to retrofit existing munition systems with health monitoring sensors without the burden of having to account for the additional space and weight that would be inherent with a wired design. This system could be used in a broad range of military and civilian monitoring applications where low-power, wireless implementations are desirable. Such applications might include unattended sensors, where extremely low-power consumption and non-interference are at a premium. Given the emphasis on HERO safety, this would allow wireless monitoring of systems in hazardous or explosive environments, areas where wired communication is presently the norm. Additionally, the use of these ultra-low power wireless technologies would enable implementation and retrofit of sensors in existing commercial and military systems. For example, new sensors could be added to aircraft without the need for additional wiring, minimal impact on power, minimal impact on RF systems, and minimal need for airworthiness recertification.

REFERENCES: 1) NAVSEA 3565, Vol. II – Hazards of Electromagnetic Radiation to Ordinance (HERO)
2) http://www.nasoceana.navy.mil/safety/Explosives%20Safety/HERO%20Brief.ppt#1 - HERO Briefing
3) ISO/IEC 18000-7(E) – Information technology – Radio frequency for item management – Part 7: Parameters for active air interface communications at 433 MHz, 2004 (and related parts to include Part 1: Reference architecture; Part 2: Air interface at 135 kHz; Part 3: Air interface at 13.56 MHz; Part 4: Air interface at 2.45 MHz; Part 6: Air interface at 860 MHz to 960 MHz).

KEYWORDS: Sensors, wireless, Hazards of Electromagnetic Radiation to Ordinance (HERO), low-power, embedded systems

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A07-021 TITLE: High-Speed Non-Intrusive Measurement Techniques for the Visualization of Droplet Clouds

TECHNOLOGY AREAS: Air Platform, Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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OBJECTIVE: The objective of this topic is to develop a high-speed measurement technique and the requisite hardware to support on-going research into water droplet demise through vehicle induced shocks. Measurement parameters of interest include: 3D volume domains, particle velocity and size distributions, shape, and mass as a function of time. Dynamic holography is one emerging technology of interest that has the potential to produce the needed capability, but other non-invasive approaches will be considered in this topic.

DESCRIPTION: Recently there has been a revived effort to investigate the impact of weather on high-speed vehicle performance and durability. These efforts focus on both ascent and descent missile trajectories through cloud formations and storms, sand, dust, and rain erosion on helicopter blades, aircraft components, and IR windows and dome performance during both flight and captive carry. In response to this need, a comprehensive roadmap as been developed by the Army in conjunction with other government organizations to address all relevant areas of research that are needed in order to advance the current state of the art in understanding of weather impact. One such area is in the realm of high-speed instrumentation that can record the demise history of a hydrometeor particle as it transitions vehicle shocks, and also measure the particle size and velocity distributions of randomly distributed particle clouds.

Established measurement techniques such as high-speed video, shadowgraphs, and Schlierens only provide two-dimensional information. Because the analytical efforts show that these events can be highly three-dimensional in nature, additional techniques are required to obtain the needed validation data. This effort will provide crucial support to ongoing Army research into the development of analytical methodologies to predict vehicle weather impacts.
In this regard, the proposed technique will need to capture events that are three-dimensional, only 100 microseconds or less in duration, and can cover a domain of several cubic inches. It is desired that the measurement hardware be either portable to enable measurements at multiple test facilities, or of low enough cost so that each facility can maintain the hardware in their inventories.

PHASE I: The focus of the Phase I effort is to develop and demonstrate a lab-scale prototype system of the basic approach. Performance parameters would be 3-D visualization of an event with velocity and density recorded during the event. The particle size of interest in the Phase I effort should focus on water droplets approximately 0.5 to 4 mm in diameter. Test set-up, planning, and execution can be coordinated through the topic monitors and the small business is not required to have the expertise in weather encounter physics needed to perform the testing.

The Phase I program should also highlight the probable performance, cost, set-up, calibration time, and usage requirements of the expected Phase II system. In addition, the Phase I program should be able to logically transition into the Phase II effort that will begin to extend the single drop measurement to droplet clouds. These clouds could consist of water, ice, snow, sand, or dust.

PHASE II: The Phase II program will develop and demonstrate a full-scale measurement device/approach that can be used in multiple facilities to record 3-D visualization and time histories of single droplet shape, velocity and density. At the end of the Phase II program, developed hardware should be considered as off-the-shelf for various test facilities to purchase.

The Phase II effort will also extend the Phase I single particle measurement capability to droplet clouds. In this phase, particle demise will not be the primary focus but will require the technique to measure particle size distributions, and velocities. The Phase II product must provide a user friendly interface to automatically calculate the mean particle size, the particle distribution function, and the velocity variations as a function of time. The volume required to be analyzed in this effort would be on the order of a cubic foot.

PHASE III: The Phase III use for this topic exists in enabling Government, major aviation/missile system integrators, and subsystem component developers to produce superior aviation and flight systems with sufficient design margin to make advanced systems “all-weather” capable. Such a measurement device is needed at government sled track facilities, both government and commercial sand and dust facilities, and whirling arm test facilities. The Tri-Service Department of Defense Weather Encounter Working Group which is coordinating the research into all areas of high-speed weather encounters has identified the need for such a measurement system as one of their five key technology areas of interest.

In addition to these uses, such a device would be highly desirable for use in the combustion industry to measure the injector spray patterns, design of spray systems for fire suppression, in any industry that requires high precision jetting such as ink jet printers, and in airborne weather collection whereby cloud physics measurements and droplet distributions are needed for research and forecasting.

REFERENCES: 1) N. Kukhtarev, T. Kukhtareva et al., “Double-function interferometer (optical and electrical),” Proceedings of CLEO, 2006
2) V. Krasnoholovets, N. Kukhtarev and T. Kukhtareva, ”Heavy Electrons: Electron Droplets Generated by Photogalvanic and Pyroelectric Effects”, International Journal of Modern Physics:B 20,no.16,2323-2337 (2006).
3) N.V. Kukhtarev, T. Kukhtareva, S.F. Lyuksyutov.M.A. Reagan.P.P. Banerjee, P.Buchhave, Running gratings in photoconductive materials, JOSA B,Vol.22,No.9, 1917- 1922, (2005)
4) N.V. Kukhtarev, T. Kukhtareva, M.E. Edwards, J. Jones,J. Wang,S.F. Lyuksyutov, and M.A.Reagan., “Smart photogalvanic running-grating interferometer’, , J.Appl.Phys V. 97, 054301-1, 2005
5) Hanson, A.R., Domich, E.G., and Adams, H.S., 1963. Shock Tube Investigation of the Breakup of Drops by Air Blasts, Physics of Fluids, 6, pp 1070-1080.
6) Kitscha, J., and Kocamustafaogullari, G., 1989. Breakup Criteria For Fluid Particles. International Journal of Multiphase Flow, 15, pp. 573-588.
7) Matta, J.E., Tytus, R.P., 1982. Viscoelastic Breakup in a High Velocity Airstream. Journal of Applied Polymer Science, 27, pp191-204.
8) Reinecke, W.G., Waldman, G.D., 1975. Shock Layer Shattering of Cloud Drops in Reentry Flight, AIAA Paper 75-152.
9) Waldman, G.D., Reinecke, W.G., Glenn, D., 1972. Raindrop Breakup in the Shock Layer of a High-Speed Vehicle, AIAA Journal 10, 1200-1204.

KEYWORDS: Dynamic Holography, Non-intrusive measurements, High-speed measurements, Disdrometer, Weather encounter, Particle demise, Particulate droplet distributions, velocity measurement

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A07-022 TITLE: <u>Automated Risk Assessment Tool to Optimize Missile System Affordability Management</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Missiles and Space

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OBJECTIVE: Establish approaches and validate an automated risk management tool that is implemented in a secure web-based environment to provide Army Science and Technology managers an efficient means to identify and manage affordability and manufacturing risks of the entire system and its subsystems and components.

DESCRIPTION: In recent years, there has been a strong emphasis on addressing affordability and manufacturing during Army Science and Technology (S&T) efforts to significantly reduce the life-cycle cost of missile systems. Studies show that applying design for manufacturing and affordability principles during the S&T phase of development yields several benefits: robust product design, mature critical manufacturing processes, earlier product presentation, enhanced product quality, and lower total costs. In addition, manufacturing costs, which usually account for 13-25% of life cycle costs, can be considerably reduced. Significant progress has been made on several DOD missile systems to incorporate this concept early in technology development and demonstration efforts by establishing, evaluating, and tracking cost and manufacturing risks and potential risk mitigation paths. However, no decision aides exist to efficiently capture and manage high-level affordability metrics related to manufacturing and integration, assembly and test (IA&T) costs. This knowledge is needed to develop an automated web-based tool to establish, track, and continually assess risks related to cost, material management, manufacturing methods, assembly and test processes, and safety concerns. The proposed tool would be available to all S&T managers as a resource in assessing and increasing the affordability of their programs.

PHASE I: Define and determine the feasibility of the proposed risk assessment tool being developed. Establish validation goals and metrics to analyze feasibility. Identify and gather necessary inputs in preparation for the design effort. These inputs may include but are not limited to the following: generic work breakdown structure (WBS), historical missile cost elements, established risk assessment techniques, and common issues related to missile manufacturing, assembly, and test processes for each WBS element. Establish Phase II performance goals and key developmental milestones for product development.

PHASE II: Design, develop, and demonstrate a working system to validate tool performance as projected to include integration and testing. Provide and implement a final robust tool that incorporates the inputs gathered in Phase I to enable a thorough missile risk assessment with emphasis on cost and affordability as it relates to schedule constraints and performance parameters. The tool should be designed for practicality of use and should be applicable across all missile programs with a modular structure to enable future upgrades. Utilize current missile programs to illustrate the functionality of the tool set and to obtain feedback on its operation and user interface. Prepare a detailed plan for Phase III effort for commercialization and expanding system capabilities to other product domains.

PHASE III: The Phase III use for this topic exists in enabling Government, major missile system integrators, and subsystem component developers to produce affordable, easily manufacturable missile systems and components. Such a tool would be highly useful during the S&T phase of any government program.
In addition to these uses, such a tool would be highly desirable for use in the automotive industry. Many times concept automobiles never make it into production because the end product is too expensive and too hard to manufacture. This tool would allow designers insight into cost issues at the start of the design, and allow managers the ability to steer the team in the right direction.

Two Phase III military applications are currently slated to use this technology: (1) Non-Line of Sight Launch System; and (2) Extended Area Protection System.

REFERENCES: 1) Shroder, Ron and Boykin, Sam, “Decision Support Tools for Collaborative Environments to Enable Affordability for Science and Technology,” 2003 International Symposium on Collaborative Technologies and Systems. http://www.scs.org/getDoc.cfm?id=2077.
2) “Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes,” GAO Report, GAO-02-701, July 2002, pp. 4-5, 22-42.

3) "Technology Transition for Affordability: A Guide for S&T Program Managers," DoD USD publication, April 2001, www.dodmantech.com/pubs/TechTransGuide-Apr01.pdf, pp. 4-7.

KEYWORDS: risk assessment, affordability, missile, manufacturing, cost analysis

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A07-023 TITLE: Embedded Vibration Monitoring and Real-Time Data Analysis and Reduction

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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OBJECTIVE: Develop and demonstrate a low power, embedded sensor platform for collection and real-time analysis and reduction of vibration data. The system should employ real-time processing techniques to extract frequency content and power distribution while minimizing cost and maximizing device operating time.

DESCRIPTION: Most electrical and mechanical equipment are susceptible to some level of vibration and/or shock conditions. Solder joints, connector assemblies, printed circuit boards, and mechanical mounts are common points of failures under vibration stress. When the equipment is designed to exist in harsh environments and is frequently exposed to all levels of vibration this can result in field failures. When the equipment is high value and mission critical, it must be determined if the induced vibration and shock has exceeded the asset's rated threshold, thus necessitating replacement. Conversely, it may be that the conditions indicative of a failure are not yet known and ongoing surveillance and data collection is required to correlate failures with actual vibration and shock stress. Ongoing, persistent collection of vibration and shock data is required to study these conditions and make quantitative conclusions of equipment health.
This effort is to develop a small, low-power, low-cost vibration sensor capable of collecting, storing and analyzing vibration event data when a user defined threshold level is exceeded (e.g. any event greater than 2g, aggregate power above some threshold, or power in a given frequency range above a threshold). Vibration data must be made available post-capture for analysis and visualization using standard equipment and techniques; and the device must have a standard and widely available interface (such as USB or RS232) for post-collection data extraction and device configuration. The device must be capable of being mounted on an asset, recording vibration events over extended periods, and must adhere to the following specifications (battery included):

Frequency Range: 0.1Hz – 1000Hz
Frequency Resolution: 10Hz
Magnitude: 0.1g – 5g
Maximum Mass: 500 grams
Maximum Volume: 10 cubic inches
Maximum Cost: $500 per unit in large quantities
Minimum Operating Time: 6 months or 50 vibration events powered with two AA batteries

In low-cost, resource-constrained, embedded sensing applications such as this, designers must often balance conflicting requirements for system cost, operating time, storage capacity, and processing power. Parameters are often interdependent. For example, current solutions store all raw acceleration samples to flash memory which require a prohibitively large capacity flash memory. This tends to increase system cost and power consumption. An improvement would be to perform in-system real-time signal processing such as Fast Fourier Transforms (FFT) to extract frequency content and power distribution. The data could then be further post-processed to store only maximum power levels at each frequency point for a given time window, thus resulting in smaller data sets. This would minimize flash memory capacity, but would also require greater processing capabilities which could impact both system cost and power consumption.
Successful proposals should discuss tradeoffs between degree of real-time signal processing, processing capabilities, memory capacity, system cost, and battery life.

PHASE I: Develop system design that includes sensor specification, details of signal processing, event and data storage capacity, mechanical dimensions, overall device mass including battery, and expected battery life. A well-defined Phase II development and demonstration plan must be generated.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility and accuracy compared to some gold standard vibration monitoring device. Demonstrate battery life and capacity over extended operating conditions.

PHASE III: Successful execution of Phase I and Phase II will result in an autonomous vibration analysis module. Based on military trends for including in-system diagnostics on tactical military assets and vehicles, this module could be included directly in next generation missile programs and incorporated in upgrades to existing programs. Missiles which integrate vibration and health monitoring capabilities enable the warfighter to screen missiles which, based on measures of mishandling, may be prone for field failure and misfires -- promoting higher mission success rates. Also, data obtained from such a system can used to develop more reliable systems which would decrease frequency and costs of logistics responses to platform component failures due to vibration.

The technology has high commercial potential as well. There are currently no direct alternatives and trends suggest that low power, in-system monitoring and diagnostics have a niche with shipping industry. The systems could be coupled with temperature and humidity measurements to be used as quality of service assurance in freight shipping and delivery applications where sensitive cargo is in transit. Shippers can provide a guarantee with a quantitative measure of meeting that guarantee. It is also expected that a corollary business could develop by utilizing the systems in test and measurement applications where size and battery power are valued.

REFERENCES: 1) MIL-STD-1670A, Environmental Criteria And Guidelines For Air-Launched Weapons.
2) Matthew, S., Health Status Assessment Methodology for Electronic Hardware, MS Thesis, university of Maryland. 2005.
3) Spanos, P.D., Failla G., Wavelets: Theoretical Concepts and Vibrations Related Applications, Shock and Vibration Digest. 2005.

KEYWORDS: Sensors, Vibration, Fast Fourier Transforms (FFT), Signal Processing, Real-Time Signal Processing

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A07-024 TITLE: <u>High Strength, High Modulus Nano-Composite Missile Structures</u>

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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OBJECTIVE: Develop a lower density alternative to 7075 Aluminum for structural components in Army missile systems. The material should be suitable for low cost manufacturing techniques (e.g. compression molding) and demonstrate a tensile modulus of at least 10 Msi, a tensile strength of 60 ksi, and a density of less than .060 lbs/cu.in.

DESCRIPTION: Recent advances in materials and processes for carbon fibers, polymers and nano-composites provide an opportunity to reduce the weight of Army missile systems. The high specific strength of polymer composite materials offers significant advantages to tactical missile systems. While most applications of fiber reinforced polymer composite materials in missiles have utilized continuous fibers, chopped fiber composites present the missile designer with more capability to remove system weight. Many of the structural components in Army missile systems are aluminum. Current composite materials and processes for discontinuous fiber reinforcement have not been optimized. The Army would like to have at the capability to integrate chopped fiber composites to replace aluminum components and reduce system weight.

PHASE I: Identify, analyze and test the fibers, polymers and processes with the potential to match the strength of 7075 aluminum. The targets for the new composite material are a modulus of 10 MSI, a tensile strength of 60 ksi, and a density of less than .060 lbs/cu.in. The properties should be attainable using low-cost manufacturing processes such as compression molding.

PHASE II: Define a representative missile system component for Phase II demonstration. Establish processing parameters and fabricate components to verify mechanical properties. Fully characterize and document the materials and processes for insertion into Army systems.

PHASE III: The new composite material and processes will have application in various Army missile systems including Advance Precision Kill Weapon System (APKWS) and Joint Common Missile (JCM). The most likely funding source within the government will be aviation and missile programs that place a premium on weight. Many aircraft and missile structures are currently made from aluminum. This material could replace the aluminum and reduce weight by 20-30%. The technology will likely be transitioned through a commercial composite raw materials manufacturer that will supply a major defense contractor for integration of the material into into new systems and existing system upgrades. Other defense applications include urban assault weapons, man portable combat systems, tube launch systems, airframes, aviation platforms and various other tri-service applications. The materials and processes will also have broad commercial application from bicycles to laptop computers.

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KEYWORDS: composite materials, chopped fiber, compression molding, high strength, high modulus

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A07-025 TITLE: Nano-composite for Impact Mitigation in Composite Missile Systems

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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OBJECTIVE: Develop impact damage mitigation for composite missile systems. Nano-composites offer an opportunity to exploit the energy dissipation potential within abundant nanomaterial to matrix interfaces. Damage mitigation should be demonstrated on filament wound carbon fiber composites with 60% fiber volume.

DESCRIPTION: Recent advances in the field of nano-materials provide the opportunity to improve the impact resistance of carbon fiber composites. The high specific strength of polymer composite materials offers significant advantages to tactical missiles but impact damage poses a threat to the structural integrity of composite missile systems. Nanocomposites present the material designer with many options to research the potential for energy absorption. The large surface area of nanoparticles and the development of surface treatment methods should lead to tailored interfaces and functionality. The challenge lies in the incorporation of improved functionality within the bounds of current filament winding and other automated composite manufacturing techniques.

PHASE I: Develop an impact mitigation material or system for integration into current composite missile fabrication techniques. Demonstrate feasibility in missile case analog carbon/epoxy pressure vessels through a combination of analysis and testing. Focus should be on residual strength after impacts of 5 to 15 ft. lbs. A trade study should be conducted to demonstrate the impact damage mitigation versus increase in cost, weight and thickness.

PHASE II: Define a representative missile system for Phase II demonstration. Establish processing parameters and demonstrate impact mitigation in analogs of a composite missile system. Conduct testing to prove feasibility over extended operating conditions and document material characterization and material processing techniques.

PHASE III: Impact mitigation will be necessary in any future tactical missiles such as the Advance Precision Kill Weapon System (APKWS) and Joint Common Missile (JCM). Other defense applications include urban assault weapons, man portable combat systems, tube launch systems, airframes and various other tri-service applications. This material system could be used in a broad range of military and civilian applications where carbon fiber composites are used – for example, aircraft wings, helicopter rotor blades, composite storage tanks, etc.

REFERENCES: 1) Impact behaviour of fibre-reinforced composite materials, Reid, S. R. (Stephen Robert), 1945- Boca Raton, FL : CRC Press/Woodhead Pub., c2000.
2) Analytical Methods for Assessing Impact Damage In Filament Wound Pressure Vessels, Chian-Fong Yen, et.al. SAMPE 1999 – Long Beach, CA May 23-27, 1999
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4) “Progressive Failure of Thin Walled Composite Tubes Under Low Energy Impact,” Yen, C., Cassin, T., Patterson, J., Triplett, M., U.S Army Missile Command, 1997.

KEYWORDS: Impact damage, Composite materials, energy absorption, nanocomposites, rocket motor case.

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A07-026 TITLE: Cheap Miniaturized Intelligent Wireless Missile Sensor Platform

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Develop a one-cubic-inch embedded sensor platform that operates for 15 years to provide missile health monitoring suitable for harsh military environments and ammunition safety.

DESCRIPTION: Army missiles must be reliable for use after long term storage up to 15 years with occasional exposure to harsh environments during deployments and return to stockpile. Existing technology for missile health monitoring is still too large and expensive for smaller missiles. Small missiles require reliable, smaller, cheaper and more intelligent health monitoring solutions. The ideal solution will monitor temperature from -50 C to +85 C every six hours, relative humidity from 0% - 100% every six hours, shock and vibration events (+/- 250g) resulting from transportation/handling twice per year; accept inputs from remote sensors (not included in the volume or power requirements); support Hazards of Electromagnetic Radiation to Ordnance (HERO)-safe wireless interrogation and firmware upgrades; provide data storage for up to 3 years of data between interrogations; operate for up to 15 years on a single D-size battery with assumed energy of 19 ampere-hours; be completely maintenance free (including no battery replacement); cost less than $100/unit (not including battery) assuming production quantity of one thousand; and is no more than one-cubic-inch in volume (not including battery or any external antenna.) Low-power operation shall be a critical element in proposal evaluation. Proposals may propose other power sources as long as they are safe for use in missile applications. It is absolutely required that all proposals meet HERO safety requirements and support the TR-AMR-SG-06-34 communication protocol.

PHASE I: Identify and propose an optimal concept for miniaturizing a complete missile health monitoring system that meets the above requirements. HERO safety and support for TR-AMR-SG-06-34 communication are absolutely required. The contractor shall propose trades in other capabilities. Reliability, unit cost, and ability to operate in harsh military environments shall be key considerations. The solution may incorporate any commercially available technology. The Phase I proposal must identify all elements of the system that are not commercially available and clearly describe how they will be developed. The Phase I proposal must describe a plan for integration of all elements of the system.

PHASE II: Develop and demonstrate at least one operational prototype system in a realistic environment. Software source code that implements the TR-AMR-SG-06-34 protocol will be provided for information only to Phase II awardees. This software may be copied. An interrogator (which implements TR-AMR-SG-06-34) will be provided as Government Furnished Equipment.

PHASE III: The final end state for a phase III product is a one-cubic-inch sensor platform with temperature, humidity and accelerometer sensors that operates for up to 15 years in harsh military and industrial environments. Such a system could be applied to a broad range of civilian and military applications, including monitoring of commercial shipping containers, vehicles, aircraft, missiles, and long-term storage monitoring such as warehoused goods. Two key military applications are unmanned aerial vehicles (UAVs) and the Joint Common Missile (JCM). The UAV condition based maintenance program requires small volume, lightweight sensors to effectively monitor key vehicle parameters and provide input for Condition Based Maintenance (CBM) maintenance actions. The UAV program office is actively pursuing CBM technology. The JCM has a system requirement for missile health monitoring with small volume and low-power operation to monitor critical environmental parameters, especially during captive carry missions. Other Army aviation and missile systems could also use this product for similar CBM, reliability centered maintenance (RCM) and missile health monitoring applications.

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KEYWORDS: health monitoring, prognostics, wireless, sensors, reliability, missile, embedded systems, Hazards of Electromagnetic Radiation to Ordnance (HERO)

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A07-027 TITLE: Development of a Fuel Gel Formulation Using Nano-sized Particulates for Tactical Bipropulsion Systems

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Demonstrate combustible nano-sized fuel gellants for gelled bipropulsion systems exploiting the properties of nano-sized materials to increase the volumetric performance and decrease the weight of gellant required.

DESCRIPTION: Gelling liquid propellants have significant safety and performance advantages. Gelled Inhibited Red Fuming Nitric Acid (IRFNA) and gelled MonoMethyl Hydrazine (MMH) have vapor pressures lower than the OSHA limit for Immediate Danger to Life and Death. Gelling the liquid also immobilizes the propellant, prevents spills, and minimizes the evaporation rate. Tanks filled with gelled IRFNA and gelled MMH have passed fast cook-off, slow cook-off, bullet impact, and shaped charge jet Insensitive Munitions (IM) tests. Gelled propellants can be formulated with high-energy solids that will maintain homogeneity for the lifetime of the system. IRFNA gel, gelled with fumed silica, is considered our baseline gel. Tertiary amine-based fuels are being developed to replace MMH. Commercially available nano-sized particulates have been used to gel a variety of liquids such as water, hydrocarbons, and MMH. As the diameter of the particle decreases, the specific surface area of the particle decreases, which increases its gelling capability. Combustible gellants provide additional energy to the formulation, which increases volumetric performance. The goal of the program is to develop a gelled tertiary amine-based fuel formulation, using combustible nano-sized particles. This formulation will have a higher volumetric performance and a lower gellant concentration than the corresponding fumed silica gel. Volumetric performance is defined as the product of the propellant density and specific impulse.

PHASE I: At least three combustible nano-sized particulate gellant candidates will be developed. The goal of Phase I is to demonstrate that the candidates will pass the standard Army developed leak test. Passing this test requires a gel formulation not to leak from a 7” high tank with a 0.5” hole in the bottom. The liquid fuel to be gelled is a mixture of two tertiary amines that will be identified by the Army. This test is performed at 25° C. The volumetric performance of the candidates will be determined by using a standard thermochemical code.

PHASE II: The goal of Phase II is to develop a baseline fuel gel that optimizes volumetric performance and physical properties. Gel formulations, using the liquid fuel identified in Phase I, will be formulated with the three candidate gellants to determine the new baseline formulation. Formulations will be made with different sized particulates of each candidate to determine the effect of particle size on gel strength. Surfactants will be screened to determine if they increase the yield point, G’ (storage or elastic modulus), G” (loss or viscous modulus) of the gelled candidates at room temperature. One of the three gellant formulations will be chosen as the baseline gel. The physical properties of the baseline fuel gel will be fully characterized between -50° C and + 65° C. The dependence of volumetric performance on the ratio of oxidizer to fuel mass flow rates ob the baseline fuel gel will be experimentally determined during engine tests using the baseline gels and compared to that predicted by a standard thermochemical code.

PHASE III DUEL USE APPLICATIONS: The fuel gel developed on this program could be used in Army tactical missiles, MDA missile interceptor Divert and Attitude Control (DACS) systems, and a variety of NASA manned and unmanned applications.

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Pein, Roland “Gel Propellants and Gel Propulsion,” Fifth International High
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KEYWORDS: Nano-particles, bipropellant fuels, fuel gel, gel physical properties, gel rheology

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A07-028 TITLE: Secure, Lightweight, Tamper Proof, Cable Technology

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: In missile and aviation platforms, weight is a critical factor. Create a new reconfigurable cable harness technology to reduce weight, provide anti-tamper through encryption for data signals and create a near “universal cable.” A reconfigurable cable also has the potential of providing built in test functions, cable operation assessment, and cable maintenance. A reconfigurable cable with spare connections, offers the potential of self healing to cable damage.

DESCRIPTION: All U.S. Army Program Executive Offices (PEOs) and Program Managers (PMs) are now charged with executing Army and Department of Defense (DoD) anti-tamper policies in the design and implementation of their systems to afford maximum protection of U.S. technologies, thus providing maximum protection against them being obtained and utilized and/or exploited by foreign adversaries. One area of vulnerability is in the electronics of the weapon system, 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 to provide useful toolsets to the U.S. Army PEOs and PMs for employment in their systems. 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.

The goal for the “universal cable” concept is to develop a more secure cable harness architecture and reduce cable weight at the same time.

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 create a technology demonstration for a “universal cable.” The input signals for the technology demonstration cable shall consist of (1) ten low speed, on/off, low current discrete control signals (3 to 5 volts for on, and 0 to 0.6 volt for off), (2) five asynchronous serial communications signals at a maximum of 56 kbits/sec, and (3) two 4 to 20 mA, low speed analog, control signals (assume a 48 dB dynamic range). Contractor shall design a “universal cable.” The cable controller shall convert all inputs to digital, provide for forward error correction, encrypt the data, send over a triple redundant high speed serial communications links to a second controller and convert all data back into the original form. Second controller shall incorporate a voting algorithm to handle a single failure in high speed serial data cables. All digital inputs and outputs should be reconfigurable. Analog signals may be “hard-wired” to a specific set of connection pins. A field programmable analog array could potentially provide reconfigurable analog inputs and outputs for the universal cable. Contractor may use commercial connectors for Phase I feasibility. Ruggedized, military specification, connectors are not required for Phase I. Contractor shall provide a detailed report describing, the hardware, software, and test results for the “universal cable.”

PHASE II: Contractor shall design a universal cable for a medium complexity missile or avionics cable system. Government shall provide the contractor with several possible cable diagrams and specifications and the contractor shall select one for development and testing. Cable will consist of a number of discrete (on/off), low speed digital data, low bandwidth analog control signals, and one analog or digital video signal.

Contractor shall develop a reconfigurable cable for both analog and digital signals. It is suggested that the contractor allow reconfiguration within two banks: (1) digital and discrete signals and (2) low speed analog control signals. Other signals, and power supply wiring, may be handled separately.
To the extent possible, contractor shall combine as many of the data signals onto a high speed triple redundant serial communications bus.
Contractor shall also develop a prototype high speed optical link. Contractor shall provide a paper on the feasibility of using a triple redundant high speed serial optical link for the universal cable.
Contractor shall investigate the potential of the reconfigurable cable providing built in test functions, cable operation assessment, and cable maintenance. Contractor shall investigate the potential for cable self healing using spare wires.
Contractor shall design and test the cable and electronics to meet the electromagnetic compatibility/radiated electromagnetic emissions of MIL-STD-461E.
Contractor shall design and test cable for operation at air pressures over the range of -1500 feet (e.g. below sea level) to 50,000 feet above sea level across temperature ranges of -50 degrees Celsius to +80 degrees Celsius according to MIL-STD-810F. A built in thermostat controlled heater may be used to achieve the lower temperature range for the electronics, if necessary.
Contractor shall perform a reliability and safety critical design review to ensure the cabling technology can attain a flight certification rating. Software, firmware, and reconfigurable logic, for the universal cable shall be developed according to FAA DO-178B. Certifications for compliance to MIL-STD-461E, MIL-STD-810F, and FAA DO-178B shall be required in Phase III to bring the technology into "general" use.
Contractor shall develop a fault tree analysis for the cable system including mechanical and electrical hardware, software, firmware, reconfigurable logic, etc. Contractor shall include failure probabilities for each node. Contractor shall provide a report on reliability and safety critical issues for the cable design including mechanical and electrical hardware, software, firmware, reconfigurable logic, etc.
Contractor shall provide a report describing the potential of creating a group of intellectual property blocks to implement the universal cable controller inside avionics equipment for use by government prime and subcontractors.
Contractor shall provide a final report on the development, testing, lessons learned and suggestions for future research and development for the universal cable. Contractor shall have an independent verification and validation (IV&V) for the "universal cable." IV&V report shall include a section comparing the old legacy cable technology (advantages and disadvantages) to the new universal cable technology (advantages and disadvantages). Contractor shall provide an IV&V report.

PHASE III: The final outcome of Phase III will be a reconfigurable "universal" cable technology to address the weight and volume challenges from aviation and missile systems. A cable controller will consist of electronics, software, and a configuration file. The cable controllers will allow the connection wiring to be modified by a simple change to the configuration file. A custom cable can be assembled from standard parts and configured for a specific application. System upgrades and wiring changes between line replaceable units can be made with a simple change to the configuration file. To reduce maintenance and testing costs, the smart cable controllers will provide cable built in testing features. To improve the reliability of the cable, the cable controllers will provide self healing to cable damage.

A traditional aviation or missile cable requires a flight worthy certificate for use. For flight, the universal cable requires a software certification in addition to the standard shock, vibration, and temperature certifications. Phase III "universal" cable development level shall provide documentation and certifications according to MIL-STD-461E, MIL-STD-810F and FAA DO-178B.
Some systems that will benefit from the "universal cable" technology are Apache III and Non-line of sight (NLOS) systems.

Defense contractors are likely collaborators to bring the cable to production. The intellectual property (IP), software and firmware components, from the "universal cable," can be licensed for use by defense and commercial contractors for integration inside systems. Contractor is encouraged to team with a prime government contractor(s) to bring the universal cable technology into general use in the missile and aviation industries. Contractor is also encourage to develop a commercial and industrial "universal cable" for use in consumer electronics, industrial controls, or communications (television, network, multimedia) industries.

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KEYWORDS: Electronics, field programmable gate arrays, system-on-a-chip, cable harness, high speed serial link, anti-tamper.

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A07-029 TITLE: Missile/UAV Dispense Interference Modeling

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: To develop innovative techniques to minimizing/eliminating the interference between UAVs and missiles during the missile dispense process.

DESCRIPTION: Missiles delivered from UAVs are potentially potent force application scheme. An affordable precision strike system is an obvious advantage to the war-fighter. The large scale use of UAVs as weapons platforms is quickly becoming a reality.

The effectiveness of the use of missiles fired from UAVs is currently limited by the dispensing technique of the missile from the UAV. This process must be accomplished with a minimum disturbance imparted to the UAV platform from the missile dispensed from the platform. This interference can be eliminated/minimized in a number of ways, e.g., missile motor design, platform ejection technique, etc.

Recent advances in multi-body stage separation processes can be evaluated using both advanced analytical computational fluid dynamics techniques and a new dynamic stage separation facility that allows dynamic weapons separation techniques to be accomplished in a ground test facility.

This solicitation seeks innovative techniques for minimizing/eliminating the interference between the missile/UAV in the dispense process.

PHASE I: Phase I proposals must demonstrate (1) a thorough understanding of the Topic area, (2) technical comprehension of key missile/UAV interaction problems. Technical approaches will be formulated in Phase I to minimize interference between UAVs and missiles during the missile dispense process.

PHASE II: The technical approaches formulated in Phase I will be developed and refined for full scale, free flight validation testing, in a Government owned/contractor operated ground test wind tunnel facility using instrumented tunnel models at a fidelity level deemed appropriate at that time. Tunnel time will be provided as GFE; tunnel models will be developed under Phase-II.

PHASE III: If successful, the end result of this Phase-I/Phase-II research effort will be validated tools for the analyses, by AMRDEC, of store dispense from UAVs.
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 UAV/store geometries, aerodynamic properties, and performance parameters.
For military applications, this technology is directly applicable to the dispense of stores, such as guided missiles and medical supplies, from UAVs. Examples include Hellfire/Predator, Viper Strike, and Quick-Meds.
For commercial applications, this technology is directly applicable to the dispense of stores from fixed wing flight vehicles such as water bombers, agricultural spray aircraft, and emergency rescue/supply aircraft.
The most likely customer and source of Government funding for Phase-III will be those service project offices responsible for the development of stores specifically for UAV dispense as they have the greatest need at this time. Indeed, the expansion of UAV capabilities and missions throughout the armed services continues as one of the most promising areas of research as evident in Reference 3 which forecasts a combined service and industry near term investment of over $20 billion.

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KEYWORDS: UAV, missile, dispense, interference

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A07-030 TITLE: Wide Waveband, Large Aperture, Trichroic Beamcombiner

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: The objective of this topic is the development and application of a large aperture tri-band beamcombiner to support the testing of multi-band co-aperture sensors within a Hardware-in-the-Loop (HWIL) simulation environment.

DESCRIPTION: In the past, optical beamcombiners supporting stressing two-color IR HWIL simulation requirements employed materials and processes for the optical combining of wavebands stretched across the visible-to-infrared region only. Today's sophisticated missile sensors have combined the all-weather radio frequency sensors, the higher resolution imaging infrared sensors and the man-in-the-loop near-infrared semi-active laser sensors into a common aperture tri-band system. To support the testing of these sensors, HWIL simulation environments must look at a new breed of optical beamcombiners. Large aperture (24-36") substrates compatible with high transmission of both the near-infrared (1.064?m) and millimeter wave (Ka-band) must be integrated with coatings which will support the transmission of these bands along with high reflectance in the long-wave infrared (8-12?m). Many existing LWIR reflective coatings are not compatible with the transmission of these other two widely separated bands. Issues associated with proper adhesion and durability must also be considered for these new coatings.

PHASE I: Explore the feasibility of developing a large aperture optical beamcombiner which meets the specifications above. Evaluate innovative coating materials and approaches which may be used to build the beamcombiner and perform trade-off analysis to determine the best approach. Develop a preliminary design for the beamcombiner substrate and coatings. Perform modeling and analysis to establish the proof-of-principle and predict the performance specifications for the final element. Prototype small-scale coating demonstrations should also be performed within the Phase I period.

PHASE II: Perform a detailed design of the concept selected in Phase I, and fabricate a full-scale prototype beamcombiner. Demonstrate and characterize its performance in an actual HWIL environment. Government furnished equipment items, such as NIR, LWIR, and RF sources can be used in the evaluation and testing of the prototype.

PHASE III: Commercial applications for advancements in the multi-spectral coating technology might be found in the fire protection, satellite surveillance and aircraft industries. Infrared and radio frequency sensors have long been employed across such industries with dual and tri-mode integrated solutions emerging quickly. Key advancements in wide waveband coating technologies can be rapidly propagated across such industries lowering costs and opening new markets and applications. The development of novel wide waveband optical coatings will facilitate such innovation across both defense-related and commercial industries. Successful completion of the Phase II program will provide a demonstration of the tri-color beamcombiner coating on a substrate of a size sufficient to support implementation into government and commercial test and research centers focused on assessing the performance capabilities of existing and emerging tri-color sensor systems. A Phase III application would be immediately available within the existing Department of Defense government test facilities responsible for the assessment of such tri-color missile systems. Likewise, many commercial missile manufactures have, or are working on, tri-color sensor systems: Raytheon for PAM and Lockheed for JCM. These efforts create a direct need for such coatings both within the missile hardware as well as the test equipment necessary to evaluate the sensor in-house.

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2) Technologies for Synthetic Environments: Hardware-in-the-loop Testing XI, Proc. SPIE, Vol. 6208, April 2006 – "The infrared and semi-active laser simulation capabilities at the AMSTAR tri-mode system simulation HWIL facility".

KEYWORDS: multi-spectral, coatings, near-infrared (NIR), millimeter wave (MMW)

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A07-031 TITLE: Boron Nanotubes for Ultra High Strength Light Weight Composites

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop a high-volume manufacturing capability for boron nanotubes.

DESCRIPTION: Currently, no high-volume method of manufacture exists for producing boron nanotubes. Boron nanotubes are materials that are in the very early stages of development. Few publications with theoretical predictions regarding synthesis, processing and properties are available and few research teams in the world are experimentally working to synthesize boron nanotubes. However, of the work that has been done, it is shown that boron nanotubes have exceptional properties - very strong covalent bonds (to impart high strength to materials), pure metallic properties (high thermal and electrical conductivity, malleability, etc.) and corrosion resistance.

Currently, carbon nanotubes are the state-of-the-art. However, carbon has limitations. Its cell wall structure and variable conductivity make it unreliable as a conductor. Thus, only one-third of the carbon nanotubes produced are conductive. The rest that are produced are a mix of structures. Additionally, boron is lighter than carbon, so greater achievements in developing light-weight structures can be obtained.

There is no high volume method of producing boron nanotubes. Thus, a method of producing them, using them in light-weight composites and for corrosion-resistance needs to be developed.

PHASE I: Based on an assessment of promising methods for producing boron nanotubes, identify the most promising methods of production using experimental analyses and theoretical literature searches. Provide a coherent plan, and rationale, for building a prototype reactor that demonstrates the feasibility of producing boron nanotubes. This may be accomplished through both laboratory experimentation and theoretical analyses. It is acceptable to draw parallels between boron nitride nanotube production and boron nanotube production. Additionally, work done in Phase I should answer questions regarding the proper handling of boron nanotubes to prevent material degradation and the proper testing of boron nanotubes to ensure that high quality and desired physical characteristics are met. This Phase I will demonstrate the feasibility of producing, handling and characterizing boron nanotubes.

PHASE II: Construct and demonstrate the operation of a prototype reactor to produce boron nanotubes. Characterize nanotubes for physical properties.
Use nanotubes in composites. Test mechanical, thermal and electrical properties.

PHASE III: Military applications include the Light Weight Small Arms Technology Demonstrator (LSAT) and the Man-Portable Robotic Systems (MPRS) program. Follow on work will entail developing more uses for boron nanotubes such as light-weight composites and electronics. Since boron is lighter than carbon and has better oxidation resistance, it should be useful for high-temperature, high-strength structural applications for aviation, electronics and automotive. The additions of carbon to aluminum and titanium metal to strengthen them has been hindered by the fact that carbon forms a galvanic cell with the metals and corrodes the composite. Boron is inert and should not create a galvanic cell with light weight metals such as aluminum and titanium thus, increasing the range of engineering materials that can be produced for various markets. Finally, boron has excellent thermal conductivity and good dielectric properties, which make it possible to produce low-loss electronic components. Low-loss components produce less heat and use less energy than high-loss components. To summarize, boron nanotubes have the potential to improve the strength and reduce the weight of structural materials and improve the performance of electronics.

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D. Ciuparu, RF Klie, Y. Zhu, L. Pfefferle, J. Phys. Chem B 108 (2004) 3967

KEYWORDS: Boron nanotubes, experimentation, theoretical analyses, handling, material degradation, physical characteristics, testing

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A07-032 TITLE: Multi-Agent Based Small Unit Effects Planning and Collaborative Engagement with Unmanned Systems

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design, develop and demonstrate innovative algorithm/processing technologies and software/hardware component technologies required to support manned/unmanned teaming and autonomous collaboration between 2 or more unmanned systems (UMS) (both air and ground) engaged in small unit mounted/dismounted effects based operations in order to achieve collaborative engagement and effects delivery on targets with Line of Sight (LOS) and Beyond Line of Sight (BLOS) fires, given appropriate operator approval of target engagement, automated air/ground space deconfliction and conformance checks with commander's attack guidance/intent.

DESCRIPTION: Armed UMS are beginning to be fielded in the current battlespace, and will be extremely common in the Future Force Battlespace. As currently configured, armed UMS require a single human controller to operate, and all collaboration between UMS human controllers typically must be moderated by an effects center in order for collaborative engagement to be performed between UMS. This configuration is not satisfactory in terms of effective usage of manpower at present, and it does not provide rapid collaboration for time critical targeting of elusive targets. As more armed UMS systems are fielded in the Future Force, the potential exists for a need to have a single operator or controller managing multiple types of these systems. This type of control will be done at higher order task levels, rather than the traditional teleoperation mode. This will lead directly to the need for the systems to be able to operate autonomously for extended periods, and also to be able to collaboratively engage hostile targets within specified rules of engagement. It is envisioned that the real time collaboration and dynamic re-planning for target engagement would take place autonomously between UMS based on pre-mission planning profiles generated prior to mission initiation, with final decision on target engagement being left to the human operator. This implies a high level pre-mission/task planning capability and a management by exception paradigm whereby the UMS collaborate autonomously for target engagement and present their decision to the human operator for final approval. Fully autonomous engagement without human intervention should also be considered, under user defined conditions, as should both lethal and non-lethal engagement and effects delivery means. The collaborative engagement capability should be developed as a distributed hardware/software processing component or components capable of insertion into multiple software architectures, and capable of use in multiple operating systems, to include real time embedded operating systems interfaced with on-board sensor, controller subsystems.

PHASE I: Investigate innovative agent based collaboration, mixed initiative planning and real time intelligent control methodologies to determine best algorithm and architecture approach to meet the topic requirement. Develop and document the overall software component design and accompanying algorithms for autonomous collaborative target engagement. Demonstrate a proof of principle of the design by showing a mission thread which allows 2 or more UMS to collaboratively engage a hostile target array, both with and without human intervention

PHASE II: Develop and demonstrate a prototype capability for insertion into a realistic, current force/future force compliant fires and effects architecture. Conduct testing to demonstrate feasibility of the component for operation within a simulation environment, and with actual UMS platforms in a hardware-in-the-loop and man-in-the-loop network configuration..

PHASE III: Phase III will result in a prototype tool that will support ARDEC initiatives in the area of Small Unit Network Lethality including user experiments. The topic author envisions spin-off to support SOCOM/Current force applications as well as transition to support Future Force Warrior/FCS. The algorithms and software developed under this effort will have dual use applications in all domestic security operations where UMS are used. Homeland Security operations such as the Border Patrol, airport security, and FEMA could use this capability in responding to urban security incidents or natural disasters. This capability can be used by Search and Rescue teams performing search and rescue operations. Local, county, state and federal SWAT teams can also use this capability and technology for SWAT operations which use UMS. This capability can also be used by private security companies which use UMS to provide industrial security at power plants, chemical plants, transportation centers, etc.

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KEYWORDS: Collaborative engagement,Unmanned Systems,Fires and effects,Autonomous operations, agents, intelligent systems, robotics, artificial intelligence

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A07-033 TITLE: <u>Miniaturized, Low-cost Processing and Software/Hardware Component Technology for Near Real-time Structure Mapping for Urban Combat Special Operations</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: This topic solicits R&D to design, develop, prototype and demonstrate innovative algorithm/processing techniques, and hardware/software component technologies required to perform automated mapping of the internal and/or external structure of a multistory building, cave complex, or ship; and share this mapped structural data in near real time to all members of a 10-12 man assault unit within a situational awareness context.

DESCRIPTION: Soldiers within the Future Force, and those in the current force engaged in combat operations must be able to quickly reduce opposition within urban environments while minimizing friendly force casualties in urban combat. This requires tremendous situational awareness and knowledge of the urban terrain. One of the key technologies required to achieve the required level of urban situational awareness and urban terrain knowledge is the ability to quickly map the internal structures of buildings and identify potential threat objects and personnel and disseminate this data to each leader and soldier participating in combat. This must be combined with the ability to track blue forces within the urban structure so as to provide complete situational awareness for urban combat. The capability must be designed so as to be either man portable or capable of being used on an unmanned air or ground robotic system (UMS) which can be inserted into the combat environment to perform the structure mapping. Data collected by the man portable or UMS-mounted system may be processed on the system and then shared to other systems in the network, or may be transmitted back to another system in the small unit team for processing and dissemination to other team members.

PHASE I: Investigate innovative real time broadband ultra-wide band sensor, sonar, multi-sensor processing and 3-D image reconstruction algorithms and processing architectures suitable for autonomous mapping of internal building structures and recognition of objects/personnel of interest using standard PC based processor technology. Develop and document an innovative low cost hardware/software component design approach and accompanying algorithms for automated structure mapping and object recognition. Demonstrate a proof of principle of the design by showing a mission thread which allows a soldier/UMS to collect structure/threat data, translate this data into a map, and disseminate the map across a radio network in near real time, along with blue force tracking data for individual soldiers and UMS.

PHASE II: Develop and demonstrate a prototype hardware/software capability for insertion into a realistic, Joint Technical Architecture/ Future Force compliant Small Unit Situational Awareness operational architecture. The component must be capable of seamless integration and operation within the JTA/Future Force Operational architecture and provide fully implemented component level API's and system level messaging interfaces. Conduct testing to demonstrate feasibility of the component/application package for operation within a steel and concrete urban environment

PHASE III: The end state of this research will a small, low cost networked sensor/processing system capable of mounting on a small UAV, UGV or dismounted soldier or individual and capable of automated and/or operator initiated 3-D mapping and transmission of interior/exterior building structure information as well as objects of interest to a remote C2 node. Capability would be used by Special Ops or Future Ground Soldier to support building reconnaissance/clearing, counter IED, EOD and urban ops. Likely transition is to FFW and Ground Soldier System and to current force under REF. Potential commercial applications of this structure mapping technology are search and rescue, site security, law enforcemen, real time mapping and navigation applications. This product/capability mounted on a robotic platform can be used by Search and Rescue teams performing rescue operations in collapsed buildings and structures by mapping passageways, doors, openings,windows, and obstructions.

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KEYWORDS: Situational awareness,Structure mapping,Collaborative data,Unmanned systems,geospatial reasoning,3-D visualization

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A07-034 TITLE: Harvesting Energy for Wireless Sensor Networks

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: To research and develop alternative energy sources for application in wireless sensor networks.

DESCRIPTION: Current wireless sensor networks are typically powered by batteries. This approach is acceptable when it is feasible to replace batteries or when it is acceptable to discard sensors after the batteries have run down. However, if individual sensors are difficult to get to (e.g. in hostile territory), or if the sensor network consists of a large number of nodes distributed over a large geographic area, then it may not be possible to replace batteries when required. A self sufficient power source deriving its power from the environment and thus not requiring any maintenance would be very desirable in these instances.

In order for any system to be self sufficient, it must harness its energy exclusively from its surrounding environment and store this harnessed energy for later use. Under most conditions the amount of power obtained can be expected to be quite small, thus application will be limited to small duty cycle applications to allow for self sustainable operations (for example transmits data / collect data for 50ms out of every minute while harnessing energy the rest of the time).

In the context of military sensing/surveillance node placement may be in difficult to reach locations and may need to be hidden. This precludes the use of solar cell technologies because light is typically not available. Methods of energy harvesting that might be applicable to the problem at hand may include systems utilizing random vibration (e.g vibrations near a roadway), temperature gradients (e.g. ground temperature is fairly constant sufficiently below the surface), or any other phenomenon that could be exploited to provide energy. The most desirable solutions will be those that are functional in the greatest number of different environments.

Wireless sensor networks systems in battlefield environments have brought enhanced capabilities to the war fighters. They are a critical component within the military because they provide a way to remotely obtain and monitor intelligence, surveillance and reconnaissance information. Self sufficient operation would allow for sensors to be emplaced and run indefinitely.

PHASE I: Design a novel energy harvesting system based on research and analysis of autonomous sensor networks and energy harvesting technologies. The power must be derived exclusively from the environment. To be useful in the context of sensor arrays a time averaged power output of greater then .5mW with peak consumption around 500mW for short times is required. Additionally, space should be conserved and final proposed solution should be less then 200cc. It should be determined in which environments the energy harvesting systems function and the corresponding conditions required to meet the given requirements and achieve self sustained operation.

PHASE II: Fabricate a prototype and demonstrate that the given requirements are satisfied. Develop a prototype of autonomous sensor integrated with energy harvesting technology and demonstrate the ability to harvest energy and be self sufficient.

PHASE III: Wireless sensor networks combined with energy harvesting technology will enhance the system and transition it into the next generation of sensor networks. But sensors would not be the only one to benefit. Possible applications of energy harvesting technology are endless. This innovation can be rigged to meet specifications of many sensor types, as well as other energy demanding products in the military and commercial industry. Phase III effort involves integrating the results into existing military and commercial applications.

The end state of this research is to eliminate all army military batteries or at least reduce the frequency of replacing batteries, especially for wireless sensor networks. Candidate systems include the FCS unattended ground sensor systems, such as the Intelligent Munition System and Tactical Unattended Ground Sensor System Program, that have a requirement to detect personal. Transition of this technology would be directly to PM-Close Combat Systems and PM-Robotic and Unmanned Systems that are developing each system, respectively.

Some examples of commercial applications include placing wireless sensor networks to monitor the health of buildings and bridges (vibrations, strength, cracking and stress). Farmers can place wireless sensor networks to monitor the health of their fields (temperature, soil condition, moisture, etc). Similarly, factories can monitor the health of machines; doctors can monitor their patients and police can monitor their areas. In all these applications, sensors collect data and transmit them to the owner. In some applications, sensors are placed in hard to reach locations, like in buildings and bridges, and in enemy territory. And in other applications, sensors save time by automating tedious and costly data collection tasks. Sensors monitor the health continuously and provide early warning signs, detect abnormalities and spot the developing problems so that they can be fixed before it's too late.

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KEYWORDS: Harvesting energy, sensors, wireless network sensors,

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A07-035 TITLE: Miniaturized Electrical Initiation Systems for Miniature Thermal Batteries

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a multifunctional micro-scale electrical igniter for initiating miniature thermal batteries. The device must be designed to allow for low-cost mass fabrication techniques. A multifunctional igniter must combine inertial activation with electric ignition in a micro-scale platform suitable for initiating miniature thermal batteries that power gun-launched smart munitions or small missiles.

DESCRIPTION: Significant micro miniaturization of thermal battery igniters is required for use with the emerging miniature thermal batteries needed to power smart munitions. Flexible and conformal thermal batteries for submunition applications will occupy volumes as small as 0.006 cubic inches (100 cubic millimeters). This small thermal battery size is similar in volume to the igniters being used today in macro-scale thermal batteries. Traditional electric igniters for thermal batteries typically require some external power source and decision circuitry to determine a launch condition and send an electrical pulse to initiate the pyrotechnic materials using the heat generated by a resistive wire. These devices are used because they are much smaller than inertial based igniters, but they require some external power source and circuitry, which limits the applications to those with multiple power sources. The desired devices should be 50% smaller than traditional electrical igniter systems, and should eliminate the need for an external battery. Thermal battery igniter in general must function when subjected to setback forces in the approximate range of 500-to-50,000 “g”. An igniter design with the capability to adjust the ‘no-fire and all-fire range’ to meet multiple predefined setback environments will expand the application set to encompass many different types of ordnance and will be considered a major plus. The technology should demonstrate electric initiation of Zr/BaCrO4 heat paper mixtures or their equivalent, similar to what is used in current thermal batteries. The proposed technology must also demonstrate the capability to maintain at least a 20-year shelf life as well as the capability of operating over the military temperature range.

PHASE I: Produce a complete design for Miniaturized Electrical Initiation System for Miniature Thermal Batteries.

PHASE II: Develop a prototype Miniaturized Electrical Initiation System for Miniature Thermal Batteries that demonstrates desired operational requirements.

PHASE III: The multifunctional micro-scale igniter will be integrated as a component part of several emerging miniature thermal battery designs for use with gun-launched smart munitions which could include those under PM MAS with MRM, PM CAS with PGK, or PM Mortal with PGMM. On the commercial side, safe and low power thermal batteries with a very long 10-20 years of shelf life would be ideal for emergency powering of communications, flash lights, or other similar electrical and/or electronic devices.

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KEYWORDS: Inertial Igniter, initiation, smart munitions, mass fabrication; micro-scale; thermal battery; smart munitions

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A07-036 TITLE: Novel Gun Hardened Low-Drift High-Resolution Miniature Angular Acceleration Sensor

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: The objective is to develop a novel non proof mass concept for rugged and sensitive, gun-hardened, low drift, miniature angular acceleration sensors. This sensor must have a high sensitivity and dynamic range, low power requirements, survive 50kGs of acceleration, and operate over the military temperature range.

DESCRIPTION: Current munition angular sensors rely on a proof mass, which suffers from several restrictions, including a low dynamic range, low sensitivity, as well as being relatively bulky and consuming a high amount of power. On top of this, current sensor technology requires a significant amount of settling time for the sensor to settle within acceptable limits following shock loading. The introduction of MEMS technology in recent years has made it possible to reduce the size of the proof mass significantly, independent of the accelerometer type and mechanism of operation. However, all existing accelerometer designs still suffer from the previously mentioned operational and/or performance deficiencies, which are all unwanted characteristics of using a proof mass based system as an angular acceleration sensor.

We have examined numerous approaches based on a lightly or freely sprung proof mass to sense acceleration in a gun-hardened environment, which do not perform adequately, and therefore are looking for a novel approach to overcome the following limitations of current sensors through elimination of proof masses.

There is a need to develop a novel sensor that is sensitive enough to provide accurate measurement of a desired parameter, such as acceleration, and yet rugged enough to withstand the severe shock loading found in a gun-fired environment. Furthermore, there is a need to minimize, or eliminate the settling time, while providing a solution that low drift (<3 degree/hour) and a sensor capable of being miniaturized (to a volume of < 400 mm3) and easily manufactured with common methods and materials. This novel sensor must be capable of operating over the military temperature range, and exhibit a high dynamic range (> 100 dB) while consuming significantly less power (<20mW). In addition the technology should be chosen to allow for common manufacturing techniques and materials that will allow for a significant cost reduction from currently available components.

PHASE I: Develop and demonstrate the feasibility of a component-level design concept for this novel non proof mass inertial angular acceleration sensor for use in gun-fired environments. During the Phase I period of this project, the feasibility of the proposed concept should be demonstrated by extensive analytical modeling and simulations of the behavior and performance of the concept, including predictions, sensor performance, and experimental data from concept prototype if possible. The concept must demonstrate the likelihood to survive accelerations kGs minimally and with an objective of surviving up to 50kGs. In addition, the concept should compare how this sensor could meet or exceed the currently available solutions in performance, power requirements, reliability, temperature performance, cost, size, and survivability.

PHASE II: Design, fabricate and test a complete system-level angular acceleration sensor for use in a gun-fired environment based on the analysis from phase I. The developed sensor is to be tested for survivability and performance in an appropriate munition application, and if needed their design modified to ensure survivability of up to 50,000 Gs. Develop design documents and drawings sufficient to support the design, manufacture, test and evaluation of the first production model of the developed angular acceleration sensor.

PHASE III: As part of the Phase III efforts, the design of the developed angular acceleration sensors for munitions can be finalized for selected munitions and preproduction prototypes fabricated for test and evaluation first by air guns then by actual firing. The developed angular acceleration sensors will also have a wide range of dual use commercial as well as other military applications.
On the military side, the end vision includes IMU (inertial measurement unit), instrumentation, and inertial guidance elements for precision guided projectiles and missiles, more specifically applications could include those under PM MAS (Program Manager Maneuver Ammunition System) under the MRM (Mid Range Munition) program, PM CAS (Combat Ammunition System) under the PGK (Precision Guidance Kit), or PM Mortar's PGMM (Precision Guided Mortar Munition) and common guidance ATO (Army Technology Objective). The form of the technology will be structured so as to be capable of adapting to both fielded and developmental programs. Additionally the technology will be applicable to both Army and Navy gun systems, allowing mutually economical benefits based on required quantities. On the commercial side applications may include automobiles, planes, ships, and personal navigation units.

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KEYWORDS: IMU, INU, angular, accelerometer, sensor, miniaturization, high G, hardening

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A07-037 TITLE: Miniature Steerable Laser Range Finder for Small Arms Airburst Ammunition Systems

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: To design and develop innovative methods for laser range finder pointing control mechanisms suitable for use in small arms applications to compensate for gun positioning jitter.

DESCRIPTION: The next generation of infantry weapons will include small arms capable of delivering air bursting ammunitions over considerable ranges. These weapons will be equipped with sophisticated target acquisition/fire control systems (TA/FC). Two of the key functions of the TA/FC system are to provide the soldier with a ballistic-compensated solution to the target and to program the ammunition to detonate at the required target range. In order to accomplish these tasks, the TA/FC system needs accurate range information to the target. This information will be provided by a laser range finder integrated with the TA/FC system. However, it will be up to the soldier to accurately aim the laser range finder at the enemy target of interest. Enemy targets will in most cases be in motion, and usually visible for a very limited amount of time. Accurately aiming the TA/FC laser range finder to these targets will be further complicated by the environment in which modern infantry soldiers operate. Such an environment includes bright flashes of light, extreme loud noises, witnessing of severe injuries and loss of life, etc. It is well know that the stress generated by these combat experiences produces physiological effects that are detrimental to fine motor skill dependent activities such as marksmanship. For example, studies have shown that the heart rate of a soldier in combat can reach upwards of 300 beats per minute, well above the typical maximum of approximately 200 beats per minute experienced by elite athletes in competition. Additionally, both respiration rate and muscle jerk response increase. These well known physiological effects significantly degrade a soldier’s ability to obtain an accurate range to the target which diminishes the effectiveness of air bursting ammunition weapons.

To facilitate the soldier's task, a target tracking component has been developed and integrated into the TA/FC system. The tracking component assists the soldier in locating the targets of interest in the scope view. While this component is helpful in locating targets, the soldier is still faced with the task of accurately aiming the laser range finder to the target. It is highly desirable to augment the tracking capabilities already present in the TA/FC system with a miniature steerable laser range finder to assist the soldier in obtaining an accurate range to the target. The purpose of this topic is to design and develop such a laser range finder. A comprehensive trade-off analysis must be performed among the candidate technologies in order to produce a design that meets the significant constraints of the target small arms application. The minimum desired (i.e. target) specifications for effective performance are: angular steering range of -/+ 4 mils; accuracy of 0.05 mils; frequency response of 2 Hz; operational range of 500 meters. All these requirements apply simultaneously to azimuth and elevation angles. Due to the limited volume available in the TA/FC system, the volume of the proposed steerable laser range finder should not exceed that of a non-steerable one by more than 25mm x 25mm x 25mm. Finally, the proposed steerable laser range finder should be rugged enough to withstand conventional operational conditions found by infantry soldiers.

PHASE I: Design a compact, rugged, actively steerable laser range finder system suitable for small arms. Compare possible options to factors including but not limited to volume, survivability, power consumption, integration issues and accuracy. Provide results of proof of principle breadboard experimentation and demonstration with a road map indicating implementation to a relevant existing weapon system. From this study down select to actuator candidate technology for transition to Phase II.

PHASE II: Build prototype system, integrate to relevant air burst munitions weapon system and test in a relevant environment. Through live fire testing, demonstrate improvement in lethality performance at various ranges. Through environmental testing, demonstrate system ruggedness and reliability.

PHASE III: The end state of this research in Phase II would be a laser steering technology amenable to qualify for supporting an advanced Army air bursting munitions under the auspices of the Army Individual Small Arms Strategy Plan. In Phase III the prototype would be integrated into current fire control systems such as those that would be mounted on the Individual High Explosive Airburst Weapon System and/or the Advanced Crew Served Weapon System. Further potential applications are not limited to the firing control of air bursting munitions weapons. Low-volume, cost-effective, actively controllable laser range finders can have wide applications in a variety of commercial markets where obtaining an accurate range or velocity measure to a distant target is desired. In the civilian market the proposed technology could be used to enhance speed guns used by traffic police, to achieve precise alignment for satellite communications, to enable conformable optical mirrors to track a signal, or to provide an enhanced ability to quickly "paint" a moving object.

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KEYWORDS: Steerable Laser Range Finder, Beam Steering

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A07-038 TITLE: Novel High Control-Authority Impulse Based Micro-Actuation Technologies for Steering Guided Munitions

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a novel large force and high speed actuation device for guiding next generation subsonic and supersonic munitions

DESCRIPTION: Since the introduction of 155mm guided artillery projectiles in the 1980s, numerous methods and devices have been developed for the guidance and control of subsonic and supersonic gun launched projectiles. A majority of these devices are based on technologies derived from missile and aircraft applications and are difficult or impractical to implement on gun-fired projectiles and mortars. In recent years, alternative methods of actuation for flight trajectory correction have been explored, some using smart (active) materials and micro-electro-mechanical (MEMS) technology. Many existing approaches suffer from one or more of the following shortcomings; 1) a limited and in some cases fixed amount of large force and high speed actuation capability, 2) require a considerable amount of battery-based power to operate, 3) occupy relatively large munitions volume and (4) cannot be implemented in munitions with very high setback accelerations of over 60KGs. A need therefore exists for the development of innovative, low-cost technologies that address these restrictions in a manner that leaves sufficient volume inside munitions for sensors, guidance and control, and communications electronics and fusing, as well as the explosive payload to satisfy the lethality requirements. To achieve the goals of the next generation actuation systems for munitions, the amount of force (torque) that the actuation device can apply and its speed of operation have to be significantly increased and methods have to be found to better integrate the actuators into the munitions structures. The focus of this SBIR project is the development of a new actuation device that is intended to be used primarily to actuate flight control surfaces such as fins and canards in munitions by applying forces (torques) of up to 500-2000 N (2-10 N-m) or more, with the peak actuation force (torque) achieved within 5-10 msec or less, and withstanding very high setback accelerations of over 60 KGs. The proposed novel concept and technology should reduce weight and occupied volume (50% or more) compared to the current (electrical) actuator device/system. The proposal must consider the cost and manufacturing as well as survivability issues, particularly the harsh launch environment.

PHASE I: Design a novel large force (torque) and high-speed actuation device that meets the parameters for use in next generation guided munitions. Analytical and/or numerical models should be used for calculating the performance of the design parameters.

PHASE II: Develop a prototype device based upon the optimum design from the modeling and simulation efforts for the selected munition. Perform wind tunnel tests on the device to validate the performance of the high force and high speed actuation components. Design and fabricate final prototype based on the results of the laboratory and wind tunnel tests.

PHASE III: The end vision of this SBIR effort is the insertion of the new novel actuation device for PM MAS (Program Manager Maneuver Ammunition Systems) (MRM (MidRange Munition) and PM CAS (Program Manager Combat Ammunition Systems (Mortar). Other military applications include UAVs (Unmanned Aerial Vehicle), UGVs, (Unmanned Ground Vehicles), guided flares and other air dropped sensor platforms. In the area of homeland security, the device can be used on low and high-flying UAVs, air dropped guided reconnaissance or sensory platforms as well as in commercial applications such as those used by the entertainment industry or by hobbyists.

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KEYWORDS: micro actuation, impulse, high control authority, real-time maneuver, high-G survivability, guided munitions

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A07-039 TITLE: Probabilistic Physics-based design of Composite (and Novel) Materials & Structures for pre-defined Hi-Reliability and Life Expectancy

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Improve the reliability of the commercial and military grade advanced composite structures by developing a probabilistic, physics-based approach for design of such structures in the hostile, diverse and uncertain military environments. The approach must allow for practical, effective, and efficient design of composite structures for a predefined reliability level and life expectancy in a full comprehensive range of environmental exposures for 5 to 30 years.

DESCRIPTION: In all disciplines of engineering, including structural engineering, the integrity of a design is the primary consideration since the consequences of product failure can be catastrophic. Historically, the design process has been deterministic in nature, i.e., has assumed that all pertinent quantities, such as loads, material properties, and dimensions, were basically unvarying. Uncertainties in the knowledge of the specification of such quantities were dealt with indirectly through the use of safety factors. It is increasingly being recognized that the traditional deterministic approach is no longer adequate. This is particularly true in design of advanced composite components. The accurate prediction of reliability requires increasing emphasis on accuracy and realism in analytical modeling. The required accuracy and realism can only be obtained by adequately accounting for uncertainty, usually by characterizing pertinent parameters as random variables, i.e., as quantities which are not deterministic and which actually exhibit statistical variations. Typical parameters include fiber wash, fiber waviness, ply thickness, ply omission, ply strength, applied mechanical loads, delamination crack parameters (e.g., size, location, number densities) and the impact threat variables (e.g., mass, velocity, contact area, impact angle). The probabilistic-based progressive damage model to be developed and demonstrated during this project will enable engineers and designers to produce safer, more reliable, and more affordable designs in a variety of industries in both DOD and commercial applications.

PHASE I: Specify the parameters needed in a model for a novel, probabilistic, physics-based design of composites. The phase I effort will produce the following deliverables: 1) a description of key failure modes for composites and novel materials used by the Army and the DOD, 2) a description of weaknesses exhibited in existing deterministic models, 3) a comprehensive plan to eliminate weaknesses in existing deterministic models, and 4) preliminary probabilistic, physics–based approaches for design of composite structures.

PHASE II: Phase II will result in a prototype model. The activity in phase 2 will include 1) final selection of all pertinent failure modes that require elimination and/or control, 2) development of new physics-based mathematical models to describe these failure modes 3) development or implementation of a comprehensive approach for modeling uncertainties, 4) development of comprehensive probabilistic models describing failure modes, 5) development of comprehensive damage models for prediction of reliability, 6) development of a comprehensive a probabilistic-based design approach for composite structures with multiple failure modes and large number of variables, 7) technology demonstration using a real world example(typical program problem).

PHASE III: This phase will concentrate on application and commercialization potential. This will be achieved by developing software using the proposed approach and then integrating it with commercially available software tools. The integrated software will be fully verified and validated and will be available in a Prototype design system using physics and rules based models integrated with probabilistic SW codes such that commercial and DOD industries and associated Government and Academic institutions can apply the capability to design and analysis of composite structural design challenges/problems.
The Transition end-state for this research will be characterized by providing matured Design and Process enhancement techniques/methods/strategies etc. along with our "application-specific" Models and Simulations to the PM/PMO/RDEC researchers and developers for such applications as Novel Composite materials for Medium and Large Caliber gun and ammunition applications, Individual Body armor, New Light weight protection for vehicles and structures; Light weight, high strength materials for weapons applications, and of course to compliment the suite of low cost materials supporting non-lethal systems and munitions.

Since various PEO/PM offices have endorsed the technology program, numerous applications can be defined. PEO-ammo has requested, with their endorsement, that once successful progress is made, they will look for multiple applications/transitions in Ammunition, ranging from light weight shoulder-fired rockets to many evolving new applications for Multi-mode indirect fire, Direct fire lethality, weapon components and packaging systems. The potential for reductions in weight, cube, and enhanced, maintenance free composites with LW High strength composites and Novel materials open the window to many such specific applications.

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2) J.W. Gillespie Jr. "Initiation and De lamination of Thick Section Composites", University of Delaware, Impact on Composites Symposium 2002.
3) J.W. Gillespie (Univ. of Delaware), "Micro mechanical Properties of Novel Organic Fibers", Fiber Society Annual Mtg 2005. "Practical Applications of Probabilistic Technology",
4) Mohammad Khalessi and Hong Zong Lin. "Engineering Design Reliability Handbook", CRC Press; "Weakest Link Probabilistic Failure", Brice N. Cassenti; "Accelerated Life Testing for Reliability Validation", Demitri B. Kececioglu

KEYWORDS: Uncertainty, Probabilistic physics-based, Time-dependent failure, fatigue-life Predictions, Crack initiation and growth, crack nucleation, crack nucleation life distribution, multi-axial stress states, fiber waviness, ply thickness, ply omission, ply strength, applied mechanical loads, impact stresses, delamination crack parameter, probabilistic-based progressive damage model, service life, degradation mechanisms, manufacturing robustness, manufacturing capacity, manufacturing productivity, manufacturing cost, manufacturing efficiency, manufacturing processes process improvement, manufacturing productivity, manufacturing quality, manufacturing environment, manufacturing materials, manufacturing coatings, Seamless Engineering Design M&S integration architecture, collaborative engineering architecture.

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A07-040 TITLE: High-flux electronically generated thermal neutron source for radiographic applications

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design, develop and demonstrate a compact, light-weight, high-flux, electronically- generated neutron source
for radiographic inspection of munitions. The flux rate should meet or exceed 10^8 neutrons/cm^2/sec at 1 meter from the source.

DESCRIPTION: Use of traditional photon (x-ray, gamma ray) beams for radiographic imaging of munitions has limitations. Namely,these short wavelength beams of electromagnetic radiation are efficiently scattered and/or absorbed by high the high density steel casing. Energies in the MeV range are required to penetrate five inches of steel. Such energetic photons do not interact well with the lower density explosive charges within the shell. Use of a thermal neutron (on the order of 0.025eV) particle beam eliminates much of this problem because the heavy and electrically neutral neutrons pass easily through high density materials but are also efficiently absorbed by low density materials (i.e., parafin, nylon, energetic materials) (Ref 1). Neutrons also interact with small volumes of low density material causing them to emit characteristic radiations. Some munitions ncorporate paper liners which can only be inspected with neutron radiography. Thus, neutron radiography ideally compliments X-ray inspection of materials that involve high density materials (steel) surrounding lower density materials (energetics).

The challenge to date has been that suitably small, portable, high-flux sources are not feasible or readily available. The Army manufactures munitions by the thousands and representative samples must be quickly inspected. A radiographic flux of 10^8 neutrons/cm^2/sec over an area large enough to cover ½ of a 155mm projectile is required to produce usable images in a reasonable exposure time.

Radioisotopes, such as Californium 252, have been used successfully as sources for neutron radiography. Cf 252 has a relatively low flux output and a short half-life (2.65 years) which limit its usefulness. Safety constraints and regulatory requirements are additional impediments to more widespread use of radioisotope sources. Accelerator sources based on the fusion of deuterium or tritium have been developed (Ref 1,2,3) with the deuterium-tritium (D-T) reaction being the most useful for neutron radiography. These sources are small hermetically-sealed tubes with an ion accelerator section and a metal hydride target impregnated with tritium. Deuterium ions from an external gas supply are accelerated towards the target at about 130 keV. The reaction produces alpha particles and 14.1 Mev neutrons. The neutrons are thermalized by an external moderator, such as paraffin, which reduces their energy to about 0.025 eV. A key advantage of these sources is that they are electronic. Emission stops when the source is turned off. Although the generated flux may be high enough for ARDEC's application, it is reduced by a factor of 100 to 1000 by the moderator. Also the metal hydride target is eventually eroded. Beam output falls as erosion occurs, increasing exposure time and limiting operational life time to a few hundred hours before the tube must be replaced.

The Army (Ref 4)and other agencies (Ref 5) have used such neutron generators in the inspection of helicopter rotor blades and lithium-aluminum alloys. The blade consists of a low density composite honeycomb structure inside the higher density metal foil, and as such, it presents an inspection problem similar to one ARDEC has with munitions. Neutron radiography has been used to successfully detect non-uniformities in the epoxy, de-laminations, broken fibers, and moisture within the blades. Lithium-aluminum alloy tubes are used in the production of tritium. The neutron generator developed by the Army for rotor blade inspection was successfully used to map the post-extrusion location of the lithium-aluminum alloy core within the aluminum tube. The flux of the generators used in these studies was on the order of 10^6 n/cm^2/sec. While this was adequate for the inspection of a relatively small number of rotor blades and alloy tubes, it is inadequate for the much larger number of munitions to be inspected.

This solicitation is for development of a novel neutron generator which has a high flux rate and long life time. The generator should be compact, relatively light in weight, and the flux rate of thermalized neutrons should meet or exceed 10^8 neutrons/cm^2/sec at 1 meter from the source. In addition, the generator should have a long useful lifetime or easily replaceable source material.

Military and civilian applications of such a generator may include, but are not limited to, use as a laboratory neutron radiography source and use as a battlefield source for neutron activation analysis (NAA) in improvised explosive device (IED) identification and defeat.

PHASE I: Prove principle by investigating the feasibility of developing a compact, light-weight, high-flux, electronically generated neutron source by either modifying an existing unit (to be supplied by the contractor) or by developing a new design/technology unit. Rationale that the design will meet the requirements must be clearly presented and substantiated.

PHASE II: Develop and fabricate the prototype neutron generator designed in Phase 1. Testing will be done at the contractor's facility prior to delivery. Demonstration is to be performed at ARDEC's radiographic laboratory.

PHASE III: Military application includes inspection of large and small munitions containing energetic materials within metallic casings as well as providing for IED detection and defeat. Other homeland security applications include inspection of containerized cargo and baggage inspection. Medical applications include treatment of tumors and body composition assessments.

End Vision: Following successful development and validation, neutron 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 NDT standards munitions plants will be required to adhere to in subsequent acquisitions.

REFERENCES: 1) Nondestructive testing handbook, 2nd edition, V3 Radiography and Radiation Testing; American Society for Nondestructive Testing (1985)
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3) http://www.lbl.gov/Science-Articles/Archive/neutronGenerator.html
4) John J. Antal, et al, The application of neutron radioscopy to lithium-aluminum alloy target elements, U.S. Army Materials Technology Laboratory report MTL TR 90-18, ADA221386 (1990).
5) M. Balasko, et al, Classification of defects in honeycomb composite structure of helicopter rotor blades, Nuclear Instruments and Methods in Physics Research A 542 (2005) 45-51.
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KEYWORDS: thermal neutron, neutron generator, neutron radiography, neutron activation analysis

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A07-041 TITLE: An Algorithm for Obtaining Bearing Information from a Single Triaxial Seismic Sensor

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Conduct research into obtaining (direction of arrival) DOA estimates utilizing a single triaxial seismic sensor. Develop an algorithm for obtaining bearing information for seismic events such as walking, or vehicles. The events of interests are close to the sensor (< 100 m) and principally surface waves.

DESCRIPTION: Several existing approaches to the seismic event localization exist. Over large distances the epicenters of earthquakes can be estimated by exploiting the time difference of arrival times between different seismic stations. Array techniques are also used for the task of gun fire localization. However, there are additional approaches available to seismic direction finding that are not available to acoustic modalities. This is due primarily to the fact that shear forces in the ground allow for more diverse modes of propagation. Of particular interest in this SBIR is the possibility of exploiting some other feature of the incoming seismic waves to obtain directional information over short distances. Over large distances this approach is simpler to implement due to the fact that different modes of propagation travel at different speeds, however it may prove more problematic for short distances (of the order of tens of meters) and/or the types of events desired (vehicles, walking, etc).

If it were possible to obtain DOA information from a single three axis seismic sensor then tracking at shorter distances might be possible with substantially fewer nodes. Additionally DOA information obtained could be utilized in other algorithms such as tracking, and classification.

PHASE I: Tasks to be completed in phase I include: Collecting recordings of the various types of events; Research what existing approaches (if any) are applicable; Identify the modes of propagation most prevalent when the ground is driven by various stimuli; Develop an analytical model that is in agreement with the observed data; Use the developed model to propose an algorithm that gives a robust estimate for direction of arrival; Verify the algorithms performance.

The types of events can include walking, wheeled or tracked vehicles, and could be in any environment including an urban environment or in a field. The distances from the sensors to the stimuli in question will not exceed 100m and will be driven at the surface. Possible solutions should not require any sort of ground characterization.

PHASE II: Develop and implement a hardware prototype capable of giving bearing information. The hardware selected should be of minimal complexity. An example of a suitable processing platform might be a Renesas 16 bit processor. Algorithms developed in phase I should be simplified where necessary to achieve these goals.

PHASE III: Military application includes incorporating the algorithms and technology developed in phase I and the hardware developed in phase II into an already existing military system(s). Candidate systems include the FCS unattended ground sensor systems, such as the Intelligent Munition System and Tactical Unattended Ground Sensor System Program, that have a requirement to detect personnel. Transition of this technology would be directly to PM-Close Combat Systems and PM-Robotic and Unmanned Systems that are developing each system, respectively.

Information obtained from completion of Phases I and II would also be of great importance in the field of geophysics and would have applications in monitoring of seismic events, e.g., the discrimination of earthquake vs. quarry blasts. This technology would also enhance techniques for exploratory seismology in the petroleum industry and in the field of civil engineering.

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2) Mamadou Sanou Diallo, Michail Kulesh, Matthias Holschneider, Frank Scherbaum, Frank Adler,. "Characterization of polarization attributes of seismic waves using continuous wavelet transforms" http://users.math.uni-potsdam.de/~hols/DFG1114/01-2005-Geophysics(eng).pdf
3) Keith Aki, Paul G. Richards, "Quantitative Seismology", University Science Books Sausalito, California

KEYWORDS: Seismics, Sensors, Situational Awareness, Algorithms, Direction of Arrival, Tracking.

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A07-042 TITLE: Visible to Short Wavelength Infrared Hyperscope for Armaments

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Ammunition

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

OBJECTIVE: Design, develop and demonstrate hyperspectral armament capabilities for real-time target detection, tracking, and identification so as to give the individual warfighter real-time threat detection advantage.

DESCRIPTION: New mission requirements drive the need for smaller and lighter weight imaging sensors but with more capability than the current generation of sensors. Hyperspectral sensors collect image data simultaneously in a large number (>15) of narrow, adjacent spectral bands. The processing of the spectral content improves the Signal-to-Clutter Ratio by making use of the differences in the spectral energy content of the targets and background radiation. The collection and processing of the spectral data in real-time provide an enhanced capability to the warfighter for target detection, identification and tracking, thereby increasing the situational awareness in complex operational terrains including urban areas. Hyperspectral sensors collect a large amount of data at the rate of 10’s of Mbytes/sec and as such 10’s of Gbytes/scene data consisting of co-registered images from many spectral bands. Naturally, parallel processing of these image cubes (i.e., x, y, wavelength) is required to reduce the time delay in making the information available. This solicitation is for the design and development of a compact, low weight and efficient visible-to-short wavelength infrared (VSWIR) hyperscope that integrates recent advances in imaging hardware, hyperspectral data analysis and parallel data processing.

PHASE I: Design a practical and advanced uncooled large spatial format self-contained visible-to-short wavelength infrared (VSWIR) hyperscope, possibly making use of concepts such as Micro-Electro Mechanical Mirrors and micro-lenses. The design will address the following specifications:

Number of spatial pixels per hyperspectral image: greater than or equal to 512 x 512, preference is 1K x 1K;
Number of spectral bands: greater than 15;
Hyperscope overall physical size: less than or equal to 200 cubic centimeters;
Hyperscope weight: approximately 1 lb including rechargeable integrated battery;
Integrated battery operation: minimum 1hr operation;
Power dissipation: 8-10 Watt;
Auxiliary Power Supply: belt wearable of approximately 118 Watt Hour capacity;
Mounting: configurations to include – handheld, helmet mount, and rifle mount (e.g. Picatinny rail);
Operation: day/night continuous operation;
Acquisition/processing rate: minimum of 50 hyperspectral cubes/sec with a goal of 60 per sec;
Processing: processor software shall differentiate targets from background, and highlight and display targets within the context of the full image at the cube rate;
Algorithms: Contractor should select existing algorithms or develop new ones that can optimally differentiate targets such as unexploded ordnance, friend from foe, buried mines, lenses, snipers, etcetera from background;
Display: 1280x1024 color micro display with auxiliary remote display;
User Interface: The user interface must not exceed more than four user inputs.
The deliverable of Phase 1 is the design document of the VSWIR hyperscope that meets the above specifications.

PHASE II: Develop, demonstrate and deliver a prototype VSWIR hyperscope for collecting, analyzing, and displaying hyperspectral images of at least 16 spectral bands meeting the specifications described above for Phase I along with the design document, user manual, and maintenance manual for the prototype. The software algorithms in the integrated processor must operate at the acquisition rate, displaying the results on the integrated micro-display and on the auxiliary remote display. The prototype must be available for field testing as specified by ARDEC at the time of delivery. Deliverables shall include quarterly progress reports and a final report.

PHASE III: In Phase III, the VSWIR hyperscope will be transitioned to both commercial and military markets. The hyperscope will be used for real-time detection of multiple targets. The hyperscope will replace military optical scopes used on rifles and other places. The hyperscope can be used on Unattended Air Vehicle and Unattended Ground Vehicle In addition, the VSWIR Hyperscope will be tested for applications including Homeland Security functions such as the Border Patrol, airport security, and Federal Emergency Management Agency in responding to urban security incidents or natural disasters.
PEO Ammuntion Full Spectrum Effects Package is a likely candidate for this technology.

REFERENCES: 1) Christopher P. Warren, Michael Friend, Arleen Velasco, John Hinrichs, Charles Carleton, Michael Duncan, Jonathan Neumann, "Miniaturization of a VNIR Hyperspectral Imager," Proceedings of SPIE, Imaging Spectrometry XI, Volume 6302, Sept. 1, 2006.
2) Algorithms and Technologies for Multispectral, Hyperspectral and Ultraspectral Imagery XII, eds. S.S. Shen, and P.S. Lewis, Proceedings of SPIE, (all papers) Volume 6233, 2006.

KEYWORDS: Hyperspectral scope, visible-to-near infrared images, hyperspectral image analysis, parallel processing

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A07-043 TITLE: Compact HF Antenna

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Design electrically large, physically small (less than 500 cubic centimeters; largest dimension <30 centimeters; weight <500 grams; transmit and receive performance equivalent to or exceeding the current whip and long HF antennas in the frequency range of 2 to 30 MHz with instantaneous bandwidth of 3 kHz or more. The HF antenna will be portable by individual warfighter without significantly affecting his endurance and agility and provide a reduced profile to opposing forces.

DESCRIPTION: The number of possible applications in which a soldier or vehicle would require a tactical antenna are increasing. The difficulties lie at the core of Antenna design physics. Antennas that radiate at the desired frequencies (as defined in the objective) are typically large, bulky "bull's eyes" for the enemy.

The driving force behind this effort is not a specific application, but rather for a core technology that would be beneficial to any number of possible applications. This is not aprocurement effort, and therefore requires that any proprietary technology to be applied in the design phase of the program be developed ebyond current capabilities of that technology. For example, simply applying a previously developed material solution to a "vanilla" antenna design is not an acceptible solution.

Desired gain of the device in radiating mode would be at least 3 dBi, and a relatively narrow beam width and handle 1 kW of pulsed power.

Please note that any application this antenna would be applicable to in current or projected Army programs would be in a high power broadcast, Directed Energy application. Areas of the highest importance are beam control, broadcast power handling, and relative efficiencies in the desired broadcast range. The use of this antenna for receiving signals is secondary.

PHASE I: Identify the materials and design of an antenna that meets the technological parameters defined in the Objective and Discussion of this solicitation. Compare materials and designs as relates to size, weight, and functionality.

PHASE II: Design and build a prototype antenna system to be evaluated. Provide recommendations based on the testing of the device. Provide test methodology such that Army Evaluators can verify performance.

PHASE III: Military applications include TALON based anti-personnel or anti-material applications, providing an antenna small and light enough to be transported via robot, sight blinding, Comm denial and Active Denial to Personnel System. Civilian applications can be any that require antennas and have a need or desire for smaller, lighter, less obtrusive devices.

PEO IEW&S and PM SW will be provided with progress reports and will be invited to attend design reviews and major milestone meetings in order to provide their input. In the event that representatives are unable to attend, breifing materials and action items (and resolutions) will be provided. Successful Phase II Technologies/Designs will also be showcased to Military Program Offices during ARDEC Annual SBIR Technology Showcase in order to ensure that any potential Military customer is exposed to the technology.

REFERENCES: 1) http://home.datacomm.ch/hb9abx/loop1-e.htm
2) http://www.realhamradio.com/Log_Periodic.htm

KEYWORDS: Antenna, HF, Small, Lightweight, Design, manufacture

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A07-044 TITLE: SUAV/SUGV Based Automated Geo-location and Hand-off

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

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Conduct research and advanced technology development to demonstrate the algorithms and software/hardware component technology required to perform automated target geolocation, designation and hand-off for precision cooperative engagement by Future Force/Current Force small unmanned air/ground robotic systems and individual soldiers in support of small unit dismounted operations and current force special operations.

DESCRIPTION: The Future Force small combat unit will possess a wide range of organic and highly deployable manned/unmanned assets that can deliver line-of-sight and beyond line-of-sight fires and effects on time sensitive targets and targets in defalade in urban and complex terrain. This capability allows the Future Force small combat unit to harness a balance of organic direct fires, LOS, BLOS fires with reachback to NLOS, joint and Army fires support capabilities to ensure optimal delivery of desired effects on time sensitive/time critical targets. The key to success is the ability for the dismounted soldier/leader to coordinate and synchronize, in real time, the diverse and versatile mix of manned/unmanned sensor/shooter assets to acquire, geo-locate and deliver desired networked effects on target. Accurate and automated target geolocation, designation and hand-off from manned/unmanned sensor/shooter assets through the small unit fires and effects network is a major building block in the synchronization and delivery of fires and effects. This requires development of innovative algorithm approaches such as embedded intelligent agents/ "assistants," on SUAV/SUGV platforms/controllers, that are able to quickly and accurately geolocate/lase threat targets, correlate, and employ, artificial intelligence-based techniques to compare and fuse sensor data in real time from multiple SUAV/SUGV platforms to achieve target location errors of less than 10 meters using low cost, light weight (less than 2 lbs), low power (less than 10 watts), gimbaled camera/range finder targeting sensors. Embedded, agent based sensor/image processing and tracking techniques which exploit emerging low cost, low power processor chip technology and architectures will enable highly automated/aided target designation, lock-on and hand-off of both target image and geo-location data to a small unit effects network via an IP based digital radio link by the dismounted soldier/operator. The automated target hand-off capability includes the determination of the optimal target-shooter pairing based on available network effects assets, capabilities, mission constraints, terrain constraints, user preferences etc.

PHASE I: Investigate innovative artificial intelligence and agent based as well as optimization and hybrid based algorithms and real time processing architectures with potential to meet the topic requirement. Conduct analysis to determine feasibility of the design concept including overall software/hardware component design approach and accompanying algorithms for automated target geolocation, designation , hand-off and communications link selection. Analysis and concept definition should address algorithm processing requirements, communication requirements, throughput/ bandwidth requirements, conceptual hardware/software architecture and interfaces. Document results.

PHASE II: Develop demonstration prototype which integrates hw/sw component technologies and algorithms for target geo-location, designation, hand-off and sensor to shooter pairing and tasking in a wireless, netcentric test environment. The component/application package must be capable of follow-on maturation and configuration to enable seamless integration and insertion within the future force/current force experiments. Conduct prototype testing to demonstrate, validate and benchmark prototype performance and document results.

PHASE III: Phase III will produce a prototype product that supports ARDEC programs and initiatives in the area of armed robotic systems, small unit network lethality including user experiments. The author envisions spin-off to SOCOM/Current Force applications as well as Future Force Warrior /FCS and planned joint ATO's supporting networked soldier lethality. The algorithms and software developed under this effort will have dual use applications in all domestic security operations where a highly automated, multi-tiered approach to security and incident response is required. Multi-tiered Homeland Security operations such as the Border Patrol, airport security, and FEMA could use this capability in automating their response to security incidents or natural disasters. This capability can also be used by private security companies which provide large scale industrial security at power plants, chemical plants, etc.

REFERENCES: 1. TRADOC PAM 525-66, Military Operations Force Operating Capabilities.
2. US Army ARDEC. 2003. Software Requirements Specification (DRAFT) for Objective Force Warrior Netted Fires Management.
3. Barry, L. & Zimet E. (2001). UCAVs-Technological, Policy, and Operational Challenges. Defense Horizons No. 3. National Defense University: Washington, D.C.
4. Coleman, N.P., Graves, K.P., & Miller, D.M. (2003). Combat Decision Aid Technology for Network Centric Operations. In Proceedings of the SPIE Aero Symposium, 2003. Orlando, FL.
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KEYWORDS: target hand-off,target geolocation,network lethality,time critical targeting,collaborative engagement,sensor to shooter,fires and effects

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A07-045 TITLE: High-throughput Metal Forming of Micro-components with Nano-scale Tolerances

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Soldier

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 SBIR topic objective is to establish a process for extremely high-rate, low-cost manufacture of micro-scale components used in the Army Micro-Electro-Mechanical System (MEMS) safe and arm (S&A) device. The process would utilize advanced metal forming modeling techniques and stamping techniques to create sub-micron tolerances on micron-scale features.

DESCRIPTION: The mechanical separation of primary and secondary explosives in munition fuses has long held as a safety requirement for all existing and new fuses. Historically, these mechanical S&A devices are relatively large and costly when in large quantities like submunition and 20-25mm munitions. Miniaturization in a cost effective manner of S&A devices will be of significant benefit to the Army because of the wide application of fuses across munitions. It will also enable small smart munitions. MEMS-based technologies have been identified as a solution by the US Army ARDEC (Armament Research, Development and Engineering Center) though the completion a successful science and technology demonstration phase. Currently the program is maturing manufacturing technologies by evaluating production technologies that will increase design manufacturability in high quantities. Technologies evaluated include electro-plating into both UV and XRAY photolithographic molds, deep reactive ion etching, sintering of molded polymer and metal powders, and micro die-casting. These micro-system production capabilities are ever evolving and becoming more capable and cost effective. Recent developments in micro-stamping of metal parts have shown promise as being the ultimate solution for cost effective S&A component manufacture. These stamping processes are proving too immature and costly to integrate at the current state of the art but show tremendous promise for high volume cost savings and throughput. Because of this potential payoff for the Army, ARDEC would like to evaluate these emerging technologies for applicability to MEMS products in development.

PHASE I: Design the metal-forming process by using finite element simulation (FEA)and by stamping similar simple structures to the MEMS S&A frame and arming slider. This phase should validate the stamping process for the MEMS S&A frame and possibly other components in the S&A before proceeding to costly stamping tool production. This phase should show feasibility of the process through a paper study documenting the FEA analysis. Samples of similar features stamped into actual components is a desired outcome but not a requirement at this phase.

PHASE II: Experimental metal forming processes will be fabricated in the Physical Tryout phase utilizing the process developed in Phase I. The tools designed via FEA will be fully dimensionally characterized prior to their use in manufacturing a statistically significant sample of parts. Measurement of pertinent S & A component features of the produced parts will be completed and a Phase II report will be submitted and presented to Army personnel at the conclusion of this phase. Optimization of the part throughput and correlation to any finite element models should be completed also so similar components can easily be made based on the Phase II results.

PHASE III: Components manufactured through methods developed in a successful Phase II would reduce the cost and increase the ability to manufacture the aforementioned S&A devices at high-rates. Working with the system production contractors, the Army ARDEC fuze engineers and fuze engineers in other DOD agencies could integrate these precisely stamped components into every gun launched munition S&A currently under development and in doing so enable smarter, cheaper, safer and more reliable fuzes. The concept for transitioning these technologies would be to work with the metal-forming technology developer to assure parts meet the design specifications. This would provide for a smooth transition to Phase III. Depending on the application, funding for these efforts would most likely come from the program management office in charge of the weapon system involved. The end state vision is for this technology to be inserted into the MEMS S&A which has interest from the program offices that support 20mm to 155mm munitions.

Though fuzing is only one military application that could benefit from these precision, deterministic stamping techniques. The technology of precision metal forming to nano-tolerances has numerous applications across the military and commercial sectors. In the military this technology could be applied to micro-robotic packaging and sensor applications. Furthermore, metal forming for commercial and military applications like, the manufacture of fiber optic connectors, electronic packages, and medical micro-systems will benefit from the improvements in metal stamping with nano-scale tolerances.

REFERENCES: 1) US Patent#: 6,964,231
2) US Patent#: 6,568,329
3) http://www.asc2006.com/posters/GP-35.pdf

KEYWORDS: metal forming, stamping, micro, MEMS, safety and arming, fuse

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A07-046 TITLE: Precision Guided Aerial Delivery of Intelligent Ground Based Munitions and Sensors

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a remote delivery system to precisely emplace multiple intelligent ground-based munitions and sensor components to their pre-determined individual ground locations once deployed from an air platform (manned or unmanned).

DESCRIPTION: Currently no viable solutions have been identified to remotely emplace the Intelligent Munition System (IMS) with precision. The IMS is a key program in the Army's modernization effort and is presently in development to provide the Future Combat System (FCS) with both offensive battle space shaping and defensive force protection capabilities. The IMS is comprised of anti-vehicle and anti-personnel munitions, sensors located both on the munitions and as stand alone devices, and a communication system which allows wireless inter-component communication. When emplaced, the IMS requires the components to be precisely positioned with respect to each other in order to effectively cover the prescribed coverage area in both complex and open-field terrains. Presently the only effective emplacement method available to the user is by hand. Current remote emplacement methods do not provide the inter-component accuracy required to effectively emplace a field whereby component area coverage is optimized and data sharing by components over a wireless communication network is achievable. Large emplacement errors may reduce such a system's effectiveness and will require the user to emplace many more components to overcome the shortcomings of the emplacement system. The known air drop parachute/parafoil type delivery systems using Global Positioning Systems and Inertial Navigation Systems do not meet the desired precision emplacement requirements, especially for small size devices, and are susceptible to weather and topography variations. The primary focus of this SBIR development effort is the precision delivery of multiple devices to multiple simultaneous emplacement points after the components have been released from an existing air platform (manned or unmanned). This effort will result in a delivery system with unique and enhanced

Guidance, Navigation and Control (GN&C) solutions to effectively achieve a radial ground target accuracy of multiple components to multiple predetermined impact points of within 5 meters. Since the IMS components are presently in development their configuration is not finalized. Therefore, for the purpose of this SBIR effort, the proposed delivery/dispenser system shall consist a quantity of 10 simulated components ranging in size from 4”x4”x4” to 8"x8"x14.5" and weight from 5 lbs to 30 lbs. A quantity of 4 components shall be chosen for the lower size and weight limit and 1 for the higher. The remaining 5 shall be incremented between the lower and upper limits. These items shall be packaged individually or grouped, as desired for optimum performance, and require individual and precision emplacement at multiple designated ground locations, in simulated complex urban/rural terrains (with natural and man-made structures), from altitudes of 500 ft and above. Any issues with ground impact survivability (ruggedness and impact attenuation) and adverse weather and environmental conditions shall be considered.

PHASE I: Identify and define the technology concept that will support the precision ground emplacement, from an aerial platform, of the described multiple multi-configuration devices, to the multiple pre-designated ground locations. The definition shall illustrate the hardware/software architecture and design methodology of the proposed delivery system and associated guidance, control and navigation capabilities. A feasibility analysis shall be provided for the probability of achieving the desired target accuracy for the various device configurations.

PHASE II: Develop a prototype proof-of-concept system based on the Phase I recommendations. Conduct preliminary performance assessment at the component level by testing and/or modeling and simulation to validate the design decision and compatibility. Demonstrate the full system operation and capabilities in a representative environment.

PHASE III: Transition viable precision guided delivery system for the IMS SDD Increment 3 developmental efforts scheduled for FY09. This technology will also have significant dual use applications for home land security, law enforcement, border patrol, fire departments, and for any other agencies that require remote precision delivery of multiple devices to predetermined ground locations.

REFERENCES:

- Project Manager for Close Combat Systems, from http://ccsweb.pica.army.mil/1pm_ims/main.htm
- Future Combat System (Brigade Combat Team), White Paper from http://www.army.mil/fcs/whitepaper/FCSWhitepaper(11_Apr_06).pdf
- Joint Precision Airdrop System (JPADS), from http://www.globalsecurity.org/military/systems/aircraft/systems/jpads.htm
- Onyx Precision Parafoil System, from http://www.atairaerospace.com/onyx/
- STARA Guided Parachute, from http://www.shephard.co.uk/UVOnline/default.aspx?Action=-187126550&ID=f0f16422-0a45-451f-9bcb-46ecc9372b42
- Nancy Harrington and Edward Doucette, “Army After Next and Precision Airdrop,” Army Logistician, Vol 31, No.1, Jan/Feb 99

KEYWORDS: precision emplacement, precision guidance, intelligent ground based munitions, parafoil systems

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A07-047 TITLE: RESS (Rapid Expansion Supercritical Solution) Technology to Disperse Carbon Nanotubes into Selected Polymeric Matrices

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a scalable volatile organic compounds (VOC's) free RESS (Rapid Expansion of Supercritical Suspension) process to disperse and configure carbon nanotubes into selected polymeric matrices to provide enhanced electromagnetic impulse (EMI) shielding effectiveness (SE), including a rapid dissipation of EMI.

DESCRIPTION: Carbon nanotubes (CNT's) have been intensively researched since first discovered in 1991. Some of their unique attributes (strength, high aspect ratio, thermal and electrical conductivity) make CNT's particularly suitable substitutes for conventionally used conductive materials (carbon blacks or carbon nanofibers) for EMI shielding applications at a much lower loading level (one order of magnitude or more). Although recent advances in CNT's manufacturing technology have reduced the cost of CNT's to a more moderate level that is comparable to that of some high end carbon blacks, cost effective and scalable application techniques are still required to deagglomerate and disperse the CNT's prior to incorporating them into the end items.

Using the high solvation power of carbon dioxide (CO_2) at supercritical conditions, the RESS process first solvates and suspends the CNT's in a pressurized stirred vessel, followed by releasing the suspended medium via a specially designed nozzle whereby the CNT's are deagglomerated through the rapid expansion of CO_2. The RESS technology differs from the majority of the on-going carbon nanotubes R&D activities in that the RESS technology does not employ VOC's during the dispersion step, and is readily scalable to virtually any production capacity. Although this proposed effort only targets specific polymeric end items with enhanced EMI shielding performance, the RESS technology can serve as a continuous supply of well dispersed carbon nanotubes for a wide range of downstream processes leading to products with novel properties and enhanced performance. As a result, the proposed effort could very well become a milestone work in the field of carbon nanotube research by enabling the wide use of carbon nanotubes in defense and industrial applications.

PHASE I: Design an RESS pressure vessel and nozzle/diffuser assembly and develop a design of experiment (DOE) to study and correlate the degree of deagglomeration of various CNT's (multi-wall, single wall and aligned) to the RESS operating variables such as vessel pressure and temperature, dwell time, and the use of selected suspension aids.

PHASE II: Fabricate the RESS pressure vessel and, with selected polymer melt processing equipment (mixer, extruder, fiber spinning, film and sheet line), produce various forms of CNT's containing polymer feedstock (pellets, rods, fibers, films and sheets) that are shaped into various testing specimens via injection molding, thermoforming, and other shaping techniques.

PHASE III: The vision for phase III is to fabricate EMI shielding technology for light-weight communication devices and anti-radiation measures, such as those found in the Paladin (U.S. Army self-propelled howitzer). The Paladin employs suites of electronic arrays (sensors active and passive, GPS for target acquisition, and electronic countermeasures) that could be rendered inoperable by EMI. Additionally, the RESS technology is particularly suitable to deliver well-dispersed CNTs into commercial paints and adhesives. A few noteworthy applications adoptable to the military and to civilian sectors are as follows:

- Corrosion resistant paints (solvent, water based, powder, and UV-curable)
- Surface coatings with signature management capability
- Transparent conductive coatings
- Conductive gaskets and seals suitable for high service temperature environment
- Sprayable EMI shielding coatings for electronic chips and circuit boards
- Conductive adhesives

REFERENCES: 1) S. Iijima, Nature (London) 354, 56 (1991).

2) J. Joo and C. Y. Lee, J. Appl. Phys. 88, 513 (2000).

3) Y. K. Hong, C. Y. Lee, C. K. Jeong, D. E. Lee, K. Kim, and J. Joo, Rev. Sci. Instrum. 74, 1098 (2003).

4) ASTM D4935-99, Standard Test Method for Measuring the Electromagnetic Shielding Effectiveness of Planar Materials, 1999

KEYWORDS: RESS, Carbon Nanotubes, Supercritical, EMI shielding effectiveness, conductivity, Percolation, paints and adhesives

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A07-048 TITLE: Simulated Job Performance Assessment

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To document a standardized process for developing job performance simulation assessment and to develop five (5) prototype simulations using this approach.

DESCRIPTION: Job performance measures are important to accurately evaluate job proficiency. In military and civilian environments, most objective job performance measures are conducted by testing fact-based or declarative knowledge; the procedural or "doing" performance aspect remains elusive from a practical standpoint. Conversely, many Army jobs, and their civilian counterparts, are characterized to a greater degree by the procedural performance aspects rather than the knowledge performance aspects (Knapp, McCloy, & Heffner, 2004).

The optimal job proficiency assessment method for these procedural aspects is to observe the employee performing his or her job in the work environment using typical tools and equipment. However, the Army's past experience (e.g., the Skills Qualification Test program) has determined this approach requires an unreasonable amount of time and financial resources (Campbell, Keenan, Moriarty, Knapp, & Heffner, 2004). Assessment based on job simulation may provide a holistic view of job performance at a reasonable cost. Simulation is seen as a vast improvement over traditional job knowledge tests because it provides greater realism, yet potentially decreases costs, protects Soldiers from dangerous environments, and minimizes reading and test-taking differences (Brannick, Roach, & Salas, 1993). To maximize cost-effectiveness for the approximately 200 entry-level Army jobs and limitless civilian jobs, simulation for job selection will be most useful if a standardized process is prepared to guide simulation developers.

A plethora of simulation techniques exist and are widely used in the training arena. An existing evaluation (Knapp & Campbell, 2005) of many of these simulations has determined that they are inadequate for selecting and evaluating job candidates because they do not provide detailed information on the various performance aspects that contribute to overall performance. For this reason, simulations specific to selection and evaluation are required.

The expected outcome of this research is to capitalize on existing technologies in job/task analysis, simulation development, and performance measurement to develop an innovative methodology for producing selection-oriented simulations that reduces up-front costs and expediently produces assessment simulations. This outcome will be achieved by identifying a standardized process for developing simulations that can be applied to a wide variety of Army and civilian jobs.

PHASE I: Using the current literature on simulation techniques, job/task analysis, and performance measurement, design a prototype standardized process in full detail for developing job assessment simulations and develop a comprehensive plan to evaluate performance using this approach. A potential approach may be to develop a set of core simulations that assess common knowledges, skills, aptitudes, and other characteristics (KSAOs) that can be applied across a wide variety of jobs. Develop a low-fidelity prototype for the Light Wheeled Vehicle Mechanic (MOS 63B) using this process. The prototype must be PC-based and require no external devices. The prototype must also provide face validity to the examinee, but predictive validity is a higher priority than high fidelity.

PHASE II: Revise and refine the methodology based on lessons learned in the prototype development. Apply this standardized methodology to develop assessment simulations to four (4) jobs. These jobs should be diverse on dimensions such as the physical and cognitive demands of the job, the equipment used on the job, the interpersonal skills required on the job, and the risks associated with successful job performance. The simulations should be

designed to evaluate all critical aspects of the job and should be developed using accepted test development procedures including:
1) a review of the job to identify the critical KSAOs for successful job performance;
2) a test blueprint to detail how the content of the simulation measures the KSAOs;
3) the development of the simulation; and
4) a pilot test of the prototype simulation.

An evaluation of the successes and the limitations of the standardized methodology should be conducted and documented. An evaluation of the cost savings provided by implementing the standardized process also should be documented.

PHASE III: The Army is currently using highly sophisticated simulation for training (e.g., armor, aviation) although it is rarely used for personnel selection. Civilian applications for personnel selection are typically low fidelity including situational judgment tests and assessment centers. The products from this SBIR may fill a niche for moderate fidelity simulation for personnel functions. Many such jobs exist for which simulation capability is ideal. Rather than using actual equipment which can be damaged or placing employees in dangerous situations, a simulated approach protects the organization, the employee, and valuable resources.

The development of a standardized simulation-based performance measurement technique will have substantial military and civilian applications. It can be used to enable a small business to identify a process for creating computerized job/task simulations and five fully-operational job simulations. These simulations can be used to support training evaluation, personnel functions such as selection and promotion, and facilitate comparison of performance across jobs, thereby improving employee productivity.

Two primary products will be developed and have the potential for transition to military and civilian environments. The first is the process for developing the simulations. It is expected that this process could be applied to any of the almost 200 different Army MOS as well as any other military or civilian job that has a heavy procedural component. The second product is the fully-operational, validated job simulations. Although only one of the five MOS is specifically identified as a required MOS, the light-wheeled vehicle mechanic is a job in heavy demand across the military, federal, and civilian sectors. Potential military customers include the mechanic proponents in the Navy and Air Force in addition to the Army. Federal customers include any agency that maintains a fleet of vehicles to include the FBI and Secret Service. Civilian applications include large and medium sized auto repair businesses. The remaining four MOS job simulations, which will be identified based on the strengths of the contracting organization, the availability of Soldiers, and support from the proponents, are likely to have similar transition possibilities. In Phase III, the contracting organization is expected to obtain funding from non-SBIR sources and/or the private sector to develop further job simulations or to transition the existing simulations to other services or the private sector.

REFERENCES: 1) Brannick, M. T., Roach, R. M., and Salas, E. (1993). Understanding team performance: A multimethod study. Human Performance, 6, 287-308.
2) Campbell, R.C., Keenan, P.A., Moriarty, K.O., Knapp, D.J., & Heffner, T.S. (2004). The Army PerformM21 Demonstration Competency Assessment Program Development Report (Technical Report 1152). Arlington, VA: U.S. Army Research Institute for Behavioral and Social Sciences.
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4) Knapp, D. J. McCloy, R. A, & Heffner, T. S. (2004). Validation of measures designed to maximize 21st Century Army NCO Performance (Technical Report 1145). Alexandria, VA: U.S. Army Research Institute for Behavioral and Social Sciences.

KEYWORDS: Job performance, simulation, assessment, personnel selection, methodology

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A07-049 TITLE: Modeling and Assessing Performance of Complex Organizations

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop organizational performance assessment tools utilizing human and automated performance data collection and synthesis. These tools should incorporate a theoretically driven computational framework of organizational performance, and be firmly grounded in organizational science.

DESCRIPTION: Modern military operations are often composed of personnel from a variety of nations, many government and non-governmental organizations, and all or most of the military services. Headquarters of this type of operation is often characterized as being Joint, Interagency, Multi-organizational, Multi-national (JIMM). The dynamics internal to this headquarters organization are such that it is relatively simple for issues between services, agencies, organizations, or nations to arise that can significantly impact the overall effectiveness of the organization – and the coalition effort (Early & Mosakowski, 2000).

In order to better understand the dynamics of these JIMM organizations, and to provide commanders and organizational leaders with mechanisms to improve their effectiveness, the capability to model and provide regular, periodic performance assessments of these organizations is vital. This capability will be of extreme value to the organizations responsible for training and certifying these headquarters organizations prior to deployment (e.g., JFCOM, BCTP), as well as to organizational leaders as they prepare themselves through Command Post Exercises (CPX) and other training. Performance assessment of organizations, and the systems of teams within them, will rely heavily on some form of computational models to project what optimal organizational or team performance should look like given environmental circumstances and to assess the differential between predicted-optimal and actual organizational performance.

This topic is to solicit the creation of a computational framework for modeling organizational performance which builds on social network analysis (Kilduff & Tsai, 2003; Wasserman & Faust, 1994), organizational theory, team effectiveness theory – specifically aspects related to multi-team systems (Mathieu, Marks & Zaccaro, 2001), and traditional forms of computational modeling. This model is to provide the basis for building an organizational performance assessment tool; minimizing, to the extent reasonable and possible, human input or intervention for generating performance assessments. The model and resulting performance assessment tool will account for specific organizational, service, agency, and national diversity as it is actually represented within the organization being modeled and assessed.

This performance assessment framework should be designed to be suitable for use in unit training exercises at the operational level, such as those conducted by Joint Forces Command and the Army Battle Command Training Program (BCTP). The computational framework should account for effectiveness in accomplishing organizational tasks and goals, as well as effectiveness of organizational processes, communication, and coordination. Primary emphasis should be placed on process-based effectiveness, to include organizational communication and coordination. Innovative means of assessing organizational communication and coordination (e.g., monitoring and tracking physical traces) will be particularly valued. If proposed solutions rely on existing collaboration environments as one data source, clear articulation of how such data will be obtained from the identified system(s) will be required. This topic is NOT soliciting the development of a new collaboration environment.

PHASE I: Develop a conceptual model framework of military organizational performance representative of operational headquarters and similar organizations, linking observable indicators to latent dimensions of team, multi-team system and organizational effectiveness. Identify useful indicators for assessing organizational performance, distinguishing between indicators that can be monitored through automated processes and those requiring human intervention or assessment. Develop and demonstrate a prototype computational model of military organizational performance based on the developed framework and identified performance indicators. Due to current deployments and high operational tempo, offerors should not plan on access to military organizations being provided for prototype demonstration purposes. Offerors should describe options for obtaining or creating organizational data from alternate sources for this demonstration. Utilization of existing relationships with military or similar organizations, with the expressed consent of the organization(s), is encouraged.

PHASE II: Develop organizational performance assessment system, based on findings and concepts developed in Phase I. Performance assessment system should be capable of providing useful and understandable performance information to organizational leaders on a regular basis, with periodicity driven in part by environmental dynamics and meaningfulness of changes. Performance assessment system should integrate automated and human-sourced data collection and processing, while allowing for the possibility of entirely automated performance data collection and processing when feasible. If possible, access to military organizations will be provided for Phase II activities, however offerors are advised to develop alternate plans that do not rely on military organizations if access is not possible.

PHASE III: Within the military, the training community –specifically the training community responsible for training and certifying operational headquarters for deployment – is likely to be highly interested in this technology if successful. Further, active, deployed operational headquarters may find regular use of this technology to provide useful information and feedback to the Commander and other organizational leaders. The technology developed here, if successful, should provide a sound basis for development of more automated assessments of human performance. Outside the military, there are a number of organizations that may find this technology useful, including NASA (e.g., space flight control), FEMA (e.g., emergency response headquarters), and public safety organizations (e.g., police or fire command posts).

ARI is currently executing a research program related to leading and participating in multinational teams and staffs. If successful, this SBIR research will contribute directly to this research program. The results of a successful SBIR effort will support the training of headquarters units in preparation for operational deployments. The Army Battle Command Training Program and Joint Forces Command – Joint Warfighting Center (J-7) are the intended primary Military customers.

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2) Kilduff, M. & Tsai, W. (2003). Social Networks and Organisations. Thousand Oaks, CA: Sage.
3) Mathieu, J.E., Marks, M.A., & Zaccaro, S.J. (2001). Multi-Team Systems. In N. Anderson, D. Ones, H.K. Sinangil, & C. Viswesvaran (Eds.), International handbook of work and organizational psychology (pp. 289-313). London: Sage.
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KEYWORDS: Organizational Assessment, Organizational Performance, Network Analysis, Multi-Team Systems, Team Performance Assessment, Automated Performance Assessment

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A07-050 TITLE: Measuring Learning and Development in Cross-Cultural Competence

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Design a measurement system to assess Soldiers' development in cross-cultural competence for current and future operational environments.

DESCRIPTION: Increasingly, operational demands require Army Soldiers and leaders to interact effectively with individuals from other cultures. Cultural differences have been highlighted in a variety of operational contexts, with the frequent perception that these differences are obstacles to strategic, operational, and tactical success. For example, counter-insurgency forces must develop relationships with the local population based on trust and security, despite their status as outsiders. Military Transition Teams training the Iraqi Army must adjust their expectations and training paradigms to Iraqi customs and military traditions. In addition to developing skills needed to function in these cross-cultural environments, Soldiers must also be prepared to function effectively in a truly multicultural environment, in which roles may be ambiguously defined and no single national culture dominates. NATO and Coalition efforts require successful collaboration across national boundaries, and learning the language, rules, and customs of a particular culture is unlikely to be sufficient.

Soldiers clearly benefit from knowledge of the specific cultures in the COE (contemporary operational environment), but also need foundational skills that facilitate intercultural interactions more generally, regardless of the particular culture. These skills should be relevant to operational demands in the COE, but also should create cross-cultural adapatability, whereby Soldiers and leaders are able to transfer skills to new operational environments and can quickly learn the particular rules and customs of a culture with which they have no expertise.

In order to provide Soldiers and leaders with opportunities to develop cross-cultural adaptability, the Army needs a model specifying the relevant competencies. This model would include the affective, cognitive, and behavioral shifts needed to progress from a relatively simple to a more complex understanding of culture and a more advanced level of behavioral skill (e.g., see Bennett, 1986). A measurement system will also be needed to assess individual Soldiers' level of cultural competence at various stages of development. Available measures rely extensively on self-report (e.g., Ang, van Dyne, & Koh, 2005), which may be appropriate for some components but is less appropriate for others. For example, self-report is unlikely to yield valid measurement of interpersonal skills. The measurement system should be culture-general and should be capable of assessing both explicit and implicit aspects of cultural competence.

The measurement system must be flexible enough to include in a variety of training and simulation contexts to enable assessment of training effectiveness. Such a system will allow for comparisons of differing approaches to training. The Army has begun to develop cultural training both for regions of current and potential conflict and for culture-general skills (e.g., OSD/Army SBIR OSD06-CR1). The proposed measurement system will enable the Army to evaluate to what extent this training increases cross-cultural adaptability.

PHASE I: Identify the cognitive, affective, and behavioral skills that comprise cultural competence. Design a developmental model of cultural competence that accounts for change over time. Identify mechanisms for providing appropriate feedback to Soldiers to support development of cultural competence. Project teams should be interdisciplinary.

PHASE II: Develop and validate a measurement system that assesses cognitive, affective, and behavioral components of cultural competence. The measurement system should not be limited to self-report, should be able to measure individual change over time, and should be appropriate across ranks. This tool may, but is not required to, include assessment of expertise specific to regions in the COE.

PHASE III: This model could be used in military and civilian environments to assess the effects of training or other developmental experiences on cross-cultural competence. The measurement tools would be useful to TRADOC in determining what level of cultural training is needed by individual Army leaders or Soldiers and in evaluating the effectiveness of current training. The TRADOC Culture Center has developed a variety of training materials, and this system could contribute to an assessment of which training materials are most effective and efficient. In addition, this tool could be used in selecting personnel for assignments requiring high levels of cross-cultural interaction, such as in Military Transition Teams or civil affairs.

In civilian environments, the measurement system could be used as a tool in multinational corporations seeking to select managers for work assignments requiring cultural skills or to assign managers to an appropriate cross-cultural training program prior to overseas assignment.

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KEYWORDS: Culture, cultural awareness, cultural intelligence, interpersonal skills, cross-cultural competence, cultural understanding, counter-insurgency

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A07-051 TITLE: Short-Range Detection of Radio Transceivers for Physical Security

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Ammunition

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

OBJECTIVE: Develop and demonstrate a system capable of detecting communications transceivers within a five-meter range regardless of their operating mode.

DESCRIPTION: The explosion in the availability and use of small communications transceivers such as cellular phones and FRS/GMRS hand-held radios has made around-the-clock communications a reality for civilians and military personnel. Unfortunately, the same technology can create significant security issues when the devices are smuggled or unintentionally carried into secure areas. Current methods for detecting such devices such as manual searches or metal detector portals are not sufficiently accurate and consistent, and can create serious bottlenecks at entry and exit checkpoints. Once the devices are in the secured area, it is difficult to detect unauthorized or unintentional use because transmissions tend to occur sporadically in short, low-power bursts. Location of the device is complicated by the presence of multipath interference due to reflections from structural materials. To date, minimal research has been focused on this problem and potential solutions [1, 2]. The most reliable current solution is the installation of low-power jammers to block communications [3], but this leads to unacceptable interference for legitimate users of the technology.

A low-cost, safe, unobtrusive, and fast system for detecting communications transceivers or components would solve these problems. The ideal system would be able to detect the presence of transceivers within a five-meter range regardless of their operating mode, i.e. whether the device is powered down, powered on but idle, actively receiving, or actively transmitting. Such a system could use active or passive detection technology, but cannot use ionizing radiation or high levels of radio frequency energy beyond those allowed under FCC regulations [4]. The system must have a high probability of detection and a low probability of false alarm even when operated by unskilled personnel. The initial implementation can be targeted for fixed installations, with a credible path to producing a man-portable system in the future. The system architecture should be verified and the receiver operating characteristics estimated in Phase I using commercial or other existing system-level simulation tools. The resulting data will be used to produce a system design, construction, and test plan for implementation in Phase II.

PHASE I: Demonstrate the feasibility and estimate the receiver operating characteristics (probability of detection and probability of false alarm) of the proposed system using existing system-level simulation tools. Develop and document the design, construction, and test plan that will lead to a working prototype system in Phase II.

PHASE II: Construct, test, and evaluate the performance of the prototype system developed in Phase I. Document the final design and measured performance of the prototype system.

PHASE III: The prototype transceiver detection system demonstrated in Phase II will be developed into a stand-alone fixed-site portal or integrated with conventional magnetometer-based metal detection systems for improved performance at security checkpoints, both military and civilian. The compact size of the system further will allow its inconspicuous installation in areas of general population movement where it is desirable to detect the presence and use of communications transceivers. As the primary technology sponsor, ARL/ARO will work with the Phase II performer(s) to identify and coordinate with potential DoD and other government customers to execute the transition from prototype to product.

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KEYWORDS: communications security, transceiver detection

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A07-052 TITLE: An Assessment Methodology for Effects Based Operations

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: To create an effects assessment tool for the decomposition of large scale effects into subordinate political, military, economic, social, information, and infrastructure (PMESII) elements. This tool would provide a data fusion capability to parse quantitative and qualitative data into bins that correlate to force objectives. This tool could ultimately have several functions: 1) to decompose broad effects into supporting actions, 2) to propose candidate actions across the PMESII spectrum for the assessor to consider, 3) a method to link measures of performance and actions with measures of effectiveness and effects, 4) a statistics analysis and graphing function to help with routine and complicated (e.g. three dimensional) assessments, and 5) a 'report card' function to automatically show periodic updates (daily, weekly, monthly) for trends of interest. This tool should provide an assessment linkage between the Brigade Combat Teams (BCTs) and the Joint Task Force (JTF) operating at the higher headquarters level.

DESCRIPTION: The Effects Based Approach to Operations (EBAO) is being employed by Coalition Task Forces (CTF) in an era of increasing complexity and uncertainty. EBAO requires novel analysis methodologies due to the nature of today's conflicts. CTF commanders, staffs, and interagency partners must develop and maintain two types of awareness. The first is an awareness of their immediate operational environment, and the second is an awareness of the political, military, economic, social, information, and infrastructure (PMESII) factors in the broader area of interest (Smith, 2006). The first type of awareness will be supported by data and information that is "linear and quantitative" (Smith, p. 167). The second will be derived from information and knowledge that is "complex, qualitative, and subjective" (Smith, p. 167). Recent experimentation (JFCOM, 2006) into the EBAO in a coalition setting shows that the assessment function, or the process of developing command awareness, is extremely difficult. First, the problems in the area of operations encountered by the CTF are extremely complex, dynamic, and uncertain. This leads to objectives that are likewise complex and comprised of many PMESII concerns. Second, the presence of human and unmanned sensors provides an unending source of data and information to be processed. This exponential increase in battlespace information demands artificial intelligence resources to support the sensemaking and assessment process. This process requires the assessment team to synchronize the linear and quantitative information with the qualitative and subjective findings. The vast amounts of data that will be used to support this function will create information overload to the user if presented in raw form. Without the use of advanced data/information fusion architectures and techniques, the assessors would be likely to perform a constricted type of data fusion by focusing on a single perspective (Akita, 2002).

PHASE I: A prototype tool that can demonstrate the ability to decompose broad effect statements into measurable actions across the PMESII spectrum and provide a statistical analysis package to enable the development of visual displays (charts, graphs). Develop a creative method for measuring and displaying qualitative measures. Include a method to connect measures of performance and actions with measures of effectiveness and effects. Discuss how interagency representatives might convey information to the military assessors without being viewed as violating their neutrality status. Discuss how a linkage might be made between the tactical and operational levels of command with respect to the assessment function.

PHASE II: A data fusion/assessment tool that can be used in coordination with a simulated knowledge base in experimentation to demonstrate required capabilities. The tool should allow users to extract informtion that is relevant to a certain objective, perform statistical analyses that are appropriate to the data, and create graphs that depict the state of the objective. Explore web-based functions that would allow users to extract data from relevant sources. The tool should ultimately help tactical and operational levels to interact and determine how lower level actions are impacting higher level objectives. This tool should allow users to link PMESII objecives to actions and identify positive/negative movement toward achieving objectives.

PHASE III: The emphasis for this tool is on Coalition Task Force (this includes both military and interagency staff) assessment of objectives, but it has application for corporate management staffs interested in tracking measures of effectiveness and performance. The goal of Phase III is to produce a system that can be both stand-alone or web based and can show that assessors can track, aggregate, and display multiple types of actions that support high level objectives. This assessment system would be used in an operational headquarters linked to subordinate tactical echelons and would provide rapid assessments of multidimensional objectives. The multidimensional factors, for instance, might highlight that some efforts are failing while others (that support the same objective) are succeeding. Thus, a more thorough understanding of the PMESII interactions would be possible, leading to changes in tactics. The system would emulate a service oriented architecture that would allow users to draw data and information from varied sources and utilize statistical packages to aid in displaying information.

Technology partners such as the Communications and Electronics Research Development and Engineering Center (CERDEC) and Joint Forces Command (JFCOM) are prospective partners for the EBA technology. During Phase III, the tool would transition to CERDEC and JFCOM programs for application during design, first as a part of the design-develop-test cycle and secondly for implementation in operational systems. Funding would come from advanced development dollars and from funded development programs.

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KEYWORDS: Battle command, Command & Control, C2, Effects Based Operations, information dissemination, scaled world, simulation, social network analysis.

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A07-053 TITLE: Information Technology Assistant for the soldier using flexible displays

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Proposals are sought to develop the novel technology and electronic architectures to enable an Information Technology Assistant that integrates a flexible display. The appliance developed will be the mechanism to show how the innovative technology solutions may be used. New ideas in packaging beyond a standard PDA configuration that take advantage of the flexibility of the display may be developed. The functionality shall include, but, not limited to; wireless communications, GPS, wired interfaces such as USB, and processors. Novel approaches are sought for power management, asynchronous display drivers, and system configurations.

DESCRIPTION: The Army has been developing flexible displays with improved performance as compared to conventional glass based Liquid Crystal Displays. The displays will be ultra low power, sunlight readable, and very rugged. The flexible display development is now advanced sufficiently to begin the development of electronic systems that integrate these advanced display demonstrators. To meet this goal, research and development is required to design novel electronic architectures that optimize power through display drive schemes such as; asynchronous updates, microprocessor and software architectures for display drive, as well as novel system packaging that cannot be realized with conventional, rigid glass-based displays. PEO Soldier and PM Soldier Warrior endorse this project and consider it to be a high priority effort. PEO Soldier endorses the development of the Information Technology Assistant (ITA) that will enable the advance performance of a digital assistant for the Soldier. While the original design will be for an Army application, the techniques, processes, and designs will have direct application to innovative commercial products that have similar attributes. The applications for the ITA demonstrator can include; PDA for reviewing Standard Operating Procedures, personal navigation, Red-Force - Blue Force tracking, and maps In parallel to this SBIR effort, the Army is developing flexible displays through the Flexible Display Center (FDC) at Arizona State University. The FDC is not developing the electronic system level functionality that would enable an application such as the ITA. The flexible displays under development at the FDC include; electrophoretic and cholesteric liquid crystal based reflective displays, as well as organic light emitting diode based emissive displays. The anticipated substrates in the early phase of the FDC program will allow the displays to conform in 1-dimension to a radius of 10 inches. The displays will be 4" diagonal up to 7" diagonal. The proposed efforts 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 for testing. 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 display in ITA may be flat or conformed.

PHASE I: Proposals are sought for the design of a novel Information Technology Assistant (ITA) that integrates advanced flexible display demonstrators. The proposed research areas of interest to be integrated into the ITA include; the development of novel power management optimized for the integrated display drive; novel electronic system architectures that lower the ITA power, novel system packaging that takes advantage of the flexible display form factors. The SBIR effort will not fund flexible display development, but, must include the source for the flexible displays, such as the Flexible Display Center or another partner. The ITA with an integrated flexible display shall have functionality that includes, human interface(s) (small keyboard, touch screen, buttons, scroll), wireless communication, GPS, wired connections such USB, and a processor. The novel power management schemes may include areas such as; asynchronous display drivers, microprocessor and software power management that leverages bi-stable displays, and others. The novel system configuration and packaging may expand upon a traditional PDA hand held or a configuration with the display module separate from the electronics package. The package shall be, at a minimum, adequate for Limited User Experiments. The Phase I deliverable shall be an interim report and final report that details the system design.

PHASE II: During Phase II, the electronics layout design shall be finalized with the Army including PEO Soldier and PM SWAR. Based on the final design specifications, the contractor shall purchase the necessary hardware and related licenses to assemble the Information Technology Assistant (ITA) and deliver (2) units to the Army for further evaluation. 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) ITA units.

PHASE III: The Information Technology Assistant using flexible displays offer significant commercialization opportunities for novel PDA applications and other information technology systems. We anticipate the contractor will pursue commercial applications. In addition, a Phase III effort would duplicate the ITA with a flexible display for PEO Soldier applications. Specifically, the flexible display appliance will have application in the Ground Soldier System program for individual soldier information electronic appliance. With PEO Soldier, we will work to identify other applications, which may include sensor systems that require a PDA control system such as unattended ground sensors and others. The designs for the SBIR product will done with PEO Soldier to maximize the utility.

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KEYWORDS: Flexible displays, Information Assistant, electronics, power management, novel electronic packaging

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A07-054 TITLE: Highly Scalable Spectrally-Narrowed Surface-Emitting Arrays for Eye-Safe Lasers

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: Develop high power 14xx-15XX-nanometer (nm) monolithic surface-emitting beam deflector diode arrays incorporating optical feedback to narrow the emission spectrum down to <1 nm. To be used as a pump source for high-power eye-safe Er-doped solid-state lasers. The manufacturing process must be scalable enough to show promise for 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). Nevertheless, the most promising of today’s technologies for high power solid-state lasers result in wavelengths near 1 um. 1-um laser wavelength shifting via stimulated Raman scattering is possible, but at the sacrifice of overall laser system efficiency and additional heat removal complications. Er-doped crystalline solid-state lasers have proven to be highly efficient eye-safe sources with laser excitation around 1540 nm [1-3, 5]. Key components for operating these lasers most efficiently (in a resonant, ultra-low-photon-defect, “pump-lase” scheme) will be pump diode arrays operating in the 14XX-15XX-nm region [3,5]. Efficient cooling is much more critical for these wavelengths than for 800-nm pump diodes because longer-wavelength efficiency is significantly lower and drops more rapidly with increasing temperature. High cooling uniformity is also important, because temperature variations contribute to spectral broadening and reduce pump absorption efficiency of Er3+-doped gain media. Conventional array architectures using closely-stacked micro-channel cooled edge-emitting bars are inadequate because impractically high coolant pressure drops and flow velocities are required to handle the heat load. Thermal and spectral uniformity is also poor because heat cannot spread into the forward (light emission) direction. The reliability of the micro-channel coolers is poor because of the high fluid flow rates required for high power operation. Thus an alternative approach is preferred based on planar “macro-channel” coolers, which have lower flow impedance, better thermal uniformity, and better reliability than micro-channel coolers. Macro-channel coolers are too thick for stacking edge-emitting laser bars, but they can be used with tightly packed surface emitting lasers to combine high brightness and efficient cooling. Vertical-cavity surface emitting lasers and grating surface emitters provide surface emission, but are unattractive because of high thermal and electrical impedance, or beam profile and steering issues. A possible approach would be the high power monolithic beam deflector diode arrays recently demonstrated at 980 nm [6]. The arrays must also incorporate optical feedback to narrow the emission spectrum from their natural linewidth (typically 10-12 nm for InP devices) to less than 1 nm for efficient absorption by Er3+-doped gain media. It is possible to provide feedback by external optical elements such as volume Bragg gratings, but monolithic approaches are strongly preferred because of superior manufacturability and ruggedness. Technical solutions resulting in reduced diode output beam divergence compared to regular edge emitters will be given preference.

PHASE I: Eye-safe (14XX-15XX-nm) pump diode array designs are sought which use planar “macro-channel” coolers in conjunction with tightly packed surface emitting lasers to combine high brightness and efficient cooling. A possible approach is the high power monolithic beam deflector diode arrays recently demonstrated at 980 nm [6]. The arrays’ output must be spectrally narrowed to < 1 nm. Monolithic approaches are strongly preferred because of superior manufacturability and ruggedness. A 1D array (1-cm single bar) emitting ~50 W CW at room temperature, slow-axis/fast-axis (SA/FA) beam divergence no more than 3°/12°, power conversion efficiency no less than 40% selected from the best manufacturing batch shall be provided to the Army Research Laboratory for evaluation in various laser pump setups.

PHASE II: Develop substantial technological process scalability and produce a 2D array (10-bar stack) emitting ~500 W CW at room temperature, SA/FA beam divergence no more than 3°/12°, power conversion efficiency no less than 40%. SA/FA beam collimation is strongly preferred. This diode bar stack shall be delivered to the Army Research Laboratory for testing in various laser pump setups.

PHASE III: DUAL-USE APPLICATIONS: The clear advantages of highly scalable spectrally-narrowed surface-emitting arrays for pumping Er3+-doped eye-safe lasers will result in higher solid-state laser overall efficiency, much higher design flexibility, and improved ruggedness - highly desirable for both military and commercial applications. One likely civiian transition of the arrays will be the direct use of their output for laser welding and cutting in the automobile industry and other kinds of manufacturing, using the fact that they will be much easier to fiber-couple and also power-combine compared to conventional edge emitting diode lasers. The military has a strong interest in incorporating advanced eye-safe high energy lasers into DEW systems for applications such as ground-based air defense, which will be enabled by this topic's improvements of resonant, ultra-low-photon-defect, diode-pumped operation of Er3+:YAG. Likely transition paths include incorporation in a future ATO for solid-state laser technology, or adoption by contractors into solids-state weapons-class laser programs for the Army Space and Missile Defense Command, the High Energy Lasers Joint Technology Office, and/or the Missile Defense Agency.

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KEYWORDS: Solid-state laser, Er3+-doped materials, diode pumping, long-wavelength laser diodes, laser diode spectral narrowing.

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A07-055 TITLE: Rapid Recharge, High Voltage Li-Ion Battery Chemistry

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Seeking exploration of electrode and electrolyte materials combinations w. a resulting battery chemistry that (1) permits recharge in 30 min or less (2) utilizes a terminal voltage of 3 V or higher & (3) provides long cycle life & performances (charge and discharge) over the full military temperature range.

DESCRIPTION: Rapid Recharge Battery – The recently developed Li ion battery is a safe and reliable power source that has found extensive commercial application. Li ion has the highest specific energy for any commercial rechargeable battery, and the transition from primary to secondary power sources could substantially reduce the military logistic cost. The present state-of-the-art carbon negative electrode, however, limits the rate of recharging. At rates that allow recharge of the cell in less than 1 hour, metallic Li can be plated on the carbon surface causing a safety hazard. We are seeking new Li ion chemistries, that through the combination of a high voltage cathode, an electrolyte with a wide electrochemical window and an anode that has rapid charging kinetics, can enable safe and near complete recharge of the cell in 30 min or less without significant capacity loss after 224 cycles at 80% depth-of-discharge. Examples of suitable negative materials could include tin-based composite alloy materials or nanostructured Li metal oxides such as Li titanate. Safe operation on both charge and discharge and storage over the full military temperature range (-40 to +70 oC) is required with minimal degradation and maximal charge retention. Positive electrode materials and electrolytes should be selected to maximize the energy density while permitting the rapid recharge. Successful proposals will include a complete battery chemistry to meet the specifications of 90% being recharged within 30 min without sacrifice in specific energy or improvement in specific energy from the present state-of-the-art Li ion battery.

PHASE I: Phase I should result in the identification/synthesis of a high voltage cathode and a compatible electrolyte formulation. Demonstration of 90% charge of the new electrode materials in cathode half cell within 30 min without metallic Li deposition or loss of capacity after 224 cycles at 80% depth-of-discharge.

PHASE II: Phase II will identify the anode materials of choice and the demonstration of a full Li ion cell that meets the above specifics. The full Li ion cell should be rapidly, safely charged to 90% of the nominal capacity at temperatures as high as 60 oC, and retain 95% of its capacity upon storage at temperatures as high as 70 oC and as low as -40 oC.

PHASE III: PHASE III DUAL-USE APPLICATIONS: The results of the SBIR effort will be transitioned to CERDEC for aquisition. It is anticipated that for Army applications, cells developed with the new chemistry of this program could replace present state of the art Li-ion cells in standrd Army batteries such as BB2590 ect but offering greater safety, more power and faster recharge. These rechargeable batteries could then be placed in hybrid configuration with fuel cells or long life metal-air batteries for extra long life power source for Land Warrior or Furture Force Warrior apllication. The energy storage components under consideration here are also of great potential value for use with cellular phones, laptop computers, camcorders and other commercial electronic equipment. In general, the smaller cells and batteries used in these types of personal electronic equipment will be less challenging to develop and manufacture than the larger batteries required for Soldier Power. Further, the added safety of this product as well as the convenience of the quick charge feature will make this product very popular in the commercial market.

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KEYWORDS: New Li ion battery chemistry, high voltage cathode materials, fast-charging electrode materials, stable electrolytes, nanophase materials

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A07-056 TITLE: Widely-Tunable Quantum Cascade Laser Technology for Spectroscopic Sensing and Optical Communication Applications

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: The development of a compact tunable semiconductor laser operating in the 3- 12 micron wavelength range. The laser should be suitable for high sensitivity spectroscopic and/or optical frequency modulated (FM) free-space communication applications.

DESCRIPTION: There are many absorption bands of various biological and chemical agents as well as trace gases in the mid infrared spectral range from 2 to 12 µm (molecule fingerprint region), for example: aromatic hydrocarbons, CO, CO2, CH4, H2O, N2O, NH3, CNH2, NO, HF, and others. A tunable single spectral mode light source operating in this range would find applications in: remote explosive detection, atmospheric trace gas monitoring, combustion gas monitoring, chemical and biological agent identification etc. Fast tuning will allow real time monitoring of chemical processes. Free space optical frequency modulated (FM) system potentially provides secure, low power and ultra-wide band communication channel.

We are seeking an infrared source based on the emerging Quantum Cascade Laser(QCL)technology and/or Interband Cascade Laser(ICL)technology designed and dedicated for spectroscopic applications in the spectral region 3 microns-12 microns. This source should have the ability to tune over the fingerprint region and possess standard laser specifications attributed to mature laser sources with regard to power output (tens of mW), beam quality (M2<2), and low beam divergence (< 2 mrad). It is expected that this source will require innovation research and development that could include one or more of the following: advanced packing schemes for multiple-chip combining, mechanical and non-mechanical tuning technologies, and broadening of chip gain bandwidth.

Electrically tuned type-I or type-II cascade lasers are promising for this application; they have recently demonstrated excellent high power continuous wave single-mode performance at or near room temperature and are sensitive to the external field due to inherently large Stark shift of the intersubband transitions. Spectroscopic applications require the development of tunable single mode lasers based on this technology. Typical approaches to achieve single spectral mode tunable operation involve development of distributed feedback lasers, distributed Bragg reflector lasers or single mode vertical cavity surface emitting tunable lasers.

Also of particular interest are technologies that are amenable to high volume production (e.g., metal-organic chemical vapor deposition growth MOCVD) and incorporation into external cavity configurations.

PHASE I: This Phase will demonstrate the feasibility, through modeling and/or experimentation, of producing a laser diode structure appropriate for spectroscopic applications in the 3-12 µm mid-infrared wavelength range, and will outline demonstration success criteria.

Phase I deliverable: Demonstrate, by lab demo experiment or detailed calculations, the feasibility of DOD (or Army) significant spectroscopic applications in the 3-12 micron range. The success criteria wiil be developed by the program technical points of contact and will be tailored to the specific successful proposal.

PHASE II: Develop and fabricate a prototype of the tunable diode laser suitable for use in a spectroscopy system. Further, a path to large-scale commercial manufacturability of the device will be required.

Phase II deliverable: Demonstrate a prototype spectoscopic system useful for DOD (or Army) significant applications. The success criteria will be developed by the government.

PHASE III: Commercialization of this program is highly feasible. Compact room temperature operated tunable diode lasers suitable for mid-infrared spectroscopy are required for many military, civilian, medical and security applications involving rapid identification of various chemical and biological agents.

There are several Army entities (RDECS)that have endorsed this particular topic. They would work closely with the successful candidate to tailor the project for rapid implementation. Again, there are applications that could/should be developed with this technology. It is expected that the interested RDECS would fund phase III. Also, Homeland security is extremely interested in this technology for chemical detection. They would be interested in not only funding the transition of this technology but also its implementation. MDA (Battle Management/Command and Control)is very interested in advancing capabilities for interceptor to interceptor and interceptor to launch platform communications as well as aircraft high bandwidth communications. They too should be a like entity to fund phase III.

The program end state would be such that tunable mid-IR lasers would have been developed with sufficient power levels, operating temperatures, and operating wavelength regions to address the requirements of DOD (department of defense)applications and those of emerging civilian technologies.

Civilian commercial applications include, for examples, secure point-to point digital data delivery and chemical detection. These commercial technologies could be inserted into defense systems used for IED (improvised explosive device) detection and the future combat systems needed to own the battlefield.

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KEYWORDS: Sensors, Electronics, Battlespace, semiconductor lasrs, quantum cascade lasers

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A07-057 TITLE: Automatic recognition of handwritten Arabic script documents

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Establish approaches to automatic recognition of handwritten text for non-Arabic languages using Arabic script, such as Urdu and Pashto, with innovative use of stochastic methods, graph theory and computational linguistics.

DESCRIPTION: While significant progress has been made in the automatic recognition of printed text in languages that use Arabic script, the automatic recognition of handwritten text in languages that use Arabic-style script is at a very preliminary state. In spite of on-going research efforts in handwriting recognition for Modern Arabic, very little consideration is being given to other non-Arabic languages that make use of Arabic-style script in their written form. Extensive processing time is required for human translators to screen captured handwritten documents, resulting in a huge backlog of translation work and the inability to respond rapidly to short-lived opportunities presented by captured information. This effect is particularly important for languages like Dari, Pashto and Urdu which are not related to Arabic, in spite of their adoption of written forms that resemble Arabic. A system that broadens optical text recognition to include handwritten text for Urdu as a language representative of the non-Arabic languages using Arabic-style script would be an important step in enabling the automatic processing of captured documents from a portion of the world's population that rarely has access to printing technology.

PHASE I: Design a concept for the recognition of handwritten Urdu text that takes into consideration the differences that separate Urdu and other non-Arabic languages with Arabic-style scripts from Modern Standard Arabic.

PHASE II: Provide an initial implementation of a handwritten Urdu text recognition system useable for screening of documents for key terms and general subject matter. Required Phase II deliverables will include a prototype system for testing by the Army's Sequoyah Machine Language Translation program at Sequoyah testbed facilities.

PHASE III: Extend the concept to Pashto, Dari and other less studied languages that use Arabic-style script for non-Arabic languages. Support the Army's Sequoyah acquisition program to acquire foreign language technologies throughout the Sequoyah program's expected lifetime, from Fiscal Year 2008 to Fiscal Year 2023.

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KEYWORDS: Natural Language Processing, Arabic script, handwriting recognition

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A07-058 TITLE: Polymer Electrolyte Membrane (PEM) with Acid-Base Pairing for Direct Methanol Fuel Cells (DMFC)

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop a stable polymer electrolyte membrane (PEM) that utilizes acid-alkaline membrane technology to compose a PEM with high ionic conductivity under low humidity conditions to control swelling and promote internal water management. In addition, low methanol crossover through the PEM is required to maximize fuel efficiency and DMFC performance.

DESCRIPTION: Direct methanol fuel cells (DMFC) offer high energy, compact power that the Soldier requires to power numerous electronic devices for extended mission times. DMFC technology would benefit greatly with the advent of a PEM that maintains high proton conductivity under conditions of low humidity while also inhibiting methanol permeability.

Swelling of the PEM due to high solvent uptake can compromise mechanical integrity and promote methanol diffusion through the membrane. A PEM that is a good proton conductor under conditions of low humidity would help to minimize these effects. It has been suggested that an acid-alkaline membrane could combine the technologies of both acid and alkaline membranes with the advantage of improved internal water management and improved mass transport. Internal water balance within the membrane through acid-base reaction chemistry would enhance water management, and alleviate the need to recycle water formed at the cathode. Some success has been achieved by combining two or more polymers with acid-base groups that create short-range directional flow channels for protons, without losing proton conductivity at elevated temperatures (1). Additionally, a bipolar membrane having cation and anion exchange layers may be another possible approach. In addition to proton-conducting membranes, anionic-conducting membranes are another alternative which offers improved kinetics, reduced crossover, and the use of non-noble electrocatalysts (2).

PHASE I: Design, fabricate, and characterize a novel PEM that makes use of acid-base strategies to achieve high ion conductivity (> 1x10^-2 S cm^-1), low methanol permeability (< 2x10^-6 cm^2 s-1), inherent internal water management, and minimal swelling (< 20%) with solvent. Either combinations of polymers or a single polymer with appropriate functionalities are acceptable. Such proton- and hydroxide-conducting membranes would need to be stable in both acidic and alkaline electrolyte. In addition to a detailed report, samples of all PEMs that are developed should be submitted for in-house evaluation.

PHASE II: Successfully developed membrane from Phase I shall be used to fabricate membrane electrode assemblies (MEA) for single cell testing for comparison with Nafion-based MEAs. Following optimization of the MEA process a stack shall be produced that is compatible for testing in a commercial or prototype DMFC system. Demonstrate the feasibility of the PEM synthetic process to produce commercial quantities of the optimized polymer.

PHASE III: Advanced membrane technology will significantly impact both military and commercial DMFC applications, accelerating product development, particularly for small, low power devices. Because the market and the number of devices in the commercial sector is much larger than the military market, widespread usage of this technology will drive down the cost of DMFC-based devices for the military and ensure a reliable manufacturing base.

The acid/alkaline membrane technology will transition into Direct Methanol Fuel Cell (DMFC) system technology for Soldier Power in support of the current Soldier Power DMFC program. If Phase III is successful, Natick Soldier Center (FFW) and PEO Soldier will support and fund procurement for an advanced DMFC. Another likely source of customer funding is CERDEC (Landwarrior power and energy). Applications for the advanced DMFC system include soldier power to complement batteries and to charge lithium-ion rechargeable batteries, significantly reducing the logistical burden (weight and volume) for the soldier by reducing the number of batteries required for extended mission time.

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KEYWORDS: direct methanol fuel cell, polymer electrolyte membrane, acid-base membrane, ionic conductivity, methanol permeability, water management

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A07-059 TITLE: Passive Detection of Acoustic Signatures via Glint Modulation

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: It has been demonstrated that the acoustic modulation of physical structures can be measured via passive optical detectors by detecting the modulation of glint on those structures. A detailed study of the feasibility of this technology is needed to include further demonstrations and assessments of the physical limitations of its performance.

DESCRIPTION: We seek a technique to monitor the acoustic signature of a target over a standoff distance through the atmosphere using passive optical detection. A proof of concept experiment demonstrating the measurement of acoustic spectra from a remote speaker using visible detectors to monitor the time varying reflectance of glint points has already been completed. An expansion of this capability, using this and other novel techniques, and a detailed understanding of its utility under realistic environments, is desired. The Phase I effort will study the phenomenology and produce a full radiometric model of this and other techniques to include, at a minimum, the optical sensitivity, noise limitations, atmospheric effects, target acoustic coupling, presence of optical and acoustic clutter, and target reflectance. The study will outline the capabilities and limitations of such techniques and describe at least one system design capable of implementing one of the studied techniques. The Phase II effort will construct a breadboard based on the design proposed in Phase I and provide support for a field test of the breadboard in a realistic environment. It is expected that the techniques proposed will include single, linear array, and two-dimensional arrays of detectors and that these detectors will be sensitive to optical radiation above 1 THz.

PHASE I: The Phase I effort will study the phenomenology of techniques to monitor the acoustic signature of a target over a standoff distance through the atmosphere using passive optical detection. The study should include parameters such as which wavelength region best optimizes the acoustic detection; atmospheric effects; glint or diffuse reflection effects; target self-radiation effects; acoustic coupling to the structure measured optically; acoustic and optical background clutter effects on acoustic detection; acoustic, optical and electronic noise sources and their limitations on acoustic detection; and post signal processing techniques used to enhance acoustic detection. The Phase I effort will also produce a full radiometric sensor model to be used to optimize a sensor design. This model will include the sensor lens, detector, readout electronics, stabilization platform, and signal processing in order to determine the final acoustic detection sensitivity. And finally, the Phase I effort will include a preliminary sensor design which will be used to construct and test the sensor in Phase II. The sensor design should use commercial-off-the-shelf (COTS) parts as much as possible but should not be limited only to COTS parts.

PHASE II: The Phase II effort will finalize the design from Phase I and construct a breadboard sensor from this design. The breadboard sensor will be used to demonstrate and validate the phenomenology and modeling developed in the Phase I proposal. If required, the Phase I models will be updated with the experimental results obtained. The breadboard model will be designed so that it can withstand controlled environmental conditions expected in an outdoor field test environment.

PHASE III: Phase III will consist of an Army sponsored field test of the breadboard sensor against realistic targets and will provide a report containing a detailed analysis of the results of the field test, recommended sensor improvements from these results, and the raw data acquired from the test. Based on the results of this report, the Phase II sensor will be redesigned in an effort to increase sensor performance. This new sensor can then be used for a number of applications, both military and civilian, such as remote monitoring of large structures (e.g. bridges) under environmental and traffic stress; remote monitoring of machinery located in hazardous areas; and remote monitoring of machinery scattered over a large area, such as a refinery, from a central location. Phase III funding could be provided by a number of federal, state, and private agencies interested in these applications as well as military agencies interested in bomb damage assessment and other remote monitoring battlefield applications.

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KEYWORDS: optical, acoustic, signal processing, remote sensing

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A07-060 TITLE: Behind Armor Debris (BAD) Data Collection Tool

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a tool /process to accurate measure behind armor debris (BAD) parameters.

DESCRIPTION: Behind Armor Debris (BAD) can cause serious damage to personnel and equipment inside a vehicle. The Army Research Laboratory is the Army's lead laboratory in modeling and analyzing BAD. Current operations have re-emphasized the need for accurate BAD modeling and analysis techniques. Part of the analysis process requires full characterization of the debris field from highly controlled experiments, and highly accurate data collection. Key parameters in the debris field are the velocity, mass, and spatial distribution of the resulting fragments. The goal of this topic would be to develop a tool or technique that can accurately measure the velocity of the resulting debris fragments. High-speed video imaging, orthogonal X-ray techniques, or other methods are all possible options and all have been used with some success. However, no one method has been proven to be ideal and effective in meeting all of the needs of this complex problem. The resulting tool or technique must also be cost effective for use on a daily basis.

PHASE I: Demonstrate the feasibility of a new tool or technique to measure the velocity of fragments in a BAD field.

PHASE II: Extend the feasibility effort from Phase I to a full working level tool that provides results in a easy to use compatible format.

PHASE III: Tool applications include the U.S Military as well as Homeland Defense. The tool may also be of interest to the public safety community (police, private security, etc.) The ability to measure the velocity of such high speed fragments may also transfer technology to some non defense related industries. The final product could be a combination of hardware and software tools. The military application of this product would a tool that would help design better armor, and help the soldier through increased survivability. The end user would be the Army Research Laboratory, and orgainzations invloved in armor design. Funding for the Phase III effort could come from armor companies or any ballsitic protection company that needs tools to accurately obtain data from behind armor debris experiments.

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KEYWORDS: behind armor debris (BAD), ballistic damage, high speed video, perforation, penetration

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A07-061 TITLE: Ultra-Dense Nano-Device Platforms for Memory Intensive Military Applications

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Ammunition

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

OBJECTIVE: To design and demonstrate a massive silicon-molecule hybrid memory array that utilizes advances in silicon-based nanoscale crossbar technology and molecular switching devices to realize information-intensive integrated-systems suitable for use in applications such as pattern recognition for theater threat assessment.

DESCRIPTION: All recent electronics industry estimates predict an upcoming technological barrier to conventional ultra-dense device fabrication that appears insurmountable beyond the year 2012. Specifically, no economically sustainable technologies are available that will permit the fabrication of memory or logic devices where a bit density of 10E11 bits per square centimeter (bits/cm**2) can be achieved with the needed demultiplexing for the address lines required for writing and sensing the information. Hence, entirely new technological device platforms must be developed now to enable the economical feasibility and scalability of ultra-dense integrated electronics past 2013. Fortunately, during the past year scientists at one of the largest microelectronics company in the world (and one of the leaders in large flash memory) have developed crossbar arrays in silicon with 4 nm gaps that they project will require groups of molecules, about 100-1000 per cross point, in these arrays for the memory elements [1-4]. These arrays can be tiled in 1K units to have the needed sense amps and demultiplexing lines to meet the 2013 challenge of 10E11 bits/cm**2 in an economically feasible and scalable commercial platform [3]. These arrays can only accommodate silicon and not metal electrodes; the latter being problematic due to electrode migration. Concomitant with the commercial breakthrough cited above, university researchers in the United States have developed a set of novel switching devices based on molecules that are 3-4 nm long with non-volatile memory properties and which function at room temperature [5-8]. Moreover, these molecules have been assembled directly onto silicon electrodes [8-10]. Therefore, these two fundamental discoveries make the confluence of the silicon crossbar arrays, switching molecular devices and the silicon-molecule assembly methods, a viable and attractive solution to the electronics dilemma for beyond-2012 technological demands in ultra-dense memory arrays. Once developed, this hybrid nano-device platform will make economic and scalable electronics technologies accessible for important military and private sector applications in the future.

The proposed ultra-dense silicon-molecule hybrid-electronics will be a significant enabler to military application requirements in the area of information gathering and threat assessment requirements. However, there are dual use applications that will be ubiquitous in the private sector, ranging from high performance systems for scientific computation, space exploration and entertainment. It is anticipated that the demands for ultra-dense memory arrays, once the approach here has been delineated, will be driven in large part by the entertainment markets' demanding needs for high-definition graphics, simulations and internet protocols.

PHASE I: The Phase I effort should focus on feasibility assessments and the initial design specifications for integrating nano-device switching elements with the available silicon crossbar array technology. Here, the minimum goal are memory arrays that are scaleable to 10E10 bits/cm**2 for pseudo non-volatile memory based on the silicon-molecule hybrid systems. Preliminary fabrication and testing is expected that can demonstrate of read-write-erase function over 1000 cycles with 60 minutes of non-volatility.

PHASE II: The Phase II effort should demonstrate tiled 1K memory arrays at 10E10 bits/cm**2 with the sense amp and demultiplexing units integrated into non-volatile memory arrays. A prototype system should be fabricated and tested that demonstrates a read-write-erase function over 100,000 cycles with 12 months of non-volatility.

PHASE III: The technical expectation of this program is the successful demonstration of massive tiled 1K memory arrays based upon hybrid silicon-molecule electronic systems at 10E11 bits/cm**2 integrated into non-volatile memory that will then be targeted for insertion into DoD relevant memory array and a commercial driver system developed by the mainstream electronics industry. Here, demonstrations of read-write-erase over 1,000,000 cycles with 5 years of non-volatility should be the targeted goal. Examples of U.S. Army/DoD relevant insertion points include, but are not limited to: the CERDEC Program for Army and Marine Corps Collaboration on Transforming Multimedia Imagery Operations which already possesses a suitable platform (i.e., Tactical Imagery Processing System (TIPS) III) for supporting information operations for the Marine Corps; the ECBC Program for Wide Area Arial Reconnaissance (WAAR) which is developing a real-time hyperspectral imaging capability for mapping chemical clouds to protect soldier-in-the-field but requires large, rapid-access computer memories for real-time storage and processing of very large hyperspectral data cubes; and the Joint-Service Range Validation System (RVS) that utilizes data taken from multiple ground-based hyperspectral imaging sensors to produce a tomographic reconstruction of vapor/aerosol plumes in real-time but that are limited by state-of-the-art computer memory density and speed.

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KEYWORDS: memory arrays, silicon crossbar technology, molecular switches, information technology devices, manufacturing engineering

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A07-062 TITLE: High-Speed Chemometrics and Data Fusion of Orthogonal Detection Sensors

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Recent preliminary work has shown the advantages in the significant reduction of false alarm rates when fusing spectral data from orthogonal techniques such as LIBS (Laser Induced Breakdown Spectroscopy) and Raman. In addition, each technique relies heavily on advanced chemometrics which presently are performed primarily in a post-processing data analysis mode. The objective of this topic is to develop innovative algorithms to significantly improve the speed of chemometric analysis for individual sensors as well as the data fusion from multiple sensors. Both highly efficient algorithms as well as advanced signal processing circuitry are sought in order to approach real-time spectral data analysis resulting in improved detection sensitivity and specificity.

DESCRIPTION: There is a growing consensus that detection of trace explosives and other hazards in a complex outdoor environment will require the use of orthogonal sensing techniques. Spectroscopy techniques such as LIBS and Raman deal with complex spectral signatures that are well-suited for chemometric analyses to determine probabilities of detection, false alarm rates, and the useful Receiver Operating Characteristic (ROC) curves. Such procedures for spectral analysis take finite computational time. But beyond that, the next level of data analysis which involves the fusion of individual sensor results is computationally intensive as well and therefore takes finite time to complete. Ultimately, it is highly desired that the chemometric and data fusion computations be real-time, or nearly so, so that the warfighter can have a quick answer whether some suspected material presents a hazard or not.

To achieve real-time sensor response, there is a significant need to develop appropriate algorithms and data processing circuitry that will process raw spectral data in a highly efficient manner so as to transform the current situation of data post-processing to real-or near real-time response so that the information to the operator is available for decision making purposes before another analysis is performed. This new capability will be particularly important in the search for explosives residues where high-speed travel in a hostile environment is necessary.

PHASE I: Develop algorithms that streamline the chemometric analysis of spectral data from individual sensors like LIBS and Raman (data will be supplied by ARL). Demonstrate a data fusion algorithm that improves detection performance relative to the individual sensors used, preparing ROC curves and confusion matrices. Develop a software modeling environment that validates the algorithm performance and further validates the overall concept, simulating sensor motion.

PHASE II: Construction of a prototype processing capability (hardware and software) that operates in real-time that allows testing of algorithm performance in limited field testing. The prototype will be tested under field conditions at ARL using the raw data supplied by the LIBS and Raman sensors. Embedded processors or other hardware acceleration should be used to offer near real-time operation.

PHASE III: Commercialization of the combined software/hardware real-time sensor data fusion packages developed under this SBIR investment will address immediate military needs for sensor performance at high detection probability and low false alarm rates for hazardous targets that include IEDs as well as sensors used for the threats addressed by first-responders engaged in homeland security operations. Military procurement organizations such as PMCCS, PMFPS, JPOECBD, and JIEDDO are expected to acquire this new capability for existing and emerging sensor systems. Additional applications are anticipated in the industrial process monitoring and environmental areas.

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KEYWORDS: Explosive detection, chem-bio detection, sensor fusion, LIBS, Raman, chemometrics

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A07-063 TITLE: <u>Processes for Metal Matrix Composites</u>

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 fabrication techniques to produce high quality MMC parts of various geometries

DESCRIPTION: Every aspect of military systems and equipment are being scrutinized for possible weight reductions. Steel, while being a common construction material, possess a high density, making it a target for substituting in lower density materials. Metal Matrix Composites (MMCs) offer the attractive attributes of low density alloys while exhibiting superior mechanical properties of higher density steels. The properties of interest are: high stiffness, strength (yield, shear, ultimate tensile, and compressive), high interlaminar strength, and low density. Currently, continuous fiber reinforced MMCs exhibit many of these properties, but are difficult to manufacture/process resulting in materials with varied quality and are plagued by high costs. This topic seeks processes to produce high quality MMC components (plates and tubes) of large volume by a cost effective approach.

The materials of interest to this solicitation are capable of replacing high density steel components with a net mass reduction. The goal is to develop processes capable of forming the composites with high quality (low porosity or inclusion levels), uniform and/or controlled distribution of reinforcement materials, and, ideally, in more complex geometries than simple plate or blocks.

PHASE I: Demonstrate a procedure to produce a metal matrix composite material in both plate and tube form. The Army's interests are for a composite structure, either continuous or discontinuously reinforced, that exhibits the following mechanical properties:

• Properties of interest
  o E = 150 GPa *
  o Room temperature tensile strength =1250 MPa
  o Density (MMC) = density(steel)/2
  o Low porosity and inclusion levels (<1%)

*average of longitudinal and transverse for anisotropic materials

The modulus metric is the Young's modulus for isotropic material, and should be the average value of the longitudinal and transverse Young's modulus for anisotropic materials. The tensile strength metric is the lower of the yield strength or ultimate tensile strength, since some composites may exhibit limited plastic behavior.
The proposer would be expected to develop, report, and, if possible, demonstrate a process for making a MMC material meeting these requirements in both plate and tube geometries. A key criterion is that the manufacturing process be developed with modeling and simulation tools to support process optimization. The proposer should address the ability of the process to scale to fabricate parts of various sizes and thicknesses (in both tube and plate geometries), or other more complex geometries, while maintaining the quality and cost benefit over current commercial processes.

PHASE II: Building on the successful results of Phase I, develop the procedure for manufacturing metal matrix composite tubes and plates. A goal of this program is the ability of the process to create tubes and plates with the same or improved material properties from Phase I. The first year of the Phase II effort will focus on the fabrication of: a tube with an ID of 30mm, an OD of 60mm, and lengths of 1 meter and progress towards 2 meter long tubes during the second year, and a plate 0.5m by 0.5m by 1cm thick and progress to 1 meter square of the same thickness by the second year. Qualify and quantify the quality and performance of the samples by nondestructive/destructive examination and generating mechanical and thermal property data using standardized procedures. Perform a cost analysis assessment for future production. Reasonable performance related goals expected to be achieved by the proposer related to the execution of this project are the demonstration of the MMC tube and plate production process through the generation and delivery of three prototypes of both geometries at the end of the first year of the Phase II effort. These materials will be delivered to the US Army Research Laboratory (ARL) for evaluation. Similarly, a successful second year of this Phase II effort could be expected to demonstrate and deliver three additional prototype samples - 2m long tubes and 1 meter square, to ARL, for evaluation.

PHASE III: The procedures developed during the performance of this SBIR for manufacturing MMC parts will then be scaled and applied to other Army applications (armor panels, various caliber gun and mortar systems, pressure vessels, or rocket motor casings). Commercial applications for a lightweight, high performance MMC would be in automotive and aerospace applications, where they are already finding some application at this time (albeit limited due to the cost of processing these materials).

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KEYWORDS: metal matrix composites, tubes, plates, processing, manufacturing technology

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A07-064 TITLE: Ultra-High Strength and High-hardness Nano-Aluminum Composites

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 composition and processes to synthesize high-hardness bulk nano-grain size aluminum metal matrix composites for armor.

DESCRIPTION: Recent research at UC Davis and John Hopkins University demonstrated extensive strengthening from reinforcing a modified cryo-milled 5083 aluminum alloy with a dispersion of nano-grain size aluminum and boron carbide particles with dynamic flow stress near 1 GPa at strain rates >1000. . For ballistic applications, high-hardness characteristic is essential to fracture and erode a projectile. The focus of this SBIR topic is to design and develop optimized (or new) alloy chemistry of nano-aluminum metal matrix composites with dynamic flow stress greater than 1 GPa (at strain rates greater than 103) and Knoop hardness greater than 14 GPa with 2 Kg load. Both macro and nano-size reinforcements will be considered in this topic.

PHASE I: Demonstrate concept of alloy composition and verify the feasibility/repeatability of a process to produce fully dense nano-aluminum metal matrix composites with:1) density within 10% of pure aluminum, 2) dynamic flow stress greater than 1GPa and 3) Knoop hardness greater than 14 GPa with 2 Kg load.
. Size and quantify of the material produced must be sufficient to verify properties from Hopkinson-Korsky Bar experiment and hardness measurements.

PHASE II: Scale up processing demonstrated in Phase I to produce and verify mechanical properties of fully dense nano-aluminum composites with plate dimensions greater than 30” x 30” x 1” (762 x 762 x 24.5 mm). This will include optimization of the entire processing stream for ballistic properties. Ballistic evaluation and materials optimization will focus on defeating both tactical and combat vehicle threats.

PHASE III: Transition materials technology for domestic and military applications in armor: This will include partnering with major plate manufacturer with tonnage capacities for armor plates. Products from this effort will support armor ATO, PMs for tactical and combat vehicles in providing enabling material for fragmentation/IED defeat and damage mitigation with significant improvement over 5083 Al.

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KEYWORDS: Aluminum, metal matrix composites, boron carbide, processing, nano

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A07-065 TITLE: Warhead Adaptive Materials (WAM) for Military Operations in Urban Terrain (MOUT)

TECHNOLOGY AREAS: Battlespace

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 perform enabling research and development that will lead to a new generation of warhead adaptive materials (WAM) composed of non-explosive solid composite ingredients (such as metals, metals and polymers, metal salts, etc.) which are not detonable, but are carefully designed to release intense heat and provide controlled overpressurization. This technology will yield novel ways of delivering energy to the target for compact weapons for ground forces conducting Military Operations in Urban Terrain (MOUT).

DESCRIPTION: Ground forces conducting MOUT need compact munitions to fully engage the enemy while moving quickly within urban and complex terrain while limiting non-combatant casualties and physical/collateral damage. Urban operations have many difficult challenges versus operations on less restrictive terrain. These include short ranges, presence of manmade structures, limited engagement areas, restrictive entry and maneuver space, the presence of noncombatants, and the ability to defeat enemy forces within the urban area without completely destroying the resource infrastructure. Unlike conventional materials, the insensitivity of these materials increases the power of the munition without simultaneously increasing the vulnerability of the weapon system. This can be done by achieving higher energy levels for the warhead and by devising novel ways of applying the energy to targets, both of which are expected to lead to more rapid mission execution with less ammunition expended. The specific goal in this program is to develop new WAM composed of non-explosive solid composite ingredients (such as metals, metals and polymers, metal salts, etc.) which can be readily integrated into small, compact MOUT munitions.

The “adaptive” nature of these materials, when coupled to conventional explosive output yield, can be controlled to tailor energy release to the target type. It would then be possible to: (1) develop munitions that have the ability to perform within the constraints of urban and complex terrain, without sacrificing their effectiveness on less restrictive terrain, (2) enhance wall breaching and obstacle reduction, (3) develop munitions with tailored over-pressurization effects that will allow them to be employed in close proximity to non-combatants or from within structures with reduced collateral damage to the main structure, and (4) enable employment of tailorable effects within close proximity to dismounted forces. Technology would provide warhead materials that combine multiple properties (high energy content and insensitivity; metal fragmentation capability with blast overpressure). Enabler for multiple use warheads (reduce inventory requirements by 30 to 40%); clearly visible damage at stand-off distances (increased damage on target); more effective kill (higher energy on target); and scalable effects and new kill mechanisms.

These weapons may be smaller which will allow forces to move lighter and more rapidly during the conduct of operations. The integration of WAM will permit scalable and tailorable penetration, blast, fragmentation when used in urban environments. These materials may allow for the destruction of target function and not damage surrounding structures or personnel. Also includes the capability to neutralize a key portion of a target without affecting other components. In addition, they the potential to double catastrophic kill radius in other applications such as anti-defeat or air defense and provide improvements in recognizable kill. Key technical challenges to be addressed are: (1) developing WAM and assessing the relationships of material ingredients and fabrication processes with associated initiation and energy release; (2) characterizing the mechanisms associated with the energy release; (3) understanding physical and performance characteristics; (4) understanding how to couple the energy to targets and understanding how to tailor WAM for specific applications; and (5) provide candidate materials/processes and associated energy release characteristics which will be configured into generic concepts for demonstrations of feasibility. Proposed new technology would support joint functional and operation capabilities for Future Force weapons and utilize service resources to achieve common focused objectives with time-phased goals.

PHASE I: Define and provide supporting analysis on all promising Warhead Adaptive Materials (WAM) materials for applications as outlined in the description.

PHASE II: Design, fabricate and test prototype materials to validate Warhead Adaptive Materials (WAM) performance and applicability. Evaluation tests will be conducted at the contractors' facility as well as at an Army Research facility.

PHASE III: The developed technology will be inserted into Army ATO programs "Novel Energetic Materials for the Future Force" and DTO "Novel Energetics" and transitioned to PEO-AMMO, PM-MAS, PEO-Missiles & Space, and acquisiton programs of record (FCS, Stryker). Technology will also be jointly integrated into Navy (Office of Naval Research) and Air Force (Eglin Air Force Base Munitions Directorate) munitions programs, and also commercialized. Transition technology to commerical applications. These include FCS artillery, mortar, warhead, fragmenting munitions, chemical and biological stockpile destruction. Civilian applications include mining, builing/structure demolition, and tunneling.

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KEYWORDS: Warhead, adapative materials, energetic materials, scalable effects, target interactions

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A07-066 TITLE: Development of continuous in-line manufacturing process for application of multi-component semi-permeable textile coating

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design and develop continuous line textile coating processes that will enable economic manufacture of specialty membrane coated fabrics utilizing multi-phase polymers, allowing the polymer morphology and full range of selectively permeable characteristics of the membrane to remain intact.

DESCRIPTION: The U.S. Army requires that all fielded systems be survivable in a chemical warfare environment. Past and presently fielded protective clothing utilizes either butyl rubber that is not breathable or activated carbon that does breathe but is heavy and cumbersome to wear. Both designs result in fatigue and possible heat stress on the soldier. Outfitting the soldier with protective gear that is lightweight, flexible and breathable is necessary to enable the soldier to move freely in hazardous environments and therefore increases soldier survivability.

In an effort to address these multiple requirements, the Army Research Laboratory has developed a series of sulfonated tri-block copolymers.2-9 The novel polymers are comprised of polyisobutylene as a major component to provide barrier properties to the block copolymer. The novel block copolymers exhibit flexibility over a broad temperature range and selectively permeable “membrane-like” characteristics. The multifunctional polymer has been shown to adhere well to woven fabric such as the battle dress uniform (BDU) and can be processed commercially using conventional textile coating equipment. The membrane has been fully characterized and has demonstrated chemical agent resistance and high water vapor permeability. The technologically advanced material exhibits selectively permeable properties as a result of a three phase morphology comprised of a soft rubbery hydrophobic phase (polyisobutylene), a hard polar hydrophilic phase (sulfonated polystyrene) and ionic domains. This complex phase morphology is sensitive to some of the stages of conventional textile processing such as the drying and heat processes. Additionally, a continuous commercial post-process needs to be developed for ion substitution of the coated fabric. A SBIR is needed to specifically address the design and development of continuous line textile coating processes that will enable economic manufacture of coated fabrics utilizing multi-phase polymers allowing their morphology and full range of selectively permeable characteristics to remain intact.

Although it is not required that a proposal for this solicitation specifically utilize the tri-block copolymer approach developed by the Army, this material is mentioned because it has shown some very desirable properties for breathable protective clothing such as high moisture vapor transport rates, chemical resistance and flexibility at low temperatures.

PHASE I: Research efforts should focus on the design and synthesis of a copolymer/ionomer comprised in part of an impermeable block and an ionic block, that exhibit numerous properties that are critical for chemical protective field operations. These properties include: flexibility over a broad temperature range (~ -60ºC-100ºC), economical processing as membranes for coated or woven fabrics, gloves, tenting, or stacked fuel cells, exhibit high levels of water vapor transport and simultaneously block transport of organic compounds such as chemical warfare agents. Results from the Phase I effort should demonstrate the above characteristics and define a clear and feasible synthetic route that will enable production of the elastomeric membrane at the pilot plant level. The synthetic routes of preparing the polymer must be in accord with methods that are amenable to large scale domestic (U.S.) manufacturing facilities. That is, solvents used must be in compliance with environmental laws in the chemical and textile industries. Material development should be focused not only on the selectively permeable properties, durability and flexibility as described above but also with careful consideration of manufacturing processes that will allow the nanoscale structure of the membrane to remain intact exhibiting the same performance properties observed in the laboratory. Economic analysis shall be performed and outlined to determine the estimated cost to produce the membrane at pilot plant level. The elastomeric membrane should exhibit durability, flexibility and selective transport properties necessary for use in field operations and chemical warfare environments. That is, the membrane should “breathe”, allowing water vapor to transport away from the soldier, thereby reducing heat stress, while simultaneously blocking penetration of harmful substances is liquid or vapor form. Water vapor transport values should be as a minimum, competitive with commercially available “breathable” fabrics used for sports and recreation.

PHASE II: Research will focus on the design and development of manufacturing processes to coat the multi-phase/multi-functional block copolymer membrane synthesized in Phase I onto a fabric substrate resulting in an economic and durable coated fabric that enables the multi-functional polymer membrane to retain its morphology necessary for semi-permeable and mechanically flexible performance characteristics. The objective of Phase II research is to design and develop a textile continuous manufacturing process and to utilize the manufacturing process to fabricate membrane coated fabric in quantities of at least 50 yards in a conventional textile manufacturing setting. The manufacturing process should demonstrate the potential to be economically implemented in a conventional textile manufacturing setting. Important design considerations will encompass relatively low heat cycles (50 ºC maximum), humidity control, solvent selection, and application methods that result in homogeneous, defect free coating of the membrane. A subsequent process will be developed for ion neutralization of the membrane. Appropriate quantities of the membrane polymer must be produced to successfully fabricate a minimum of 50 yards of coated fabric. The coated fabric will be thoroughly evaluated to ensure that the semi-permeable characteristics of the coating are fully functional; exhibiting the same water vapor permeation and chemical agent resistance as that of laboratory generated coated fabrics, as well as mechanical integrity, adhesion to fabric, and mechanical flexibility. Acceptable coated fabric will then be fabricated into a protective suit prototype and evaluated further for acceptability as protective clothing.

PHASE III: Successful completion of Phase II would benefit military applications and the private sector in the areas of chemical protection, hazardous waste, environmental protection (spills), biological protection/waste, filtration and potentially, alternative fuel cells. This SBIR topic has been coordinated and endorsed by Natick Soldier Center-Individual Protection Directorate and all successful technology resulting from this SBIR will be transitioned to Natick Soldier Center for further evaluation and field testing.

Economic manufacturing processes are required to successfully manufacture technically advanced "nanoscale" materials. In addition to Army applications such as protective chemical clothing for the soldier,raw materials suppliers and manufacturing companies would benefit from a successful outcome of this research to better enable successful manufacturing of nanotechnology as it applies to a variety of application areas.

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KEYWORDS: Triblock copolymer, membrane, semi-permeable, selectively permeable, polystyrene-polyisobutylene-polystyrene, textile coating, textile manufacturing, water vapor transport, ionomer, counter-ion substitution, sulfonation.

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A07-067 TITLE: Processing of Bulk Nano-Magnesium Alloy and Composites

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 processes to synthesize bulk nano-grain size magnesium alloy and magnesium alloy metal matrix composites.

DESCRIPTION: Magnesium is the lightest commercial metal for structural commercial and defense applications. Wrought magnesium alloys with strength and corrosion resistance comparable to aluminum alloys are now available. Lighter than aluminum structural armor materials are needed for future combat and tactical vehicles. The exploitation of nano-grain-size magnesium based material with ultra-high strength is prohibitive from the lack of processing technology available to produce this material in quantity. The focus of this SBIR topic is to develop manufacturing processes, suitable for production scale-up, for bulk wrought nano-grain size magnesium alloys and composites with grain sizes <100 nm and to optimize chemical and phase compositions for structural armor applications.

PHASE I: Demonstrate alloy design concept and verify the feasibility and repeatability of a process to produce fully dense nano-grain size (<100nm) magnesium and magnesium reinforced with boron carbide (>10 volume percent) composites with dimensions greater than 2” x 2” x 2” (51 x 51 x 51 mm).

PHASE II: Scale up processing demonstrated in Phase I to produce fully dense nano-grain size (<100nm) magnesium and magnesium reinforced with boron carbide (>10 volume percent) with dimensions greater than 30” x 30” x 1” (762 x 762 x 24.5 mm). Characterize and optimize quasi-static and dynamic properties with strengths and ductility greater than 6061 alloys as well as corrosion resistance comparable to 6061 alloys.

PHASE III: In Phase III, the vendor will target a minimum of 2 applications: 1) armor plates for blast and armor kits, and 2) commercial and millitary structural applications for ground and air vehicles.

For 1), ballistic test data and advanced armor/mine blast concepts utilizing this new material from Phase II results will be presented to Army and USMC Combat and Tactical Vehicle PMs for field trials to demonstrate immediate enhancement to meet operational capabilities.

For 2), mechanical properties from extrusions and load bearing elements will be presented to both FCS and Future Heavy Lift Rotorcraft PMs for consideration for utilization in weight reduction. FCS MTO on Affordable structure and armor PMs will evaluate this material for potential applications. Vendor will also partner with automotive and aerospace industry for immediate application for weight critical systems.

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KEYWORDS: Magnesium, metal matrix composites, boron carbide, processing, nano

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A07-068 TITLE: Antimicrobial Coatings for Military Textiles

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: The objective of this research is to develop a coating that provides long-term antimicrobial activity to textiles used in DoD clothing. The use of antimicrobial coatings will prevent or reduce the colonization of microorganisms, some of which cause life-threatening diseases. This is an important component in the overall strategy for improving soldier performance.

DESCRIPTION: The reduction of disease and non-battle related injuries is critical to U.S. global casualty prevention. The need for an effective preventative treatment is particularly important now due to a recent increase in infections for wounded soldiers in Iraq, resulting from multi-drug resistant strains of A. baumannii and S. aureus. Research by the Army and others has focused on combating infection and the colonization of microorganisms by treating textiles to make them antimicrobial. Approaches include application of coatings that contain cationic surfactants,[1] polycationic polymers,[2] polyamines,[3-4] and metals.[5] In particular, the Army has pursued approaches that involve placement of cationic polymers or polyamines on the surface of textiles to provide them with microbial resistance. Materials of this type have exhibited antimicrobial properties, but the resulting coatings are often non-uniform and cause degredation of other properties. This Topic is focused on developing a process to generate thin, durable, non-leaching antimicrobial coatings on the surface of textiles. The coating process should not be detrimental to other textile properties (e.g., porosity, mechanical properties).

Recent research results have shown that a gas-phase process can be used to apply a thin (20-100 nm), conformal coating of a polymer onto a variety of surfaces.[6-7] This low energy process yields linear polymers in which pendant chemical moieties remain intact and are available for further reaction if necessary; antimicrobial coatings have been incorporated into textiles using this methodology.[8] The goal of this topic is to build on these results to apply light-weight, durable, antimicrobial coatings to textiles such that no degradation of other properties occurs. Research will focus on developing a gas-phase process to provide passive protection to uniforms and clothing by application of durable, conformal, flexible antimicrobial coatings. The resultant technology should ultimately lead to the development of a high through-put process such that large volumes of fabrics can be treated.

PHASE I: Initial research will focus on polycationic or polyamine functional groups, or groups that undergo facile post-secondary reactions to provide this functionality, to generate polymer coatings with high antimicrobial activity via a gas-phase process. Processing parameters should be defined such that a controlled thickness, conformal polymer coating can be applied to cotton strips in a reproducible manner. Should a minor secondary solution-phase step be required (e.g., quaternization), then key reaction parameters need to be defined and investigated. Key coating properties that need to be addressed include non-leaching behavior of the coating, coating adhesion to the substrate, coating durability, and an initial assessment of the lifetime of antimicrobial activity under typical conditions encountered by Soldiers and after multiple laundering cycles. Characterization should be done using reliable metrology that produces success and failure criteria for coatings and textiles. The coating process must not lead to significant degradation of other properties (i.e., porosity, dyeability, printability, durability, mechanical strength). The use of plasma to oxidize a textile surface for attachment of an antimicrobial moiety is non-responsive to this Topic.

PHASE II: In this Phase, the process and characterization need to be expanded to include cotton, polyester, and nylon. Application of the most promising gas-phase process should be investigated and optimized for mono- and multi-filament fibers and bulk fabrics. Relevant data for either a batch or continuous coating process should be generated to make a sound prediction as to the ultimate scalability of the process (e.g., bulk reactor size, continuous line-speed). Antimicrobial activity must be determined for coatings on all fiber types. Coating longevity and antimicrobial activity need to be determined for fabric samples that have been both pre- and post-exposed to microbes. Textile properties should be determined using reliable metrology (e.g., ASTM methods) and compared for three sample types: 1) before any processing, 2) after application of the coating, and 3) after exposure of the coated sample to a variety of microbes. The final coating and textile must be characterized to provide data on the extent of coating coverage, film thickness, functional group density, coating adhesion, and antimicrobial activity and lifetime. All coatings and textiles should be characterized using reliable metrology as described in Phase I.

PHASE III: This technology will find applicability for both DoD and civilian applications, including coatings for antimicrobial wound dressings, hospital gowns, bedding, surface coatings, cleansing wipes, antimicrobial textiles (e.g., uniforms, tents), food/water containers, water treatment membranes, air filters, and medical devices. The Natick Soldier Center will be the specific Army customers of this technology. Their participation in the development of this technology will be instrumental in its transitioning to larger S&T efforts with and external to the DoD.

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KEYWORDS: Antimicrobial, Coatings, Disease, Gas-Phase, Polymers, Surfaces

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A07-069 TITLE: DNA-based barcoding for identification of Army materiel

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop an unambiguous DNA-based barcoding system to track and identify critical Army materiel. The system should consist of barcodes which can be readily applied to equipment (foodstuffs, munitions) and a hand-held device capable of monitoring and authenticating the tags.

DESCRIPTION: Counterfeiting, theft and diversion of military equipment are significant issues within the Army especially during times of warfare. The loss and falsification of equipment can severely hamper the Army in its ability to maintain readiness and can significantly compromise the safety of the warfighter. The ability then to label and track food supplies, munitions, support equipment and other military materiel using identification markers that are unambiguous, unforgible, and readily authenticated would have tremendous utility in maintaining the warfighter's vigilance and safety.

Among the possible means of effectively labeling equipment, the use of DNA and DNA analogs appear to be highly suited for this application. DNA is in essence an information-rich bio-polymer encompassing nature's bar code for preserving important cellular information. The information is contained within the chemical identity of the nucleotide bases (adenine, thymine, cytosine, or guanine) that comprise each link of the polymer chain; the longer the DNA chain, the more possible sequences that can be formed and the more specific and secure the bio-tag. For example, a DNA strand that is 10 nucleotides in length can form 4E+10 or over 1,000,000 unique sequences or "tags". Among the attractive characteristics of DNA oligonucleotides for this application are their relative stability, their low cost (sequences up to 25-30 nucleotides can be routinely and inexpensively synthesized in millimolar quantities) and the ability to rapidly detect and identify specific DNA sequences. Single-stranded DNA sequences form specific complementary base pairs with other uniquely specific DNA sequences; this inherent feature of these molecules has been used for years to develop well controlled procedures for biosensing. More recent advances in the field have developed DNA-based barcoding systems for genetic and genomic screening. Unfortunately, this methodology often requires DNA amplification techniques such as PCR which necessitiates the involvement of multiple reagents in the detection scheme. The vision seen for this effort calls for the development of DNA or DNA analog based authentification tags in combination with the development of a hand-held device for the rapid, sequence-specific detection of these tags in a manner that requires no reagents or amplification protocol.

PHASE I: Develop a system capable of detecting specific DNA sequences from 20-25 nucleotides in length. The system should require no reagents, produce a rapid signal and be capable of detecting a variety of specific DNA sequences. In addition, the detection should be highly specific and unambiguous; that is, the detection scheme should discriminate between the exact DNA sequence specified and a sequence containing a single base mismatch present at any location within the oligonucleotide. The signaling system should have the capability of being incorporated within a portable hand-held device.

PHASE II: A system consisting of DNA barcoding labels and a prototype of a hand-held detection device should be developed. The DNA within the barcoding labels should be contained in a manner that protects the DNA from environmental extremes (heat, dust, effects of DNA damaging agents) while maintaining the ability to be specifically detected. The labels should also consist of material that is economical, readily and stably applied to a variety of Army materiel, protected from physical damage and not be obviously noticeable to individuals outside of those responsible for using the system. The detector should be rugged, portable, easy to use, have low power demands and be capable of producing a variety of positive unambiguous signals.

PHASE III: This detection system will have utility as a rapid, unambiguous tool for identifying a variety of materiel for both military and civilian locations in which verification of the identity of that materiel is critical. Since the barcodes will be made of materials that are readily available and inexpensive, they can be mass-produced and

efficiently deployed. The detection device will also be compact enough to easily deploy multiple units to any number of required locales.
The most likely transition route for this technology would be through the Natick Soldier Center which is responsible for developing soldier support equipment from a variety of technical platforms including biotechnology. Natick could test field-ready devices on different forms of Army materiel. Given that the sensing platform is DNA-based, it is foreseen that the biotechnology industry would also have a stake in funding these efforts.

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KEYWORDS: Deoxyribonucleic acid, optical tracking, identification systems, optical detection, portable equipment, hand held, reagentless detection, materiel tracking

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A07-070 TITLE: Stochastic Programming of Computer Agents and System of Systems Designs

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Combine and utilize the technologies of 1) stochastic programming, 2) agent-based simulations, and 3) distributed processing to advance the development efficiency and design quality of military systems and their operational use. Develop an integrated software environment capable of computing the design of agents, the systems they employ, and predicting the response of adversaries.

DESCRIPTION: The design and development of military systems and their CONOPS is typically a man-in-the-loop intensive and iterative process. Systems designers originate a few baseline concepts, composed of air, space, sea, and ground assets, and then intuitively explore operational and design variations within a large multi-dimensional trade space. Arriving at the most well designed, robust, and cost-effective solutions is a daunting task.

Until recently, modeling and quantifying the effectiveness of military systems in a dynamic theater environment was nearly impossible.
Agent-based modeling represents the latest in analytic simulation technology and offers a simulation environment in which small-to large-scale joint war fighting scenarios can be constructed and explored.
Agent based simulation tools such as SEAS (http://www.teamseas.com) provide analysts with the ability to represent networked military units and platforms that react and adapt to perception-based scenario dynamics in a 3-D physics-based Battlespace.

Stochastic programming is a framework for modeling optimization problems that involve uncertainty. Evolutionary algorithms and stochastic diffusion search (SDS) are illustrative examples. The application of these techniques to optimize the design of both the agents and the systems they employ is ideally suited for exploring and quickly converging on transformational war fighting concepts, effects-based operations, and network centric warfare solutions. Easy access to stochastic programming will provide system designers and architects with the most advanced techniques for arriving at robust and cost-effective solutions. It will also open the door to predicting how an adversary might co-evolve in response to new war fighting technologies and concepts.

Due to the level of processing that could be involved, there is a clear advantage to distributing the computational work load for such an integrated model across a network of computers. Methodologies and software tools are needed for intelligently load balancing multiple simulations' runs and providing an operator the ability to monitor progress and in-process results.

For these reasons, the development of an integrated software environment that will utilize the combined technologies of mathematical optimization algorithms, agent-based simulation, and distributed processing - will advance the development efficiency and design quality of military systems and their operational use.

The proposed research will enhance C4I research efforts at CISD/ARL and research on Near Autonomous Unmanned Systems under SEDD/ARL. The output of this research can be directly transitioned to Army G2 Critical ISR Technologies (POC: Mr. Collin Agee of the Army Intelligence Office), Army Capabilities Integration Center (POC: COL Kevin Brown), and RDECOM System of Systems Integration Office.

PHASE I: Phase I: Conduct feasibility study on the theoretical developments for stochastic programming techniques that are specifically applicable to optimal design of distributed computer agents system and system of systems. The deliverables shall include monthly reports as well as the algorithms and executable computer codes obtained during the Phase I research.

PHASE II: Develop stochastic optimization theory and its computational algorithms for optimization of distributed computer agents system and system of systems. The deliverables of Phase II research results include quarterly reports, advanced algorithms, and executable computer codes. Visit of the awardees and simulation demonstration of the research results at relevant Army laboratories and POE offices are expected near the end of Phase II research.

PHASE III: Dual use commercialization of the research results: During Phase III, the awardees are expected to work with the military services and their contractors to transition the technology for applications to military systems. Specifically, the awardees shall work with scientists at CISD/ARL and SEDD/ARL for automation of design searches and distributing the search and modeling processes over the ARL network of CPUs and with RDECOM System of Systems Integration Office for testing and evaluation of the effectiveness of the stochastic search and optimization alogrithms developed in a dynamic military systems environment. The output of this reseach can be directly transitioned to Army G2 Critical ISR Technologies, Army Capabilities Integration Center. Commercial computer software designers can be engaged to design and produce multi-agent simulation automated distributed processing software for military and commercial use.

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KEYWORDS: stochastic optimization, stochastic programming, computer agents, system of systems

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A07-071 TITLE: Development of Innovative Fusion Algorithms for Color Night Vision

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop and demonstrate innovative fusion algorithms for color night vision with close to photorealistic imagery through fusing multi-modal images and knowledge of visual color.

DESCRIPTION: Adding color can increase depth, contrast and perception of night vision compared with monochromatic images. Study has shown that color can improve soldier's reaction times and reduce fatigue associated with staring at traditional night vision images. Recent research has pointed to the feasibility of creating color display for nigh vision through data and information fusion [1-5]. For example, [2] considered fusing images from InGaAs Short Wavelength Infrared (SWIR), InSb Mid Wavelength Infrared (MWIR), uncooled microbolometer Long Wavelength Infrared (LWIR), and Charge-Coupled Device (CCD) cameras. While existing results are encouraging, significant effort is needed to improve the quality and resolution to bring the fused color images closer to natural appearance. This topic calls for innovative approaches to fusing multi-modality (intensified or infrared) images with visual color from knowledge base. The end goal is a system that generates images close to natural appearance. Challenging issues include color assignments appropriate for a vast range of conditions and environments, maintaining resolution, and fast processing for real-time applications. Several enabling technologies are available. First, research on fusing multi-modality images, e.g. visual, intensified and infrared, for the last decade has provided efficient algorithms that maintain the quality of imagery while preserve characteristics of individual modalities and increase contrast of intended objects [6]. Second, super-resolution techniques can increase image resolution from series of individual frames [7-8]. Further, recent progress has provided methods for intelligently transferring source image’s color characteristics to its grayscale image [9]. This effort is expected to focus on the development of computational algorithms. The system should use Commercial Off-The-Shelf (COTS) Digital Signal Processing (DSP) hardware. This topic is intended to move beyond purely traditional false-color assignments for single grayscale images. The fused image should increase the contrast of the intended object from the rest of environments by exploring characteristics of infrared images of different bands. Real-time operation is required.

PHASE I: Phase I may be directed toward feasibility demonstration by designing fusion algorithms that provide reliable and consistent color assignments. Modalities of consideration may include offline visual, intensified and infrared imagery of different wavelengths (Near infrared, SWIR, MWIR, and LWIR). A prototype knowledge base for visual color should be generated. In addition to fusing images of different modalities, reliable color generation may require scene/terrain understanding and must be adaptive to dynamic environments. Factors considered for determining continuation to Phase II include color consistency, color representativeness, contrast, object visibility, and resolution of the fused imagery.

PHASE II: Efforts should be devoted to implementation of the algorithms. Further refinements are expected for robust performance. Knowledge base of visual color for operation environments and conditions should be significantly expanded. A prototype system is expected. Performance should be tested under realistic representative conditions and properly documented.

PHASE III: New algorithms and associated software will be ready for transition to Army labs such as CERDEC and defense industry such as Lockheed Martin and Raytheon for incorporation into night vision products. There will be enormous opportunities for civilian commercialization given the increasing interest in infrared technologies for civilian security, manufacturing, and non-invasive inspections.

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KEYWORDS: Night vision, image fusion, infrared

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A07-072 TITLE: Development of a Naphthalene Exposure Dosimeter

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: To develop and validate a small, rugged, low-cost, wearable dosimeter through which individuals' exposures to naphthalene can be measured.

DESCRIPTION: Battlefield fuels have been transitioned to jet fuel propellant 8 (JP8) for all military operations well beyond the year 2025. DoD is estimated to use 5.5 billion gallons of JP8 each year, and exposure to JP8 represents the single largest source of chemical exposure to DoD personnel. One to three percent of JP8 is naphthalene. Chronic inhalation of naphthalene has been reported to cause cytotoxicity, genotoxicity, alveolar/bronchial adenomas, and affect neurocognitive functioning. The Environmental Protection Agency is currently reviewing its naphthalene human health risk assessment, and preliminary drafts indicate that naphthalene is likely to be changed from a "possible human carcinogen" to a "likely human carcinogen". Mixtures that contain more than 0.1% of a known carcinogen are classified as carcinogens, thus JP8 may soon be regulated as a "likely human carcinogen". The cost of removing naphthalene from jet fuel is estimated at 27-90 cents per gallon, making the expenditures for removing naphthalene from DoD jet fuel at $1.4 - 5.0B per year. The aim of this SBIR topic is to develop a reliable, low cost, wearable dosimeter that can be widely used throughout DoD. The overall goal is to monitor the exposure levels of naphthalene to protect warfighter health. Having accurate exposure data will enable DoD to identify the most cost effective methods to reduce exposure, and will also provide a scientific basis for identifying what level of exposure is safe.

PHASE I: Conventional methods for detecting naphthalene utilize chemical and physical approaches such as mass spectrometry, laser-induced fluorescence, catalytic beads, infrared optical spectrometers, etc. The instrumentation for these methods is generally large, energy intensive, expensive, requires well-trained technicians, and is not readily amenable to miniaturization. Biological methods have assessed chemosensory responses in animals, such as blue crabs or mine-adapted dogs. A bioluminescent response in bacteria (Pseudomonas putita) has been reported. Antibodies against naphthalene diogenase from Pseudomonas aeruginosa have been used to detect naphthalene utilizing organisms. The challenge in developing a microdosimeter is in the selection of a reliable detector platform that is amenable to nanotechnological development. During Phase I, it is expected that a myriad of detection systems, that would have applicability and specificity for naphthalene, would be evaluated. The investigators will design and deliver a cogent and coherent plan for developing a low-cost, wearable model dosimeter for naphthalene exposure.

PHASE II: The investigator's characterization of the capability of the dosimeter shall be in units of nanograms/parts-per-million/minute measured in a dynamic atmospheres of 1 microgram per cubic meter over four hours. Standard error should be less than 3%. The investigator will demonstrate, a dosimetic capability of measuring an eight-hour naphthalene exposure, in air concentrations ranging between 0.01 and 1000 micrograms of naphthalene per cubic meter of air. The measured dose shall be validated by showing a correlation of at least r=0.7 with one or more biological samples, such as post exposure exhauled air in representative exposure ranges. A plan would be provided for large scale production of low-cost naphthalene dosimeters. Collaborations with a DoD laboratory or agency would be conducted to demonstrate the dosimeter's effectiveness in the work place. With the assistance of the DoD, a protocol would be validated for dosimeter deployment, collection, transport, and laboratory analysis. Using the accumulated data, correlations would be determined between the naphthalene exposure data and naphthalene in the blood, urine, and expired breath of study subjects.

PHASE III: Large-scale production of low-cost reliable naphthalene dosimeters will commence. The concept is that at the end of phase III low-cost reliable naphthalene dosimeters will be readily available to DoD. Civilian use of jet fuel is 30B gallons per year in the U.S., thus the civilian market for naphthalene dosimeters is also expected to invest in widespread use of naphthalene dosimeters in order to limit liability and reduce operating costs.

Likely Army partners in Phase III include Natick (soldier protection), and the Army Research Lab (power and energy sections). The end user is any warfighter who is, or might be, exposed to JP8, and Army management personnel who must make strategic decisions on how to limit JP8 exposure at minimal cost to DoD. This data could also be used to demonstrate to the EPA that soldiers' exposures to naphthalene can be effectively managed by more cost effective means than extracting naphthalene from JP8.

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KEYWORDS: naphthalene, dosimeter, JP8, fuel, exposure

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A07-073 TITLE: Logistical Decision Support and Planning in a Counterinsurgency Environment

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a suitable architecture/framework supporting a suite of predictive decision support capabilities for planning logistical sustainment operations that reduce the risk of insurgent attack against U.S. and coalition logistical operations. Identify those Mission, Enemy, Terrain, Troops and Time Available (METT-T), cultural/political, historical events, and intelligence factors that are most relevant to insurgents in selecting Courses of Action (COAs) against U.S. and coalition logistical operations. Integrate these factors into a predictive model simulation framework for assessing risk in terms of 1) probability of attack, 2) modality of attack, and 3) ability to examining alternative logistical COAs that U.S. and coalition forces can implement to minimize risk from insurgent COAs. Determine the appropriate predictive analytics, (e.g. mathematical, statistical, modeling, and simulation) to characterize the probability of attack and the potential severity of the attack in the form of risk potentials for a geospatial area of interest. Based on this framework, develop a tool or suite of tools that military logisticians can use to examine risk due to insurgent COAs and assess alternative COAs that minimize risk (e.g. alternative logistical lines of communication, optimum mix of force protection assets).

DESCRIPTION: Army transformation is focused on reducing the in-theater logistics footprint to better support velocity. Therefore, the remaining combat zone CSS assets must be better protected while remaining efficient and agile. Currently in Operation Iraqi Freedom (OIF), insurgents have been able to effectively employ rapidly changing low technology swarm tactics (i.e., improvised explosive devices – IEDs, mortars, small arms, suicide bombs, etc) that have proven difficult to counter. U.S. Defense Secretary Robert Gates has "expressed frustration at the ability of insurgents to adapt their technologies and so far beat U.S. measures against these improvised explosive devices, know as IEDs. … So far, however, some analysts say the military's efforts have been only marginally effective at defeating these home made bombs."1 One reason for this is that insurgency contact can be initiated quickly against targets of opportunity, after which that attackers simply disappear into the local populace. In addition, the direction and modality of attacks is difficult to gauge since insurgents can rapidly alter attack profiles and rely on a variety of unique cultural and environmental circumstances to sustain the attack.

In addition to the question of effectiveness of efforts to date, many of the technical programs underway tend to be narrowly focused. For example, detecting IEDs, predicting the effectiveness of insurgents after removal of top leadership, where and when insurgents will attack, and many focus on attacks within the United States. Some of these efforts are exploring novel approaches (e.g. dynamic network analysis, social network analysis, reflexive theory of perception) that are experimental, have yet to be validated, and in some cases skepticism amongst colleagues as to their effectiveness.2 It will be virtually impossible to predict with any acceptable degree of certainty where, when, and to what severity a specific insurgent attack will occur. It is also clear that no single analytic method is likely to provide the answer. A more risk management approach that uses a variety of analytic techniques will be required to minimize the risk due to insurgent COAs.

To plan and support logistical operations that take into account insurgent risk factors and attempt to minimize those risks, the Army needs a decision support capability that characterizes military (METT-T), non-military (psychological/political/cultural/religious), intelligence, and historical event factors as an integrated set of risk variables with some associated level of risk for a given area of interest such that it can: 1) profile the level of risk to logistics operations due to insurgency attack as a set of geospatial regions of risk, 2) characterize the vulnerabilities to attack, 3) provide the ability to assess alternative COAs to include force protection packages that minimize that risk. The decision support capability must also provide flexibility to allow logistician to rapidly incorporate new risk characterizations in response to a rapidly adaptable insurgency. This flexibility is essential in order to continually provide viable decision support capability for mitigating risk from insurgent COAs against U.S. and coalition logistical operations.

PHASE I: Perform exploratory research to identify and prioritize the key information resources/factors required to both effectively characterize insurgencies and fully integrate CSS operations. Using military (METT-T), non-military (psychological/political/cultural/religious), intelligence, and historical event factors, identify the analytics that would be required including statistical, mathematical, data mining, modeling and simulation techniques to characterize the probability and severity of an insurgent attack in terms of risk across an operational area of interest. Identify suitable architectures/frameworks (software and knowledge structures) that can successfully encapsulate the required analytics to: 1) support assessments of insurgency risk for areas of interest for currently planned logistical COAs in terms of geospatial risk levels, 2) provide simulation assessments for alternative logistical COAs that minimize risk of insurgent COAs, 3) provide a flexible mechanism for logisticians to quickly incorporate new risk characterizations in response to rapidly changing insurgent COAs. Demonstrate concept feasibility through analysis and simulation.

PHASE II: Implement, test and demonstrate a proof-of-principle prototype capability based on the concepts identified during Phase I. A Stability And Support Operation (SASO) sustainment scenario will be employed for the purpose of tool demonstration. This application should include elements currently common to ongoing DoD SASO missions to best establish proof of concept viability, while remaining flexible enough to adjust to evolving insurgent tactics.

PHASE III: Pursue defense, public sector, and private sector opportunities to harden and fully commercialize the chosen technologies/concepts. Efforts have been made and will continue to be made during the phase I and phase II efforts to make the research and development products of this project available to appropriate Army and DoD PEO, PM, and Agency heads for possible leveraging into existing programs. Early collaboration and support for this project has been achieved from the Logistics Innovation Agency (LIA) and TARDEC. LIA has identified resulting technologies from this SBIR project as relevant to their program on Prediction and Preemption technologies for the Army and DoD. Technologies developed are anticipated to be leveraged by LIA in support of their 'Prediction and Preemption' program. TARDEC has expressed interest in leveraging technology from this SBIR project as well. Early discussions with TARDEC indicate that technologies from this SBIR project will enhance a decision support tool for pipeline trace planning that is a requirement as part of the Rapidly Installed Fluid Transfer System (RIFTS) program under development by PM Petroleum and Water Systems. Direct collaboration with LIA and TARDEC is anticipated in phase I, phase II and beyond.

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KEYWORDS: logistics, sustainment, insurgents, modeling, simulation, prediction, cognitive, decision support

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A07-074 TITLE: Bio-Inspired Approaches to Secure Scalable Networking

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop and implement bio-inspired energy-efficient, scalable, resilient, robust, architectures and protocols for tactical communications networks.

DESCRIPTION: In tactical wireless communication networks, self-configuration, resilience, and rapid recovery from disruptions to the network structure (both nodes and links) are critical, both for mobile ad hoc networks as well as for sensor networks. Such networks are predominantly wireless, and must be capable of operating in a distributed manner without centralized control or fixed infrastructure. Features such as resilience to failure, cooperative self-organizing behavior, and adaptation to dynamic network conditions, are found in biological systems. The focus of this effort will be the extraction, development, and application of bio-inspired network architectures and protocols for secure, possibly mobile, multi-hop ad hoc wireless networks.

PHASE I: Investigate and develop models, theories, and algorithms for creating self-organizing resilient sensor and mobile ad hoc networks inspired by biological systems. Investigate the use of modularity as a means of simplifying the construction of a complex network. Metrics of interest here include energy efficiency, overhead, latency, and reconfiguration time. Based on these and other appropriate metrics, determine, develop and design one or more practically useful and theoretically well founded bio-inspired networking architecture and sets of protocols. Conduct a feasibility study of adaptability of such protocols when networking goals must be changed. The phase I study should consider the feasibility of implementation in a real-time, distributed, scalable fashion. Implement the architectures and policies in a simulation system and demonstrate feasibility for networks consisting of hundreds of nodes.

PHASE II: Finalize the formulation of the architecture, medium access and routing policy(ies). Carry out extensive validation and verification of the architecture and protocols via physical experiments, simulation and emulation for networks consisting of hundreds of nodes or more. Such experiments must take into account RF channel characteristics such as fading, interference and jamming, and dynamics in terrain, traffic, and topology. Validation and verification should confirm that the theoretical predictions of performance (including computational overhead) developed in Phase I and early Phase II are correct, and should provide guidance for appropriate adjustments. Carry out computational and/or experimental comparisons of these architectures and protocols with one or more baseline "standards". Identify limitations of the bio-inspired networking architectures, protocols and policies and determine whether these limitations are due to fundamental technical barriers. At the end of Phase II, carry out a demonstration.

PHASE III: In Phase III, the recommended architectures, multiple access and routing protocols and policies should be implemented in wireless networks designed for use in various military and civilian situations, such as information dissemination in commercial peer-to-peer (P2P) networks. MARCONi/PILSNER ATO, WIN-T, and follow-on Army programs would be natural transition paths. It is anticipated that further effort may be needed to integate / transition the SBIR technologies into these programs.

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KEYWORDS: bio-inspired networking; auto-configuration; robustness; resilience, peer-to-peer networks

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A07-075 TITLE: Very Small, Heavy-Fuel Engine (VSHF) Concepts

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Design, develop, and demonstrate a very small (less than five horsepower), fuel efficient, heavy-fuel, internal combustion engine concept that overcomes present day size limitations.

DESCRIPTION: The Army has a great need for very small, heavy-fuel (diesel or JP-8) engines for a wide variety of applications (e.g. small, unmanned air and ground vehicles, and power generation). However, there are numerous difficult, technical challenges with the use of heavy fuel in conventional, small engines (gas turbines, as well as internal (or intermittent) combustion (IC) engines). In very small sizes, gas turbines become extremely inefficient, and IC engines have difficulty burning heavy fuel. For this solicitation, very small, heavy-fuel (VSHF) IC engines are defined as engines producing less than 5 (five) horsepower (3.7285 kW).

Small IC engines run at high speeds, and have very short "strokes" in their power producing process. There is only a limited time in which to burn the fuel (usually over 180 degrees of power-shaft crank angle). While the fuel must be atomized as finely as possible, high pressure pumps and atomizing nozzles (such as those used in conventional size engines) cannot be scaled down to the needed sizes. In addition, heavy fuel does not burn rapidly (low flame-front propagation speed). Thus, it is the fuel atomization and injection/burning process that need attention. This problem can be circumvented by going to an external burning engine concept (such as the Stirling cycle), but at the cost of increased mass and weight, and reduced power density.

This solicitation seeks new, innovative ways of circumventing the above mentioned, very small, heavy-fuel (VSHF) IC engine shortcomings. Of particular interest are: 1) innovative concepts to efficiently atomize/vaporize unmodified (no additives) heavy fuel; 2) engine configurations that allow for longer burn times (over more than 180 degrees of crank angle); and 3) external burning concepts combined with cycles other than the Stirling cycle. Note that gas turbine and Stirling cycle engines are explicitly excluded from this solicitation. The proposed engine concept need not be a compression-ignition cycle; spark-ignition is acceptable. The proposed engine must be fuel-efficient, power dense, and be able to readily burn unmodified heavy-fuel (diesel or JP-8).

PHASE I: The proposer must demonstrate the feasibility of his/her concept(s) by either analytical means, by bench-top experiments, or by combinations thereof. The proposer must demonstrate a thorough understanding of the physics of the proposed concept(s) and must be able to predict the resulting engine's performance parameters, physical dimensions, and weight. In addition, the proposer must ascertain the scalability of his/her engine design and identify the smallest possible engine size achievable with the chosen concept. The proposer must also submit a preliminary Phase II plan which outlines the steps to be taken to build and test a prototype engine and demonstrate its attributes

PHASE II: The proposer must design, build, and test a prototype engine and determine its performance under realistic operating conditions. The proposer must address all aspects of engine design including, but not limited to: cooling, sealing, rapid power changes, emissions, noise, and life.

PHASE III: A very small, heavy-fuel engine not only has broad military applicability (for small, unmanned air and ground vehicles), but it can perform similar, civilian duties for home land security (e.g. border patrol). As a small power producing device, it has utility for soldiers, as well as civilian campers, emergency power generators, and power lawn and hand tools.

The outcomes of this R&D effort would feed 1) advanced R&D efforts within the Army's unmanned air and ground communities and their affiliated PMs; 2) SOCOM, EOD and current operations end users of unmanned robotics systems for the Army; and 3) also USAF and NAVY programs. The current focus of this research examines the propulsion requirements communicated by the RDECOM Robotics IPT for unmanned systems in the lighter weight classes.

If the research outputs look promising, ARL-VTD would recommend that AMRDEC and TARDEC, The Unit of Action Battle Lab, and the joint community evaluate it and discuss best options and tie into existing PMs and ultimately PM-FCS (the lead requirements driver on future robotics requirements in the Unit of Action). By understanding these requirements up front, we can focus the technology effort to ensure that an industry partner effort is also developed to provide, in the end, a COTS item that the PM can field to meet operational requirements.

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KEYWORDS: heavy fuel, internal combustion engine, external combustion engine, fuel efficiency

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A07-076 TITLE: <u>Generalizable Linked User Evaluation of Operational Neuro-cognition and Performance (GLUE-ON)</u>

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop a real-time monitoring and analysis tool for Soldier-System neuro-cognitive and performance assessment in lab, field, and operational environments via non-intrusive “glue-on” technology, with immediate application to cognitive readiness and system design.

DESCRIPTION:The development of online human performance measurement techniques is critical for operational safety and their application will ensure safety by identifying changes in human behavior before performance deterioration occurs. Physiological indicators of performance deterioration have been validated and implemented in the operational environment (e.g., eye blinks, heart rate variability, electrocortical activity). The current set of validated physiological indicators are, generally speaking, not robust. More specifically, there is no 1:1 mapping between any currently identified indicator and operator state. One of the technical challenges is to define a set of indicators that provide the most robust and accurate mapping to state, or alternatively, to identify a new indicator that is robust. Another challenge, once such an indicator or indicators are identified and validated, is to implement it (them) in a system that is impervious to the factors that comprise the operational environment. Furthermore, many of the current approaches yield information about the operator’s performance through post-hoc analysis and require either extensive integration resources or are a disruption to the human-system actually of interest.

This effort would use advancements in neuro-cognitive monitoring and performance assessment to develop a GLUE-ON technology that can track operator state in real-time. The system should be a dual use system that can assess and predict when an individual's level of performance deviates from an optimal state. This deviation would be determined by neuro-cognitive and performance measures obtained real-time, during performance. This approach is distinct from predictive (pre-performance) or assessment (post-performance) methods, which constitute the standard measurement tools today. This technology would apply directly to the system interface on which the operator is working to enable measurement in militarily-relevant environments. The implementation would be such that the GLUE-ON is an add-on to an actual system in a plug-and-play sense, and would not require full integration to function.

The GLUE-ON system should be portable, easily reconfigurable, and adaptable to various crewstations and simulators. For example, while an individual is operating a crewstation during a scenario or test mission, the GLUE-ON would monitor neuro-cognitive state and performance level through sensors that may be tailored to track indicators such as EEG, pulse rate, and/or real-time task performance. The GLUE-ON system must take into account measurement artifacts that can be induced in operational environments, and provide robust measurement and state prediction. It should be as unobtrusive to the operator's tasking responsibilities as possible. The GLUE-ON would analyze the data and provide a timeline indicating operator state and performance levels, for example, times and responses. The system would also record the variables for post-scenario analysis.

This technology is needed to monitor the human state and ultimately refine human performance measurement capability across temporal dimensions with reduced instrumentation overhead, both in the laboratory and in the field. The identification of real-time assessment of changes in performance would significantly enhance the Army Cognitive Readiness initiatives of operational safety, performance optimization, and reliability. The current emphasis is on military crewstation development but will readily adapt to the automotive, medical research and medical rehabilitation industries.

PHASE I: Identify concepts and methods for non-intrusive real-time monitoring and assessment of human state changes. Phase I should establish a rationale for the use of one or a set of measures that result in the best indicators of early performance changes. Phase I should also outline the conceptual design for GLUE-ON.

PHASE II: Using the results from Phase I develop and demonstrate a field-practical prototype tool that monitors human state during the performance of a task.

PHASE III: The current emphasis for this tool is on military crewstation development but has application for the automotive, medical research and medical rehabilitation industries. In all of these applications, individuals are interacting with complex technologies that impose high cognitive demand. This tool could be used in both military and civilian applications in which success of the mission is dependent on the ability of all individuals to maintain a high level of performance and in which operational safety and reliability are critical.

This tool can be used to determine which aspects of cognitive processing are most challenged due to battlefield or other stressors. With this information, decision aids, changes in manning, and changes in training, can be implemented at critical points in time. Military applications include (but are not limited to) effective command and control and Soldier interactions with unmanned systems. Technological developments such as unmanned systems and command and control environments are tools to be used by Soldiers to achieve their missions in complex, distributed, and nonlinear battlefields. GLUE-ON may be used to monitor the Soldier state during these complex interactions and potentially augment their performance.

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KEYWORDS: Field-Practical, Real-Time, Measurement, Performance, Neuro-cognitive, Crewstation

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A07-077 TITLE: Near-real-time Biological Field Sampling System-Miniature Mass Spectrometry

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: The objective of this topic is to develop a fast-responding mass spectrometer (MS) sampling system and automated methodology that is small, light, and ruggedized. The MS must quickly sample and detect biological threats in the field. Such near-real-time field technology does not currently exist for measuring bacterial threats.

DESCRIPTION: One way to protect a soldier from exposure to a chemical or biological threat is to develop a hand-held point detector to give stand-off, near-real-time detection of biological agents. Current biological detectors takes hours to develop a threat prognosis. This topic proposes developing a biological sampler that will convert - within minutes - biological threat agents of into characteristic chemical marker compounds that will comprise a chemical signature of the biological threat. Once the sampler has converted the bioagent into chemical markers, the compounds will analyze the chemical signature.

Private industry and government research organizations are performing Research and Development (R&D) on how to convert biological threats into chemical markers. But one of the first challenges of this SBIR will be to identify and analyze the known conversion processes and determine the most suitable processes for this gas chromography/mass spectrometer (GC/MS).

The portion of this topic requiring significant R&D is miniaturizing, automating, and integrating of these known processes to into hand-portable GCMS technologies. Rapid data sorting algorithms must be developed to detect and recognize emerging signature patterns real-time.

The entire process should take minutes instead of hours. An effective sampler must: (1) be capable of accepting the purge gas flow rate from the permeation test fixture, (2) produce rapid conversion of biological threat agent into marker compounds, (3) trap and concentrate the marker compounds prior to analysis by gas chromatography-mass spectrometry, (4) produce a narrow pulse of sample to the gas chromatograph-mass spectrometer for analysis, and (5) generate reproducible chemical signatures of the test biological threat agents.

Since each chemical signature will be comprised of a gas chromatographic profile (i.e., retention data and relative peak areas of separated compounds) and mass spectrum for each of the separated compounds, a computer algorithm must be developed to extract the relevant biological threat agent chemical signature data. The algorithm should be capable of adjusting the chemical signature for age and growth conditions. The latter technique is typically performed at lower temperatures than the former and is more easily controlled. Therefore, more reproducible chemical signatures are obtained.

While the initial military applications are a field biological detection system and on a swatch test fixture, there are also many other potential applications for this system as a monitoring tool for detection of biological threat agents in water, on contaminated surfaces, in medical assays, etc. as outlined in the Phase III description. In each of the afore-mentioned scenarios, detection would be significantly more rapid than conventional methods.

PHASE I: The phase I deliverable is a feasibility study focused for creating a hand-held, portable, RAPID GC/MS biological detection system. The small business should consider identifying all current biological to chemical conversion processes and determine the most suitable processes for integrating into this new detection system. The study should outline the baseline characteristic chemical marker signatures for a range of biological agent threats. The study then should analyze how each conversion process works including but not limited to, the time, reliability, and accuracy. The study should outline the specific R&D requirement needed to adapt these biological to chemical conversion processes into a hand-held device that will RAPIDLY and accurately provide the chemical marker and convert that using the biological agent the detector sees.

PHASE II: Research, design, construct and demonstrate a prototype of the detection system and its applicability for generating reproducible biological agent chemical signatures, and deliver a working interface to the military for testing. This interface prototype will have a workable library of known biological to chemical signatures and algorithms that will successfully extract the relevant biological threat agent for each chemical signature.

PHASE III: During Phase III, the biological agent detection system will also be demonstrated as a hand-portable monitoring tool for purposes beyond materials testing. A successful prototype would have tremendous potential outside of the Army. A few examples within the US government are: the Air Force, Marines, Navy, and Department of Homeland Defense. Other commercial agricultural, food quality, biomedical, first responder applications, and environmental applications.

One specific US Army application includes supporting the implementation of Future Force Warrior Advanced Technology Development since chem/bio protection of forces is necessary to achieve Future Force objectives.

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KEYWORDS: biological protection, biological sampling system, biological detection, biological threat, chemical threat, point detection, permeation, thermal hydrolysis/methylation, mass spectrometry, domestic manufacturing, fatty acid methyl esters, dipicolinic acid

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A07-078 TITLE: Real-Time Scalable Emulation of Communication Networks

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this SBIR effort is to design and develop a scalable emulation capability and demonstrate its use in emulation of networks with a few thousand heterogeneous, wireless radios.

DESCRIPTION: The purpose of this research is to develop repeatable test cases/scenarios that can stress a communication system under test with appropriate traffic loadings, interoperability scenarios, enemy/threat representations, and capabilities.

Traditional simulation-based evaluation techniques are ineffective at adequately capturing the real-time dynamic interactions of thousands of networked radios. The reason is, simulation models lack the high-fidelity modeling necessary to represent the interactions. In addition, the performance evaluation of novel commercial applications, such as streaming voice and video over IP, is much easier via perceptual evaluation of audio/video streams than from reliance on statistical metrics like packet loss rates, latency, or jitter, as typically provided by simulation-based evaluations.

Physical test beds can address many of the preceding shortcomings of simulation-based approaches; they can model the network with high fidelity and expose the necessary interactions among applications, protocols, and physical channels and can also assist with debugging.

However, physical test beds require a substantial effort and cost for set up and maintenance and they typically do not provide the repeatability or scalability attributes.

Emulation is defined as modifying to imitate another computer system; modifying a computer system so that it appears to behave like another computer system, and can thereby accept data and run programs that are designed for the system being emulated. Emulation is a viable alternative to physical testbeds that can provide an evaluation framework that is simultaneously accurate, scalable, repeatable, and flexible.

The greatest advantage of an emulation testbed is reduced equipment and labor costs, all the while, the fidelity of the test data between a physical test and an emulated test remains constant. Emulation testbeds are flexible in the sense that changing configurations can be easily done, which would otherwise be very difficult, if not impossible, in physical testbeds. Moreover the experiments are repeatable with controlled parameters to support fair comparison among different system optimization techniques.

PHASE I: To deliver a feasibility study that provides a conceptual design plan for developing a wireless radio emulation capability. The capability must be able to incorporate at least three thousand heterogeneous, wireless radios. The study must consider all pertinent operating data such as, but not limited to, radio inputs/outputs, power requirements, terrain data, antennae characteristics, data exchange, world-wide environmental condition. The design should also incorporate scenarios with appropriate traffic loadings, interoperability scenarios, enemy/threat representations and capabilities, etc. The study should consider Internet Protocol Version 6 and Global System for Mobile Communications.

PHASE II: The deliverable for phase II is a working prototype and a final report that details the research and design of the prototype. The prototype must be able to satisfy the requirements as set forth in Phase I. The prototype must be able to satisfy/emulate the radio characteristics of the Current Force as well as the wireless radios in the Future Combat Systems.

PHASE III: This new communication emulation technology has tremendous potential as a tool that any war fighter can use to war game tomorrow's mission. So the government commercial basis expands to all the services.

If this topic successfully completes Phase I and is funded for Phase II, ATEC will consider applying matching funds (Phase II Plus). ATEC has also tagged this topic as an instrumentation development requirement in our POM. As such, if the technology matures into a successful prototype, ATEC will be positioned to secure additional units.

From a commercial perspective, this technology can be used to predict communication dead spots from cell phones to emergency vehicles.

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KEYWORDS: radio, scalable, emulation, network, wireless, environment

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A07-079 TITLE: Dual Band Infrared Coatings

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 new coatings and coating methods to maximize transmission and meet the needs of dual band infrared systems (simultaneous Medium Wavelength Infrared (MWIR) and Long-Wave Infrared (LWIR)) for 3rd Generation Forward Looking Infrared (FLIR)s.

DESCRIPTION: Recent advances in detector technology is leading towards a high demand on broadband coatings Coatings have been optimized for both the LWIR and MWIR spectral band for systems where only a single band is being used. The next generation of systems being developed by the Army will be imaging simultaneously over a much broader band. There are currently coatings available that cover this broad spectral range, however, their performance are insufficient to meet all the needs of the future systems. The coatings are not limited to just one component of the optical systems, each set of components needs improvement in transmission to see the largest improvement in performance. The components are listed below in the order of the potential for most significant impact on overall system performance. Radioactive coatings are not an acceptable solution.

Refractive lenses:
Typically these coatings are degraded by 3-5% versus a standard coating for just the MWIR or LWIR individually. Overall system performance is degraded both because of the lower transmission coatings and due to the increased complexity in the design of these systems which result in an increased number of optical elements. The goal is to obtain greater than 98.5% average transmission per lens with high yield for the 3.5 -5.0 µm and 7.8 – 10.5 µm spectral bands (based on a 1mm material thickness). At a minimum, materials to consider are Germanium, Zinc Selenide (ZnSe), Zinc Sulfide (ZnS), Barium Floride, and Gallium Arsenide, but also chalcogenide glasses such as AMTIR, GASIR lenses, and any other materials that will meet the transmission spectrum with environmental stability.

Mirror coatings:
Mirror coatings have two different requirements depending on their location in the system. Typical 3rd Generation FLIR systems will consist of a reflective afocal that will be required to pass light from 0.5 µm to 11 µm tend to have a reflective component to them creating a demand for high reflectivity coatings over an extremely broad range. Greater than 99% reflectivity is desired in the 3.5 -5.0 µm and 7.8 – 10.5 µm spectral bands while maintaining greater than 97% reflectivity over the remainder of the spectral band. In addition to the afocal coatings, fold mirrors will exist that do not require transmission beyond the 3.5 -5.0 µm and 7.8 – 10.5 µm spectral bands. These coatings can be further optimized due to the limited spectral bands.

Beamsplitter coatings:
In order to pass multiple spectral bands through the same aperture, it is required to combine the light paths prior to the afocal. This is accomplished via a beamsplitter that will be required to either pass the 3.5 -5.0 µm and 7.8 – 10.5 µm spectral bands and reflect the 0.5 – 2.0 µm or reflect the 3.5 -5.0 µm and 7.8 – 10.5 µm spectral bands and pass the 0.5 – 2.0 µm spectral band. It is desired to be able to achieve greater than 95% for the 3.5 -5.0 µm and 7.8 – 10.5 µm and greater than 92% for the 0.5 – 2.0 µm spectral band.

Cold filter coatings:
An important component of the 3rd Gen FLIR dewar is the cold filter located inside the cold shield. This filter is at nearly the same temperature as the focal plane (~80K) and controls the amount of out of band radiation that reaches the detector. It is desired to have very high transmission in band while rejecting the out of band spectrum. A transmission of greater than 95% within the 3.5 -5.0 µm and 7.8 – 10.5 µm spectrum is desired.

Windows:
Broadband windows are another significant component that needs improvement. Windows offer an additional challenge in that they require a coating that is not only highly transmissive, but also durable. In addition, windows may be required to pass light from 0.5 µm to 11 µm in order to maintain the desired common aperture between sensors that is present in 3rd Gen systems. It is desired that a 3rd Gen window be able to meet a 95% transmission over the spectral band while maintaining a severe abrasion resistance.

PHASE I: Create theoretical coating designs that will exceed the performance of the current state of the art as described in the topic description. Develop plan for improved processes to increase yield in coating quality to achieve as built coatings closer to that of theoretical. Deliver witness samples for multiple IR materials of new coating designs with current coating practices to demonstrate losses between theoretical and as built.

PHASE II: Revise coating designs from phase I as needed and provide witness samples for coatings of all IR materials and components suggested in the topic description meeting each requirement. Develop coatings for other materials that are applicable for dual band applications. Implement improved coating processes developed in Phase I to increase yield in coating process of dual band coatings. Provide samples for testing of transmission and durability.

PHASE III: Successful demonstration of this technology will lead to its insertion into systems that are being fielded with 3rd Generation infrared technology. Funding would expect to come from the PM's and program offices, such as Future Combat Systems (FCS), that are presently working to field these technologies. The success of this technology will immediately improved the performance of 3rd Gen technology (and other dual band infrared technologies), and be immediately insertable without impacting any other system components. The same impact would be expected for commercial applications that would utilize dual band focal planes. Applications include law enforcement, searh and rescue, and high sensitivity broad-band radiometric measuring devices.

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KEYWORDS: coatings, optics, infrared, dual band

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A07-080 TITLE: Ultra-High Temporal Resolution Laser Radar (LADAR) Receiver

TECHNOLOGY AREAS: Electronics

OBJECTIVE: A LADAR receiver with a pulse return timing resolution of better than 0.5 ns is required. The receiver should consist of an APD photo detector operating at 1.5 um, signal amplifiers, and electronics for determining pulse time of arrival.

DESCRIPTION: Recent advances in laser radar systems and components have made ultra-high resolution 3D imaging of hard targets a reality. Numerous short-pulse direct-detection ladar designs are being investigated by DoD based on fiber-laser transmitters, which have the capability to emit sub-nanosecond laser pulses at pulse-repetition rates greater than tens of kHz and operating at the more eyesafe wavelength of 1.5 microns. In targeting situations in which high resolution imaging is important, such as imaging through foliage or obscurants, multiple-pulse detection is critical. A compact and integrated receiver design is necessary to sense and record ladar signals for these targeting scenarios. The receiver for this application will have a very fast response time and be capable of responding to multiple 500 picosecond wide return pulses. An avalanche photo diode (APD) with an integrated preamp is envisioned which is sensitive at 1.5 microns. The receiver will include timing or counting circuitry suitable to determine the range to the target(s) based on time of flight calculations. The active area of the detector will be as large as possible while still accommodating the bandwidth requirements described above, having a diameter of at least 50 microns desired, 100 microns desired.

PHASE I: Design an innovative ultra-high resolution ladar receiver capable of being integrated into a short-pulse direct-detection ladar system. The receiver will receive and resolve multiple return pulses from a fiber laser transmitter with an operating wavelength of 1.5 microns. The laser pulse durations will be 500 picoseconds, and return pulses arriving within 500 picoseconds of each other should be resolvable. The laser will operate with a pulse repetition rate of up to 1.5 MHz (1.5 million pulses per second). The transmitted beam divergence will be on the order of 500 microradians, so the ladar receiver should be capable of less than 1 milliradian instantaneous field of view with compact optics. The receiver will include timing or counting circuitry suitable to determine the range to the target(s) based on time of flight calculations. The analog receiver output signal will also be accessible.

PHASE II: Develop, build and demonstrate an ultra-high resolution ladar receiver designed in Phase I capable of being integrated into a short-pulse direct-detection ladar system. The receiver will be coupled to a fiber laser transmitter with an operating wavelength of 1.5 microns. The laser pulse durations will be 500 picoseconds, and return pulses arriving within 500 picoseconds of each other should be resolvable. The laser will operate with a pulse repetition rate of up to 1.5 MHz (1.5 million pulses per second). Consideration will be given to a compact and rugged system suitable for a Laser radar sensor for unmanned ground vehicle (UGV) or unmanned air vehicle (UAV) type applications.

PHASE III: The Ultra-high resolution receiver will be fully integrated into a UAV-class Laser Radar and flown in a field-test environment. The receiver integrated into a laser radar will have application to the commercial world as an eyesafe terrain mapper, long-range laser rangefinder, or profiler for security applications. A receiver meeting these specifications could also be applied to applications such as 3D robotics navigation, obstacle avoidance, or construction site evaluation and monitoring. Targeting applications such as target identification of military targets in heavy foliage, multiple-look target ID and landmine detection give the technology good crossover into military applications and the most likely funding source for manufacturing is from PM NV/RSTA.

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KEYWORDS: Laser Radar, LADAR, Avalanche Photodiode, LADAR receiver

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A07-081 TITLE: Persistent Surveillance in an Urban Environment

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: To develop algorithms that perform the detection and tracking of dismounts in a persistent, multiple-sensor urban surveillance scenario. The algorithms will integrate state-of-the-art advances in persistent, multiple-sensor surveillance and tracking, human activity modeling, pattern recognition techniques to recognize human activity, and automatic/assisted target detection and recognition. The system will be composed of distributed nodes and be able to track relevant targets through multiple sensors’ field of view.

DESCRIPTION: Over recent years, much research has taken place in the fields of dismount detection and tracking in terms of persistent surveillance in general with success limited to simple perimeter intrusion detection or variations from learned, regular pedestrian traffic patterns. Even more intractable is the problem of detecting single dismounts in urban environments, associative tracking of individual dismounts, and analysis to determine dismount activity in data from multiple sensors. Success is needed in associative tracking of dismounts in urban environments and determination of patterns of adversarial intent once effective tracking has been established. The innovation here over previous work is the ability to not only perform associative tracking of individual dismounts in urban environments (meaning many dismounts going about their normal routines) but also to track long enough to recognize adversarial intent. As of yet, no military system effectively maintains a long term, persistent, urban surveillance environment that can track and monitor the activities of dismounts through multiple sensors.

PHASE I: (Respondents are not required to develop hardware for program.) Will investigate, enhance, combine, and create algorithms and methodologies for persistent, multiple-sensor surveillance and recognition and modeling of human activity. Will provide specific and detailed testing plan focused on proving applicability. Will conduct limited tests.

PHASE II: Will conduct full interpretation/classifier system tests. Will demonstrate functioning and utilizable prototype system. System will perform successful persistent, multiple-sensor surveillance and enable assisted human activity modeling and interpretation.

PHASE III: Commercialization of technology would involve all types of surveillance--end of state would be a viable system for interpretation of human intent. A specific military application of this would be base protection by the Army in Afghanistan and Iraq. Most likely customers of technology would be commands seeking to utilize surveillance capabilities. Phase 3 funding should be provided by these organizations. In addition, results of Phase 2 will be utilized in NVESD persistent surveillance efforts. Also, upon success of Phase 2 results, PM RUS has expressed interest in possible Phase 3 utilzation in their Persistent Surveillance Threat Detection System (PTDS). There is currently one system in Theater and six more on contract.Transition will be achieved by direct implementation of Phase 2 software package in existing sensor hardware. Commercial applications would include building and property security--the remote supervising of the perimeter of an office or physical plant for hostile action, or the remote supervising of crowds in shopping malls, sports stadiums, or casinos for illegal activity.

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KEYWORDS: dismounts, human tracking, surveillance, multi-sensor fusion, human activity modeling, artificial intelligence, urban warfare, automatic target recognition

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A07-082 TITLE: Direct Patterning of Emitters for Micro-Displays

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 materials and processes that provide direct patterning of individual red, green and blue inorganic photo-emitters on silicon micro-display substrates. The materials and processes must demonstrate micro-display growth potential from the current 15 um per pixel density, to approximately 9 um per pixel density or higher.

DESCRIPTION: The advantages of indirect view vision systems are becoming apparent in the modern battlefield. The transition from current direct view (photon coupled) night vision goggle systems to indirect view (electronically coupled) systems is dependent upon the ability to achieve comparable resolution and power consumption to currently fielded systems. The micro display is a key component in the indirect view system and as such must address the resolution and power consumption issue head on. Near term planned head mounted display (HMD) research approaches are addressing these issues through chip level electronic integration and parallel processing to reduce data handling requirements. Novel materials and processes are sought to develop a high resolution micro-display with both improved electro-optical performance and greater power efficiency. Currently developing micro-displays for military applications use broadband emitters that are subsequently filtered to provide the sub-pixel red, green, and blue (RGB) colors. The color filtering exacerbates the already difficult problem of providing sufficient brightness in a small pixel (~15 um) micro-display architecture. Since each sub-pixel must discard approximately 2/3 of the broadband emissions, the resultant color filtered display luminance is reduced to one third of the original emitter/modulator luminance. Direct patterning emissive sub-pixels will provide a 3X increase in micro-display brightness that translates directly into reduced power and increased micro-display component operational life. The elimination of the color filters will also provide increased color fidelity in the display. Three separate, narrow band emitters will provide a color gamut that meets or exceeds current NTSC display standards thereby providing improved distinction and recognition of color coded data, such as maps, IFF, and chroma-keyed image fusion algorithms. Due to the high bandwidth of 2K x 2K, full color video information, high density micro-display approaches are anticipated to require 3D silicon architectures. These micro-displays must exhibit the fundamental parameters of resolution, luminance contrast, chromatic fidelity yet may not sacrifice power efficiency, thermal management, and operational lifetime to achieve electro-optical performance goals. These factors shall be achieved for display luminance levels > 50 fL operation. This topic is considered to be an enabling technology for solid state night vision system-on-chip concepts.

PHASE I: Perform a study of the fundamental materials and processes necessary to establish a direct RGB sub-pixel patterning of emissive display pixels on a silicon substrate with out the use of color filters. Phase I shall provide proof of concept analysis and/or demonstration of materials and components that validate the principles necessary to achieve the desired RGB sub-pixel architecture. The Phase I data deliverables shall include a study to establish process development for high resolution (minimum pixel pitch 15 um) RGB pixel patterning and analysis of the following military micro-display parameters: white luminous efficiency and color gamut at 50 fL, luminance life, differential aging (RGB), package shelf life, device level power consumption, pixel temporal response, pixel cross-talk and viewing angle. These parameters shall be investigated and reported for both ambient and extreme temperature environments.

PHASE II: Develop materials, processes, and packaging techniques for direct deposition of emissive RGB sub-pixel micro-displays. Design and fabricate prototype full RGB micro-displays utilizing direct deposition, emissive materials and processes. The Phase II hardware delivery shall include, as a minimum, patterned red, green and blue emitters on separate substrates with a goal of simultaneous patterning of red, green and blue emitters on the same substrate. Phase II shall also include the preliminary design of a video drive electronics to permit test and evaluation of micro-display electro-optical performance using both video pattern generator and live video camera inputs. Data deliverables during this phase shall include quarterly progress reports and a final report detailing the development study. Included in the final report shall be a feasibility of directly patterning RGB pixels with <3 um sub-pixels.

PHASE III: Phase III effort shall include the detail design and fabrication of a prototype (15 um pitch ojective, 9 um pitch goal) RGB micro-display and video driver electronics hardware and software based on the direct patterning of emitters established in phase II. Hardware deliverables shall include two each, prototype micro-displays and two sets of corresponding fully functional micro-display drive electronics (the video interface format must be approved by the Government prior to fabrication and delivery). Patterned displays delivered under this phase will be tested by the government for display performance, usable life and environmental susceptibility.

In addition to their pervasive role in military mounted pilotage and dismounted combat mobility and weapon sight applications, micro-displays have a growing presence in the commercial arena. Industrial security, police surveillance, fire & rescue, remote-telepresence, and medical micro-surgical techniques are among the application areas that would benefit from the increased pixel density, reduced power consumption, and extended device life stemming from this development effort. This phase will generate low power, high efficiency microdisplays capable of insertion into existing military systems currently fielding OLED or AMLCD. This would include the fielded Thermal Weapons Sights or Land Warrior head mounted display.

OPERATING AND SUPPORT COST REDUCTION (OSCR): Through the elimination of the RGB optical filters, and the utilization of inorganic emissive materials, this effort will lead to increased reliability and the associated reduced cost of ownership of higher MTBF system components. This program will could also significantly reduce the cost of development for planned military micro-display improvement programs by providing a new device technology that is easily scaled to higher resolution imaging system development goals.

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KEYWORDS: direct deposition, display, electronically coupled, emissive, head mounted display (HMD), low power, micro-display, RGB.

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A07-083 TITLE: Micro Patterned Electrically Variable Attenuation Filter

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 materials and processes that provide high resolution patterned variable transmissive pixel structure filters compatible with high resolution focal plane detectors

DESCRIPTION: The advantages of direct and indirect view visible, near IR and thermal vision systems are evident in the modern battlefield. One of the key weaknesses however for electronic vision systems is the ability to handle scenes which have a wide dynamic range of input signal within the same scene which is typical of the urban battleground. Bright sources within the scene of a low light imager cause local area pixel saturation but also can result in pixel cross talk, halo, blooming or smearing. Important tactical information is often contained in darker regions of a scene which also contain very bright sources (street lights, burning buildings). Standard low light and image intensified digital imaging systems which include CMOS camera electronics or CCDs provide adaptive compensation for bright sources in the form an auto gain control (AGC). While AGC can reduce pixel saturation when bright sources are present, the trade off is decreased information in the dark areas of a scene since AGC is applied over the entire imaging array. Some camera systems also apply image post processing techniques to regain localized histogram control to expand the intra-scene dynamic range and extract the low level signal data in the presence of bright sources. These techniques, however are limited because they are applied after the AGC of the camera has been applied so that much of the dark region information remains unrecoverable depending upon the AGC algorithm applied. A novel material and/or process is sought which can selectively and locally isolate bright sources within a scene thus reducing the signal level of the bright source prior to photo/thermal detection at the focal plane providing in effect a pixel level AGC such as an addressable array of variable transmissive filters within 1 mm of the focal plane or intermediate image plane within the optical train. The addressable optical filter being sought should have a minimum of 320X240 pixel resolution with pixel sizing scalable to interface with 8.5 to 25 mm diagonal focal planes. The transmissivity of each pixel in the clear or full transmissive state should exceed 90% and the dark or full attenuation state should be less than 10%. The end goal for the speed of transition is a maximum of 16 milliseconds with a near term objective of less than 500 ms. The total transmissivity is to be computed as the integrated spectral transmission weighted by the spectral responsivity of the focal plane to be utilized. The transition time is to be measured as the time from 10% above the full attenuation state to 10% below the full transmissive state. The final device should also be compatible with camera and lens systems that permit a minimum of 15° horizontal field of view with a desired goal of 40°.

PHASE I: Perform a study of the fundamental materials, processes and technologies necessary to establish a spatially addressable variable transmissive filter with pixel size of no greater than 50 micron x 50 micron capable of meeting the stated transmissivity, transition time, and camera system compatibility goals for at least one type of visible, near IR or thermal direct or indirect view vision system. The phase I study shall also show technology compatibility with existing low light or thermal camera fabrication techniques through an established working relationship with a key camera manufacturing industry partner. Phase I shall provide proof of concept analysis and/or demonstration of materials and components that validate the principles necessary to achieve the desired addressable pixel filter architecture. The Phase I data deliverables shall include a study to establish the material and process development for high resolution (minimum pixel pitch 50 microns) and analysis of the following military environment issues: extreme operational and storage temperatures, operational and shelf life of materials and electrical power consumption.

PHASE II: The Phase II hardware delivery shall include, as a minimum, a functioning array of addressable filter pixels and associated drive electronics hardware and software required to demonstrate the addressability of the filter pixels. The delivered addressable filter array should at a minimum demonstrate a 160X120 array with pixel pitch of 100X100 microns capable of meeting the stated transmissivity and transition time goals with a goal of a 320X240 array with 50X50 micron pixels. At a minimum engineering development will be performed to establish materials, processes, and packaging techniques for a 320X240 array with 50X50 micron pixels. Phase II data deliverables are 1) a final research report study including a section on the feasibility of pixel pitch reduction and resolution increase, 2) monthly status reports and 3) operations manual for the filter array demonstration hardware system delivered to the government.

PHASE III/DUAL USE APPLICATIONS: The phase III effort will focus on system level integration of a prototype array with a camera. The deliverable prototype shall also be integrated into a functioning camera system with standard analogue or digital output. The camera system and integrated filter with driver electronics delivered to the Government will demonstrate active pixel level bright source control utilizing camera image feedback to the addressable filter drive electronics. This camera system hardware will be retained by the Government.

In phase III, the improved dynamic range technology would be transitioned in large part directly to military sensors employed in urban environments. This would include PM Soldier Sensors and Lasers in programs such as DENVG, ENVG, TWS and PVS-14. The increased dynamic range sensor would also be applicable to vehicle mounted sensors including PM Apache. In addition to their pervasive role in military mounted pilotage and dismounted combat mobility and weapon sight applications, direct and indirect view sensors have a growing presence in the commercial arena. Industrial security, police surveillance, fire & rescue, remote-telepresence, and medical micro-surgical techniques are among the application areas that would benefit from the increased sensor intra-scene dynamic range stemming from this development effort.

OPERATING AND SUPPORT COST REDUCTION (OSCR): This effort will lead to increased survivability through improved performance in urban area situational awareness. This increase in survivability for weapon systems supported by this technology will have a direct cost impact in reducing the operational losses of weapon systems.

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KEYWORDS: direct view, indirect view, electronically coupled, vision system, focal plane, spatial filter, emissive, low light sensor, thermal sensor.

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A07-084 TITLE: <u>Sensors, Signal and Image Processing for Threat Warning</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: a) The development of a signal and image processing toolbox that allows for the optimization and quantification of the performance of wide area flash detection sensors, imaging flash localization sensors as well as the combination of the two types of sensors. The toolbox will involve clutter suppression/mitigation, flash isolation and feature extraction methods for both the single wide-area detector and the imaging sensor array. The toolbox will also allow combination of processed results and optimization methods. The end product will be a processing toolbox that will allow the comparison and optimization of different flash detection and localization methods.
b) To design and build a hyperspectral sensor capable of detecting the LWIR (long-wave infrared) spectrum of a “flash event”. The system will enable the user to learn the LWIR (long-wave infrared) hyperspectral signature of man made explosives and propellants, and naturally occurring flash events which could be mistaken for explosives or propellants. Thus, the user will be able to learn whether the LWIR (long-wave infrared) spectrum can be used to

distinguish between explosives and natural clutter. The battlefield application of this would be threat warning and situational awareness.

DESCRIPTION: a)Many proposed threat warning methods involve the use of separate flash detection and threat localization sensors. A wide area flash detector is used in combination with an imaging threat localization sensor. The combination of sensors is thought to optimize the performance of the threat warning sensor suite while reducing the signal processing burden from that of a fast framing camera alone. The proposed toolbox will allow comparison of proposed threat warning solutions which combine the detection and localization sensors and optimization of single approaches. Present ways of comparing different proposed approaches involve direct testing of actual systems, which usually does not allow an understanding of the details of a particular approach nor does it allow for optimization.
b)Some typical battlefield threat weapons signatures have been spectrally and temporally quantified, and signature research continues today. Most of the measurements have been in the UV through MWIR (mid-wave infrared) spectral bands. Affordable threat warning and situational awareness systems remain an elusive goal. Uncooled LWIR systems present an attractive sensing capability, however without information on the optimal spectral subbands within the LWIR (long-wave infrared) and optimal frame rates it is difficult to quantify the utility of such sensors.
A fast LWIR hyperspectral sensor would allow for the quantification of the spectrotemporal signature of battlefield flash events (missile firings, explosions and solar glints) which would both indicate the utility of such sensors and allow the optimization of the spectral band and frame rate of the sensors. While such sensors exist in the Visible, SWIR (short-wave infrared) and MWIR (mid-wave infrared), no such sensors yet exist in the LWIR (long-wave infrared) band. This research will push technology to design, develop, fabricate and use such a sensor in the LWIR (long-wave infrared).

PHASE I: a. Phase I will involve the design of the fast LWIR (long-wave infrared) hyperspectral sensor. It will also involve a concept feasibility study which will identify possible vendors for key parts of the sensor and predictions of final sensor performance. The end product of this part of the effort is a report summarizing the study.
b. Phase I will involve a study to identify the suite of algorithms to be included in the signal and image processing toolbox. The study will include a detailed investigation of the different variants for particular algorithms. The end product of this part of the effort is a report summarizing the study.

PHASE II: a. This phase of the effort will include the fabrication of the prototype sensor and the use of the sensor in initial laboratory and field testing. Lab testing will be designed to quantify the spectral and temporal resolution and sensitivity. Field testing will include signature measurement of current threats. The required deliverables are a working fast LWIR (long-wave infrared) sensor and a report describing the results of lab and field testing using the sensor.
b. This phase of the effort will include the writing of signal and image processing tools identified in phase one. It iwll also include their incorporation into a well designed software framework that allows for convenient performance quantification, comparison and optimization. Testing of the toolbox using example signal and image sets will be included. Deliverables will include the software toolbox and a report describing its use on sample images and signals.

PHASE III: a. A fast hyperspectral sensor could possibly be the sensor which provides the signals which enable distinguishing between threats to military vehicles and benign confusing background events. The robust threat decisions would cue a future active protection system for ground or air vehicles. PM-NVRSTA has strong interest in such capabilities as evidenced by their overwatch program and related efforts and would be the most likely to transition this capability to the field. Commercially the technology could be used to characterize hot sources in smoke to aid in fire fighting or to provide information on processes taking place at elevated temperatures.
b. The suite of algorithms produced could form the basis of embedded algorithms used in an automated threat detection and situational awareness system. The PM-NVRSTA has expressed interest in situational awareness systems, muzzle flash detection systems and threat avoidance systems. They would be the most likely transition path to operational capability. Commercially the suite of algorithms could be modified and optimized to focus on the task of muzzle flash for policing crowds or areas of high crime rate.

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KEYWORDS: long-wave infrared, hyperspectral, sensors, flash detection

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A07-085 TITLE: Improved Far-Target Location Accuracy for Man-portable Systems Through Application of GPS, Gyroscope, and Magnetometer Technologies

TECHNOLOGY AREAS: Electronics

OBJECTIVE: To develop a prototype hybrid sensor that merges advances in GPS, Gyroscope, Accelerometers, and Magnetometer technologies to achieve a <.3° (<5mil) azimuth accuracy in the presence of typical battlefield disturbances (e.g. buildings, vehicles, power lines, etc).

DESCRIPTION: Determining Far-Target Location (FTL) is a key component of the Force Operating Capabilities (FOC) doctrine to see, understand, and act first. The azimuth, or bearing, to the target is one of four variables that must be defined in order for an observer (e.g. Soldier) to calculate the location of the target on the Earth. The other variables are; distance (range), vertical angle (elevation), and self-position (latitude, longitude, and altitude above sea level). The military developed target location systems for dismounted soldiers (e.g. Mini Eyesafe Laser Infrared Observation Set (MELIOS, Lightweight Laser Designator Rangefinder (LLDR), Mark VII, etc). These devices, along with a host of other similar devices, use a laser rangefinder to determine the range to the target, a digital magnetic compass to determine the azimuth and elevation, and a Global Position System receiver (GPS) to determine their “self-location”. Using the information generated by these systems, the soldier can locate the target for direct and indirect fire missions, surveillance missions, and maneuver missions The commercial sector also has similar, though typically less capable, devices designed for hunters, golfers, boaters, and outdoor adventurers. Additionally, the automotive industry has embedded hundreds of thousands of digital compasses in a variety of vehicles.

This research is designed specifically to address the need for more accurate targeting information. The largest source of Target Location Error (TLE) in the existing systems is in azimuth. Target azimuth is determined using an embedded digital magnetic compass. Though current digital magnetic compasses provide better than 1° accuracy (<17.8 mils), they are prone to errors induced by local magnetic disturbances. Field reports from current operations indicate that there is a need for improved accuracy and greater precision, <.3° or <5mils. In addition, maintaining this greater accuracy in the presence of magnetic disturbances is critical in a tactical environment. These disturbances are caused by nearby building, vehicles, power lines, buried pipes and even the soldier’s individual combat load. Application of non-magnetometer based solutions, such as GPS receivers and gyroscopes, can greatly reduce, if not eliminate, errors caused by nearby objects. New GPS receivers have the capability to determine heading, when used in combination with other sensors. This has been demonstrated in navigation systems for un-manned and manned vehicles. This research will attempt to accomplish this marriage sensors in a package that can be embedded within a man-portable handheld target location system.

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. Low-cost GPS chip receivers, Ring and MEMS gyros, accelerometers, and magnetometers are available in automotive and handheld navigation systems, cell phones, and in commercial avionics. and will be explored during this activity. A cost savings may be achieved verses traditional military sources.

PHASE I: Requirements Analysis & Design Study: Requirements for the sensor component (e.g. GPS, gyroscopes, accelerometers, and magnetometers) will be analyzed in terms of the mission requirements, specific performance parameters will be defined, and a survey of compliant component availability conducted. Once the requirements analysis is complete, a notional architecture and performance predictions will be developed.

PHASE II: Prototype Fabrication, Integration, and Demonstration: During the early part of this phase, selected components will be purchased, demonstrated, and tested to determine their suitability. Subsequently, a breadboard prototype module will be fabricated based on the architecture developed in Phase I for experimentation and demonstration. Results will be used to validate key performance parameters, component selections, system concepts and compensation algorithm design. Requirements and concepts for the full-up module capable of being integrated into an FTL system such as LLDR will be explored.

PHASE III: Technology Transition: During this phase, the detailed design process will commence. A preliminary design of the sensor module capable of being installed into an existing FTL system (such as LLDR) will be completed. Up to five modules will be fabricated and tested; two modules will be integrated in a host system (LLDR and Mark VII). The prototype modules in the host systems will be evaluated through a series of technical tests and informal user trials. Results of this phase will be used to determine if the new sensor module is suitable for insertion into an ongoing acquisition (production) program like the LLDR, Small Tactical Optical Rifle Mounted (STORM) laser rangefinder, Mark VII(E), or Joint Enhanced Targeting System (JETS) programs managed by PM - Soldier Sensors & Lasers (PM-SSL) under PEO - Soldier. Assuming successful test and demonstration, the updated host FTL system will be type classified for full-rate production. Additionally, the test and evaluation information will be shared with the commercial sector enabling “spin-off” into commercial products.

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KEYWORDS: Digital Magnetic Compass, Far-Target Location (FTL), Global Positioning System (GPS), magnetometer, magneto-resistive, magneto-inductive, MEMS Gyro, compass compensation algorithms, azimuth, Target Location Error (TLE)

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A07-086 TITLE: Wideband Filter Networks for Joint Tactical Radio System (JTRS) Size, Weight, and Power (SWAP) Reduction

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop and demonstrate dynamically reconfigurable wideband filter and impedance matching networks for hand held military radio applications that significantly reduce Size, Weight, and Power (SWAP) over conventional technologies.

DESCRIPTION: The goal of the Joint Tactical Radio System program is to enable interoperable communications between all branches of the military for JTRS fielded platforms as well as support for legacy radios. To facilitate this vision, the JTRS system must be able to support the full suite of military waveforms ranging from legacy to next

generation, such as SINCGARS and Soldier Radio Waveform (SRW). The broad support for current and future voice, data, and video applications requires the hardware to operate with a variable operational bandwidth covering a very broad frequency span. In addition, the JTRS Handheld, Man pack, and Small form factors (HMS) variants must be able to meet the all performance objectives, including reduced size and weight, while operating under battery power.
The requirement for extreme broad band coverage with a varied operational bandwidth in order to support the numerous communication waveforms results in a complex circuit design that contains a vast amount of filtering networks. The filter networks are applicable to inter-stage and power amplifier impedance matching networks, antenna matching, and numerous band pass filters that are employed in the transmit and receive chains.
The proposed effort will involve the design, development, and demonstration of prototype novel circuit designs that enable are employed in wireless RF front ends including band pass filters and all impedance matching networks which result in substantial reductions of SWAP or cost. The circuit elements and resulting network designs must be able to operate at sustained RF power levels up to 10 Watts, from 2 MHz through 3 GHz, and be compatible with conventional multi-chip module design, fabrication, and testing. The resulting technology must be able to support embedded applications for handheld and small form factor (sensors) communications, dynamically reconfigurable through hardware (control circuitry) or software.

PHASE I: After reviewing the current HMS approach, identify and provide the implementation of a novel wideband preselector filter that meets or exceeds the performance requirements with a reduced SWAP-C. Successful completion of phase 1 work shall include modeling results of the core technology demonstrating the RF, DC, and thermal performance. Along with these simulations, a roadmap showing the insertion of the technology into the HMS core transceiver shall be delivered. The final technical report for phase 1 shall include lessons learned and transition plans to phase 2 brassboards.

PHASE II: Design, build, and test a brassboard model that demonstrates the filter defined during the phase 1 development. The final technical report shall include lessons learned and a plan for transitioning from the phase 2 prototype to a Manufacturing Readiness Level (MRL) 5 module that can be inserted into the HMS core transceiver.

PHASE III: The filter module has the potential for use across all JTRS variants and all branches of the United States Armed Forces. The filter module can also be utilized for Homeland Security applications or commercial software defined radios. The final technical report shall include lessons learned.

REFERENCES: 1) Affordable Software Defined Radio (SDR) Components for JTRS Cluster 5 Manufacturing Technology Objective #04-01; http://www.armymantech.com/MTbropgs/mtbroc04/pg5.pdf
2) Radio Enabling Technologies and NextGen Applications (RETNA) Science and Technology Objective; POC: Jonathan Keller (732)427-0292, jonathan.s.keller@us.army.mil (This reference will be posted on SITIS system - http://www.dodsbir.net/sitis/)
3) JTRS Home Page: http://jtrs.army.mil/index.html
4) General Dynamics JTRS HMS SFF Home Page with contact information: www.gdds.com/radiosystems/jtrssmallformfactor.html

KEYWORDS: Wideband, JTRS, tunable, power efficient, RF, WNW, SRW

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A07-087 TITLE: Innovative Electronics Components and Circuit Designs for UHF RF Diplexer

TECHNOLOGY AREAS: Electronics

OBJECTIVE: To research and develop technologies that have application for the design and manufacturing of high performance, small, lightweight and cost effective RF diplexers operating from 225 MHz to 450 MHz. Some of the technologies may include: component material science, circuit design, integration/package design, and manufacturing processes.

DESCRIPTION: RF diplexers are very common and becoming more useful for military and commercial applications. The RF diplexer would allow two transceivers/channels to independently and simultaneously share one common antenna system with minimal degradation in performance.

State-of-the-art diplexer circuit designs, using existing advanced components and low loss substrates, are approaching the theoretical performance limits. Therefore, there is a need for research and development to advance the desired characteristics of electronics components and substrates that will enable innovative circuit design to realize a diplexer with expanding performance.

For military use, the RF diplexer design should include ruggedization and electromagnetic compatibility to adapt to military environments. One potential military application could be, but is not restricted to, Joint Tactical Radio System (JTRS) Handheld Manpack Small Form Fit (HMS) program. Current state-of-the-art diplexers have performance limitations in gap bandwidth, isolation, insertion loss, voltage standing wave ratio (VSWR), size, and weight. Such limitations have a direct impact on spectrum utilization and the overall performance of the JTRS HMS SFF-H system.

PHASE I: Research and analysis on the electronics components and circuit designs for an RF diplexer operating from 225 MHz – 450 MHz. Efforts would include simulation analysis or paper design with tradeoffs considered in size, weight, isolation, nominal impedance, duty cycle, channel separation, insertion loss and VSWR. Phase I deliverables should include a final report with the analysis results and design recommendations.

PHASE II: Fully develop and fabricate a prototype of electronic components. Complete the circuit design and the prototype diplexer. Demonstrate the diplexer prototype in a bench top integration and in simulations with surrogate transceivers and antennas. Deliverables should include monthly technical reports, and a final technical report.

PHASE III: The military applications include JTRS-HMS program and multi-band antennas for low visual signature. If successful, Product Management (PdM) JTRS-HMS program will most likely provide funding for Phase III to develop the proposed product. The developed product can be used in the SFF-H System of the JTRS-HMS program, to meet the needs of the system in terms of size, weight, isolation, nominal impedance, duty cycle, channel separation, insertion loss, VSWR, and ruggedness. The development of the advanced electronics components and substrates would also have improved performance on other electronic circuit designs for wide range of products. It is highly likely there will be interest from commercial wireless communication companies, such as the cell phone industry, in a high performance and bandwidth conserving UHF diplexer like the one proposed herein.

REFERENCES:
1) A. Williams and F.J. Taylor "Electronic Filter Design Handbook (Fourth Edition)" The McGraw-Hill Companies, July 2006
2) R. L. Ozenbaugh "EMI Filter Design (Second Edition Revised and Expanded)", CRC Press, January 2001
3) M. S. Ghausi, and K. R. Laker "Modern Filter Design: Active RC and Switched Capacitor", SciTech Publishing, Inc., January 2003
4) P. V. Ananda Mohan, V. Ramachandran, and M. N. S. Swamy "Switched Capacitor Filters: Theory, Analysis, and Design", Pearson Education, June 1995

KEYWORDS: RF Diplexer, JTRS HMS, Electronics components, Circuit designs.

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A07-088 TITLE: Improved Fault Management/Correlation for Tactical Networks

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PM Future Combat Systems Brigade Combat Team

OBJECTIVE: Technology for performing fault management/correlation exists in many areas; however one designed for the changing conditions of a tactical ad hoc network does not exist. A new engine needs to be developed to manage the new types of faults that occur in the future networks.

DESCRIPTION: The goal of this effort is to investigate the kinds of problems an ad hoc network could have and determine why they are occurring and how to remedy the problem in an easy fashion. The goal is also to develop an understanding on how to correlate the faults in an efficient manner to perform fault management techniques on the data.

Today's networks are typically infrastructure backed networks. These networks are richly connected, reliable, and have a high bandwidth backbone with a stable topology. If there are mobile hosts there are very few and they connect at known locations. Typically a central manager uses this backbone to query any device in the network to perform fault management. Usually this is done by a skilled network engineer.

A tactical mobile ad hoc network has very different characteristics. It is intermittently connected, very low bandwidth, and has a highly dynamic network topology. There are many mobile hosts connecting and disconnecting at random. Also, no single node has access to the entire network at all times because of the dynamic nature of the network. This network is much more complex than an infrastructure backed network and fault management will be done by the Warfighter.

Existing fault management systems do not allow for distributed and automated decision making and fault recovery. They also cannot adaptively collect information based on network bandwidth availability. Current fault management systems have difficulty managing the dynamic configuration/reconfiguration of tactical networks. Also, current tools are targeted at high bandwidth network environments.

Since tactical mobile ad hoc networks are relatively new, nobody has defined what the types of network faults occur in this environment. It is not simply the node is disconnected. These are complex networks that implement QoS, routing, and security measures that require constant adjustments to optimize their performance to support a mission. Rules must be developed to determine what the various types of faults are for this type of network. The other issue in this network is correlating the fault information and sending it higher level managers. The system must be scalable so that it can operate in a relevant military environment. In a tactical network the transmission of fault management data must be kept to a minimum to give the Warfighter the ability to use the network more efficiently. The correlation of this data is important because it give the network manager a clear picture of what is going on in the network and how to fix any faults that are occurring.

Once fault management rules are defined and a way to correlate the information in a tactical network is discovered an engine must be created to perform the fault management/correlation tasks. By having such a tool the user gains a better insight into what is happening in their network and can increase network reliability by correcting faults quickly and efficiently. The payoff from this technology will be a new design which resolves the current gaps in the proper way to perform fault management/correlation for tactical ad hoc networks.

PHASE I: Feasibility study to determine the types of faults that occur in a tactical ad hoc network and the proper way to correlate the fault management data. This study will determine what kinds of faults can occur when QoS, routing, and security are implemented in a tactical network, what defines a fault in the tactical network, and who should receive the fault alert messages. This study will also determine the proper way to correct these faults once they are discovered in the network. Initial architecture documents will be created that describes how to build a tool to perform this fault management task.

PHASE II: Prototype of the fault management/correlation technology that is relevant to tactical ad hoc networks. Deliverable will include interface control document, modeling and simulation results, and architecture documentation. This phase will include a prototype demonstration that will show the technology operating in a relevant environment.

PHASE III: Build fully functional system that can be incorporated into network management systems. Deliverables include final product, any documentation written on the product, and all models used in the validation and verification of the system. Software will be demonstrated in a relevant operating environment.

Military Application: Primary application for fault management/correlation engine is for the PM FCS Network Management System. PM FCS has defined fault management as a technical gap that needs addressing. Other applications are the WIN-T and JTRS programs. Each system needs a fault management correlation engine that can be used for tactical ad hoc networks.

Commercial Application: Future commercial wireless networks will be ad hoc networks which will require the same type of fault management/correlation techniques. By researching them now and building a prototype software solution the commercial world would have tools to manage this emerging networking technology.

REFERENCES: 1) Warfighter Information Network - Tactical (WIN-T) Operational Requirements Document (ORD): http://www.fas.org/man/dod-101/sys/land/docs/WIN-T5NOV.htm

2) Future Combat Systems Overview: http://www.army.mil/fcs/whitepaper/FCSWhitepaper(11_Apr_06).pdf
KEYWORDS: Fault, Management, Correlation, Engine, fault tolerance, network rules, network policies, network management

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A07-089 TITLE: Low Power High Performance Signal Processor for Joint Tactical Radio System (JTRS)

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop and demonstrate a dynamically reconfigurable scalable High Performance Signal Processor (HPSP) architecture for embedded hand held military radio applications that significantly reduce Size, Weight, and Power (SWAP) over conventional technologies.

DESCRIPTION: The JTRS radio is transforming the concept of Department of Defense (DOD) communication systems. Specifically, it combines the small size, low cost, and increased battery life from the commercial marketplace with the rugged, extended environmental requirements of the Warfighter. The JTRS radio will be designed to support the full suite of military waveforms ranging from legacy to next generation, such as SINCGARS and Soldier Radio Waveform (SRW). SRW and the next generation Wideband Networking Waveform (WNW) require an extensive amount of real time information processing within a short period of time in order to facilitate battlefield network applications for voice, data, and video. The JTRS Handheld, Man pack, and Small form factors (HMS) variants must be able to meet the performance objectives, including reduced size and weight, while operating under battery power. These requirements for processing massive amounts of information dictates the need for low power, highly computational, embedded real time processors that can be tailored to the application.

The proposed effort will involve the design, development, and demonstration of a prototype novel signal processing architecture that is highly reconfigurable, supports fixed and dynamic application requirements, and be capable of a lifetime of seamless field upgrades. The HPSP must be able to operate as "hardware under software control", have an open [hardware and software] architecture, and be capable of supporting applications for embedded system integration in a military environment. A modular software developer kit (SDK) will be developed for the processor architecture that allows for the rapid development of parallel processing aware waveform source code. The software developer kit will allow for rapid development of parallel processing aware waveforms through the translation of common single threaded or single processor source code. The software developer kit will also maximize the efficiency of a parallel processor array by utilizing an optimization algorithm that allocates processor resources in the most efficient manner possible. The optimization algorithm of the software developer kit will dynamically optimize the utilization of each processor contained in a specified software defined radio. This will decrease waveform development time while also increasing the performance of a software radio waveform as measured in computational power per mWatt. The signal processor architecture and resulting hardware should demonstrate the capability for 5 to 10 fold improvement in processing capability, high bandwidth and low latency (high throughput, massively parallel), with substantial reductions in prime power as compared to current state-of-the-art signal processors (General Purpose Processors, DSP, ASIC, FPGA).

PHASE I: The Phase I effort will concentrate on researching new software translation models that will be developed into a supporting software developer kit (SDK) and programming model that allows for mapping of advanced wireless communication algorithms for parallel execution on a specified target processor architecture. Investigations into single processor software to large scale parallelization will also be performed as the computing industry has yet to innovate in this area and future processor developments will gravitate towards increasing parallelization instead of faster single processor operations per second. The offeror shall submit tangible evidence, actual demonstration of hardware and software, modeling and simulation data, to support hardware capable of an order of magnitude improvement in processing throughput compared to current state of the art signal processing technology, GPP, DSP, ASIC, FPGA, etc. A final report is required with compiled results for benchmarking to a wireless waveform (such as 802.11a or similar) with comparison to conventional processing technology including simulated or measured metrics for millions of operations per second (MOPs), processing latency, total latency, and power consumption in both standby by and full operation. Phase one goal is demonstration of parallelization algorithm that scales computations across multiple processors while also offering a decrease in power utilization versus conventional single general purpose processors. The parallelization algorithm will be delivered and should be utilized as a baseline to design the processor architecture in Phase II.

PHASE II: Phase II will continue with the performance investigation of the parallel signal processor architecture through the generation of metrics by development and testing of the signal processor hardware and further innovative research into single threaded to multi-threaded translation models. Performance metrics are to be established through the development, implementation, and demonstration of an 802.11a or g Orthogonal Frequency Division Method (OFDM) physical (PHY) layer on the developed processor architecture. This excursion will include the development of the 802.11 a/g OFDM PHY on the just developed parallel processor prototype board utilizing the modular software developer kit to illustrate the effectiveness of the SDKs optimization algorithm. Further performance metrics will be captured through the implementation of the 802.11 a/g OFDM PHY translated to a digital signal processor (DSP) or field programmable gate array (FPGA) development board. This is to be accomplished by defining and utilizing additional processor modules and optimization algorithms for the SDK. Comparisons on the performance of a parallel processor array versus DSP or FPGA implementation can then be drawn. This demonstration will also illustrate the effectiveness of developing source code for one specific processor architecture and then utilizing the SDK to translate it or port it to a different architecture.

PHASE III: The HPSP hardware and SDK will transition from their initial development so that it can be utilized by future JTRS radios and commercial developers. Integration with the JTRS HMS radio will be performed to maximize the performance efficiency of the HMS components while decreasing waveform development time. Utilizing SRW 2.0 or a similar waveform, the HPSP device will be fully characterized under actual operating conditions. With these measurements in hand, along with cost, the physical attributes, and complete understanding of the design flow, a detailed HMS SWAP-C analysis will be completed. The HPSP and the SDK can be made available for use or insertion into any commercial computing application that has a high computational speed requirement. This includes high speed networking, commercial software defined radio development, data manipulation and mining, media encoding/decoding, modeling and simulation, and general purpose computing. The SDK will allow commercial software developers to more readily adapt and write parallel processing aware source code by providing a tool to transition from single threaded to multi-threaded code. Commercial industry can then refine and tailor the HPSP and SDK Phase II delivered capabilities to include the automation of both common and advanced serial tasks to parallel ones. Through this action the SDK will encourage commercial software developers to take advantage of additional processing capabilities as found in the HPSP and develop software that will be more powerful while also being more power efficient. This will aid the commercial transition of developing single threaded software applications to applications and tasks that can take full advantage of future parallel processing arrays.

REFERENCES: 1) Affordable Software Defined Radio (SDR) Components for JTRS Manufacturing Technology Objective #04-01; http://www.armymantech.com/MTbropgs/mtbroc04/pg5.pdf

2) Radio Enabling Technologies and NextGen Applications (RETNA) Science and Technology Objective; POC: Jonathan Keller (732)427-0292, jonathan.s.keller@us.army.mil (This reference will be posted on SITIS system - http://www.dodsbir.net/sitis/)

3) JTRS Home Page: http://jtrs.army.mil/index.htm

4) General Dynamics JTRS Cluster 5 SFF Home Page with contact information: www.gdds.com/radiosystems/jtrssmallformfactor.html

KEYWORDS: JTRS, power efficient, RF, WNW, SRW, General Purpose Processors, DSP, ASIC, FPGA

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A07-090 TITLE: High Efficiency, Low Power, Low Noise Amplifiers for SATCOM

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Current low noise amplifiers utilized in phased arrays draw excessive power, resulting in a large heat load. Efficient low noise amplifiers are needed to reduce the power consumption and dissipation and the cooling requirements of receive phased array antennas.

DESCRIPTION: Monolithic Microwave Integrated Circuit (MMIC) Low Noise Amplifiers currently used in phased array antennas for communications on-the-move draw up to 300 milliwatts of power each, requiring a large, expensive heat exchanger to remove the dissipated heat. Efficient low noise amplifiers are needed to reduce the power dissipation and the cooling requirements of practical receive phased array antennas. Efficient, low power consumption MMIC Low Noise Amplifiers are needed for 20.2-21.2 GHz, 10.95-11.7 GHz bands to support on-the-move communications systems for the warfighter.

PHASE I: The phase I effort will conduct an analysis and preliminary design of high efficiency, low power consumption, fully self biased MMIC Low Noise Amplifiers. The objective is power consumption of less than 50 milliwatts (25 milliwatts desired), a gain of >20 dB at 20.2 to 21.2 GHz and 10.75 to 12.75 GHz and a noise temperature of <100 degrees Kelvin at 20.2 to 21.2 GHz, and <60 degrees Kelvin at 10.95-12.75 GHz. Technologies considered shall include, but not be limited to pseudomorphic and metamorphic high electron mobility transistor (pHEMT and mHEMT) technologies. The product of Phase I will be a technical report detailing the preliminary design and expected performance of the low noise MMIC amplifiers for 10.75-12.2 GHz and 20.2-21.2 GHz frequency ranges.

PHASE II: The phase I designs will be refined and low noise amplifiers will be fabricated, tested and evaluated. The designs will then be modified as necessary to produce the final prototypes. The Phase II product will be low noise MMIC prototype amplifiers for the 10.75-12.2 GHz and 20.2-21.2 GHz frequency bands. The final prototypes will be demonstrated to highlight their low power consumption and power dissipation, gain, and noise temperature. The 1 dB compression point of the amplifiers will also be demonstrated.

PHASE III: These amplifiers will transition to the PM WIN-T and FCS for use in low profile, multibeam phased array antennas for Satellite communications on-the-move. Commercial applications include mobile direct broadcast television reception and mobile satellite internet for land, marine and airborne systems.

REFERENCES: 1) United Monolithic Semiconductors data sheet CHA2069 (self biased device)(available at http://ums.openkast.com/ums/home/home_page.php)
2) Hittite Microwave Corporation Data Sheet HMC517 (external biased device)(available at http://www.hittite.com/)
3) "50-nm T-Gate Metamorphic GaAs HEMTs With Ft of 440 GHz and Noise Figure of 0.7 dB at 26 GHz", K. Elgaid, et. al., University of Glasgow, IEEE Electron Devices Letters, Vol. 26, No. 11, November 2005, p784-786.
4) "X-band GaAs mHEMT LNAs with 0.5 dB Noise Figure", M.S.Heins, et. al., Tri Quint Semiconductor, 2004 IEEE MTT-S Digest, p 149-152.

KEYWORDS: Monolithic Microwave Integrated Circuits (MMICs), Pseudomorphic high electron mobility transistors (pHEMT), metamorphic high electron mobility transistors (mHEMT), Noise Temperature, Low power consumption, low power dissipation

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A07-091 TITLE: Enhancements for Military Ground Based GPS Receivers in Urban Environments

TECHNOLOGY AREAS: Materials/Processes, Electronics

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

OBJECTIVE: Develop and demonstrate GPS receiver improvements for ground users to optimize their positioning performance in urban applications.

DESCRIPTION: The military specification of GPS Precise Positioning Service (PPS) for horizontal position is 11.1 meters, 95% (ref 1). Receivers that are continually tracking PPS, experience typically about 3 to 6 meters, 95%. However, vehicles, soldiers, robotic platforms and sensors engaged in operations in urban environments have observed erratic GPS receiver performance. This is due to an environment that is ever changing and includes multi-path and varying signal levels caused by partial blockage/ non-penetration of signals through different materials. Loss of lock and subsequent re-acquire episodes are frequent in these environments, along with widely varying quality of signals. GPS receiver users in these conditions report apparent jerky behavior while observing user interfaces and map displays (in many cases several 100 meters of shift have been observed within one second increments). Under this topic, the contractor shall study the application of digital signal processing techniques, receiver integration with commercial-off-the-shelve small/low cost sensors, the application of software algorithms which analyze the platform’s motion, and other solutions in order to improve the performance of the GPS receiver’s position solution. Networking techniques for the sharing of information with collaborative partners may be considered as well as the benefits that can be obtained through the processing of emerging GPS Modernization signals (for example the dataless M-Code channel) (ref 2).

A major concern in the employment of GPS receivers in US Army platforms is size, weight, power, and cost. Hence, all techniques/sensor integrations that will be studied and prototyped under this topic, must add significant performance benefit while having no, or only minimal impact to the platform.

It is expected that through the employment of the techniques/sensor integration that horizontal position performance will by improved by 90% under all urban (outdoor) operations.

Under this topic the vendor will develop and demonstrate receiver improvements for ground users to optimize their positioning performance for vehicular, robotic, sensor and soldier applications in urban applications.

PHASE I: The contractor shall conduct trade studies that will analyze enhancements, via modeling and simulation, that will improve position performance resulting in a specification for a GPS receiver optimized for ground user operation.

PHASE II: The contractor shall develop, demonstrate and evaluate a prototype system implementing the enhancements that were investigated in phase I.

PHASE III: Commercialization – The use of position information in the battlespace is evolving as a shared utility, for virtually all military operations. This naturally expands into the urban environment along with all military operations. Planning by US Army and other military service applications of GPS has started to approach a one receiver per platform. Application of the technology developed under this topic will be applicable to virtually all military applications and expansion of most of the techniques developed under this topic have a translation to the commercial application of GPS.
In support of PM GPS, CERDEC will manage the phase III program that will finalize prototype and militarize the product for application in GPS receivers and implement in Army ground platforms. Army ground platform include Future Force Warrior, Future Combat System, Stryker and Land Warrior which could all benefit by the improvements provided to their platform. PM GPS and the platform PM users are the most likely funding sources for Phase III. Development on this effort is a combination of added hardware and software modifications for GPS receivers that will enhance performance in ground platforms in degraded conditions. Path to transition for the software would be that the small business could provide (sell) a license to a primary GPS supplier for the software design. For the hardware either the small business could sell it as a kit to the GPS manufacturer or Army Platform PM, or provide (sell) the design rights to the GPS manufacturer.

REFERENCES: 1) Performance (PRF) Specification for the Defense Advanced Global Positioning System (GPS) Receiver (DAGR)
2) Brian C. Barker, John W. Betz, John E. Clark, Jeffrey T. Correia, James T. Gillis, Steven Lazar, Kaysi A. Rehborn and John R. Straton. "Overview of the GPS M Code Signal". Proceedings of ION 2000 National Technical Meeting, Institute of Navigation.

KEYWORDS: Global Positioning System, urban environment, M-Code, GPS modernization, digital signal processing techniques, software algorithms.

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A07-092 TITLE: Advancement of State of the Art Fuel Cell Technologies through Innovative Component Development

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

OBJECTIVE: Develop new and innovative components that will improve performance in state of the art fuel cell technology systems. The end deliverable would be a fuel cell system that provides 20-30W power, is less than 0.8 kg dry weight and energy density of at least 800Whr/kg for 72 hours. This development effort could include changes to the balance of plant components, stack development, fuel processor development, control development, or casing improvements. The total system design must be rugged and reliable. Non-fuel specific.

DESCRIPTION: Soldier Power fuel cells in the 20-30W range have made significant progress over the past few years. However there are still several areas of internal development that require innovative solutions to meet the weight, efficiency, and energy density targets for future power. This topic will focus on innovative component development in advanced fuel cell systems to meet increased energy density, power density, and stringent weight targets. The innovative and unique components will then be integrated back into the current fuel cell system demonstrating a clear advantage in system outputs. The end deliverable would be a fuel cell system that provides 20-30W power, is less than 0.8 kg dry weight and energy density of at least 800Whr/kg for 72 hours. This could include changes to the balance of plant components, stack development, fuel processor development, control development, or casing improvements. The design must be rugged and reliable. Non-fuel specific.

PHASE I: Develop and Demonstrate new and novel components for a 20-30W fuel cell system. The Offeror must demonstrate the ability to actually integrate these components into a complete system. Improvements to components may include changes to the balance of plant components, stack development, fuel processor development, control development, or casing improvements. Ph I will deliver the design and system analysis of prototype components. These components should be designed and analyzed for the feasiblity of meeting Ph II system goals of 800 Whr/kg and less than 0.8 kg.

PHASE II: Ph II will take the work completed in Ph I and fabricate and integrate these novel components into a prototype system. The system protoype targets for Ph II are 20-30W, 800 Whr/kg, and less than 0.8kg. Ph II will deliver 2 fully functional prototype units to the Army for testing.

PHASE III: Potential Phase III military applications include transition to the Land Warrior or Future Force Warrior Programs. Fuel Cells are already being examined for use in these programs but need improvements to components and balance of plant in order to meet the ultimate expectations. This SBIR program would focus on those needs and provide a product that will transition. Potential Phase III military applications include a power source for sensor technolgies that require long unattended run-times, sattellite communications that are power intensive devices, and also military radios that require mutiples batteries or frequent recharge. Potential Phase III commercial paths for this technology are in the laptop market. the miliatyr path is ruggedized laptops as well as the commercial laptop market. Additional commercial applications include small generators, and the recreational market for camping, sailing, and RV.

REFERENCES: TRADOC Pam 525-66, FOC-09-01 Sustainability
TRADOC Pam 525-66, FOC-09-03 Power and Energy
TRADOC Pam 525-66, FOC-09-08 Soldier Supportability

KEYWORDS: Fuel Cells, fuel cell components, soldier Power Source, methanol fuel cells, balance of plant

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A07-093 TITLE: Economical Power Source for Dismounted Soldier and Unattended Ground Sensor Missions

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To spawn a new area of technology interest for fueled power supplies for dismounted soldier (DS) and unattended ground sensor (UGS) applications. A cost-competitive, high energy density source is sought for UGS missions, and a high power density source is sought for DS missions.

DESCRIPTION: Currently, the DS and UGS applications rely on either a primary or secondary battery solution for power needs because no other alternatives are available. Alternative, fueled concepts currently under consideration/development include the use of fuel cells, and various internal/external combustion engine-driven approaches.

Future DS and UGS missions could benefit from a fueled power source if system power density, energy density and cost benefits are achievable. Benchmarks for each metric are as follows:

Power density: 20 W/kg (Li-145 battery for Land Warrior)
Energy density: 320 W-hr/kg (BB-8180/U Zinc-air battery)
Cost target: < $0.32/W-hr to be competitive with primary batteries
[$291 (GSA price of BB-8180/U Zinc-air battery) / 320 W-hr / 2.8 kg = $0.32/W-hr]

All known research in fueled power sources for soldier power applications has focused on long life components and subsystems. Though this may be a desirable goal, it has led to high cost components and subsystems that have not resulted in cost competitive alternatives to batteries over the life-cycle. The intent here is to take a new approach to fueled power sources and determine whether it is practically feasible to tradeoff system life and/or other features to improve upon the cost and energy density characteristics of state-of-practice primary batteries. A true life-cycle approach is sought.

Alternative fuels (solid, liquid, gaseous), alternative fuel-to-electric conversion methods (electrochemical, electromechanical, electrothermal, etc.), and methods of fuel oxidation are to be considered as part of this research effort. A study of each shall be conducted to determine those fuels, conversion technologies, and oxidation approaches most likely to produce an economically competitive, fueled, and safe alternative to primary batteries for DS and UGS missions.

PHASE I: Identify and describe energy storage and power conversion technologies that will yield novel & economical power and energy systems for UGS and Dismounted Soldier applications. Baseline system-level performance metrics are as follows:

• Fuel: JP-8, diesel, or alternative packaged fuel
• Output:
UGS: 0-4W continuous with ability to satisfy short-duration peak loads
DS: 10-30W continuous with ability to satisfy short-duration peak loads
• Environment: full-spectrum military environment (AR70-38 temperature extremes, MIL-STD-810 shock & vibration, sand & dust, humidity, MIL-STD-461 electromagnetic environmental effects etc.)
• Transport: Ability to be safely transported by commercial and military vehicles and aircraft. Ability to be safely stored in a similar fashion to current battery storage concept.

Develop conceptual component , subsystem, and system-level designs per the above. The designs should include the following elements:

a. Narrative and graphical depiction of the design
b. Projected physical attributes (power density, energy density)
c. Projected performance metrics (fuel consumption, power output, etc.)
d. Identification of the technology readiness level of the technology

A decision model of selected components and subsystem designs shall be constructed with weighted values for performance & operational/logistics parameters. Weighting factors shall be assigned to each parameter by the contractor and justification for these weights shall be provided. It shall also be possible to easily change weighting factors to study the effects on the overall utility of the design (sensitivity study).

Using this decision model, or another suitable approach, the contractor shall conduct sensitivity studies to determine optimal combinations of fuels, components, and subsystems to pursue in Phase II.

PHASE II: Technology development, design, and fabrication shall be conducted for one or more UGS and one or more Dismounted Soldier power systems. Conduct baseline performance evaluations. Develop a business case analysis showing how the UGS and DS power systems will benefit the Army / DoD from a mission and life-cycle cost standpoint. Develop a marketing strategy for launching the technology into multiple commercial market segments.

PHASE III: The results from the Phase II effort will afford the contractor the technology, mission insight, and marketing capability to provide industry advanced state-of-the-art UGS and DS power systems. Potential military applications are video-capture UGS associated with security missions, soldier portable power and battery charging systems, etc. The most likely path for transition of this technology would be through direct sales of “alpha” units (low quantity) to organizations such as USSOCOM, Rapid Equipping Force, and the CIA. After successful demonstration, the most likely path for sales of higher quantities would be through direct marketing to organizations such as PM-Soldier Warrior and the program office for Future Combat Systems. Another path would be participation in an Army Technology Objective program with CERDEC to militarize the technology and transition to the organizations above. Outside the military, there is potential for sales to the Dept of Homeland Security.

Commercial UGS applications will be similar in nature to military needs (security, surveillance, etc.). Commercial 10-50W applications could include boating, camping, and recreational vehicle power markets.

REFERENCES: 1) MIL-STD-810, Department Of Defense Test Method Standard For Environmental Engineering Considerations And Laboratory Tests
2) MIL-STD-461, Department Of Defense Interface Standard Requirements For The Control Of Electromagnetic Interference Characteristics Of Subsystems And Equipment
3) Army Regulation 70-38, Research, Development, Test And Evaluation Of Materiel For Extreme Climatic Conditions
4) Unattended Ground Sensor (UGS) Systems for Homeland Defense, http://www.nova-eng.com/downloads/wp_ugshomedef.pdf

KEYWORDS: fueled power supplies for the dismounted soldier (DS), unattended ground sensor (UGS) applications, power density, energy density; Alternative fuels (solid, liquid, gaseous); alternative fuel-to-electric conversion methods (electrochemical, electromechanical, electrothermal, etc.), fuel oxidation

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A07-094 TITLE: Framework for Mobile Services

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Research creating a framework for building software services that facilitates the transfer and functional interoperability between multiple service oriented architectures. For example: this framework would allow services developed for the Army’s System of Systems Common Operating Environment (SoSCOE) to also be run in the DoD’s Net-Centric Enterprise Services (NCES) with very little or even no modification. This framework should be generic enough to work with and accommodate any service from various architectures.

DESCRIPTION: Network Enabled Battle Command (NEBC) is a work package in the Network Enabled Command and Control (NEC2) Army Technology Objective (ATO) in Communications-Electronics Research, Development and Engineering Center (CERDEC) Command and Control Directorate (C2D) focused developing C2 (Command and Control) mission planning and execution monitoring services. Legacy C2 applications come in many flavors and variations, but in general, something they share in common is their standalone mode of operation and general incompatibility with other systems, save for marginal stove-piped data sharing capability. Each application requires its own machine and utilizes significant hardware and software resources. To solve this fundamental design problem, the Army has explored service oriented architectures in an effort to centralize functional components and extend information availability and software capabilities over networks. Network service solutions have already been implemented by the military over the last few years and will continue to be developed into the future. Two of the service oriented architecture (SOA) solutions currently under development by the military include NCES and SoSCOE. The solutions, while making military applications and services available to many end users, are not compatible with each other. For example: If a user has a program that has been enabled to utilize services from SoSCOE alone, it would be unable to utilize services from NCES or elsewhere. Current efforts like the Managed Connector research program under NEBC are exploring how one could access SoSCOE services from the NCES level. However, there exists a need to create a centralized framework that can use the abilities of all the major military data services, as well as have the extensibility to be used for future data services. This is analogous to how commercially available software like the Java VM (Virtual Machine) and the Microsoft .NET platform are designed to be generic software platforms, able to run the machine code and make operating system calls on a wide number of computing platforms. The goal of this SBIR is to create a framework for mobile services that provides a structure that services could be developed under which would allow those services to work in many different SOAs. This framework should be generically designed as to be compatible with current major military service providers such as SoSCOE and NCES, as well as with future providers that will inevitably be proposed and developed. Research of current generic application frameworks such as the various JVMs (Sun, IBM, Blackdown) and the Microsoft .NET framework should be completed to investigate how these solutions are able to generically run on multiple platforms and operating systems. These solutions, while not all specifically web service oriented, are able to generically call machine and operating system functions, which could be likened to generally calling services or their discovery services. In the commercial world various companies are beginning to employ SOAs, but as of now, there are no solid standards which dictate what an SOA must use. With a great variety of available technologies that can be used to create a SOA, the possibilities of service incompatibilities increase as well. A common service framework will create the foundation for applications that can use services from many different sources. As an example, the book retailer Amazon has implemented many services for its e-commerce environment. They have generally used the web service standards such as SOAP (Simple Object Access Protocol), WSDL (Web Service Description Language), and UDDI (Universal Description, Discovery, and Integration), to interface between their different services. A 3rd party developer implements a SOA using different technologies like Jini or CORBA (web service messaging formats). This developer may want to use a service provided by Amazon such as a book rating system, but may not be compatible with their implementation due to different SOA constructs and communication standards. A common service framework would allow the current SOA web service standards to generically communicate with other SOA designs thusly making services from all SOAs available to everyone.

PHASE I: Research commercially available multi system software frameworks such as the JVM and .NET to see how solutions used could be applied to create a Mobile Network Services Framework. Design a preliminary architecture which describes how a mobile services framework could be built.

PHASE II: Build a Mobile Services Framework which facilitates the creation of services that could be deployed across different SOAs. This framework would enable service designers to utilize 3rd party services that were developed under different SOAs, without having to connect to those SOAs. Essentially, they would deploy those services they need to access in their own SOA. This framework should have an API that allows other services to be incorporated later and should be able to accomplish various military needs.

PHASE III: The final product including an API will be licensed to commercial entities wishing to utilize the network based services of different architecture backgrounds in their own environment. Military applications will include the ability to produce NCES and SoSCOE (and ultimately, any net-centric service) interapplicable applications including NECC. Commercial applications will include licensing this inter-SOA framework API to commercial companies like banks and service providers such as online commerce sites who all need to work with each others independent service architectures.

REFERENCES: 1) .Net Framework Description, Wikipedia, http://en.wikipedia.org/wiki/Microsoft_.NET_Framework
2) The Java Platforms, OnJava.Com (The Independent Source for Enterprise Java, http://www.onjava.com/pub/a/onjava/2006/03/08/what-is-java.html?page=2#java-virtual-machine
3) Java Virtual Machine Description, Wikipedia, http://en.wikipedia.org/wiki/Java_Virtual_Machine
4) Net-Centric Enterprise Services (NCES), Defense Information Systems Agency, http://www.disa.mil/nces/
3) System of Systems Common Operating Environment Presentation, Paul Schoen,http://www.boeing.com/ids/soscoe/index.html
4) A Conversation with Werner Vogels, ACM Queue vol. 4, no. 4 - May 2006, http://www.acmqueue.com/modules.php?name=Content&pa=showpage&pid=388&page=1

KEYWORDS: Service Oriented Architectures (SOA), Mobile Services, Service Platform Interoperability, Platform Independence, System of Systems Common Operating Environment (SOSCOE), Net-Centric Enterpirse Services (NCES)

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A07-095 TITLE: Optical Character Recognition for Arabic Ruq

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a fast, accurate and precise Optical Character Recognition (OCR) engine for imagery files or scanned hard copy documents containing Arabic Ruq'ah writing scripts.

DESCRIPTION: US Army war fighters and intelligence analysts have continuous need and demand for efficient means to review voluminous Arabic handwritten documents and conduct data mining to accurately search and identify specific key words or group of words/short sentences of interest for further review and analysis.

The domain of off line Arabic handwriting recognition research presents unique technical challenges that has been globally under study the last fifteen years by numerous independent academic institutions, commercial sector and Government agencies, however despite years of fragmented R&D initiatives in this area, to date the available tools do not provide a practical and useful application and solution is still evasive and remains in a laboratory environment. To date, there are no known available OCR that can meet/satisfy the stringent military requirement in this area.

Under this solicitation, we are looking for innovative technology means to develop an Arabic Handwriting OCR (AHOCR)software module that can perform a set functionalities to read cursive Arabic handwriting scripts (from imagery files/scanned documents)where ligatures, vertical or horizontal overlap and style variation pose challenges to the Arabic script recognition system.

PHASE I: Develop a comprehensive set of plans including methodology employed to conduct research and evaluation for developing a fully functioning and matured prototype Optical Character Recognition (OCR) system to accurately read and recognize Arabic handwriting scripts. The plans should include the feasibility study, conceptual design, technical approach, roadmap, and methodology to evaluate and measure performance. Deliveries under Phase I shall be primarily technical studies and reports. Specific functionalities for the design shall include the following capabilities:

a. Correctly read and recognize variations of Ruq'ah script Arabic handwriting scripts with 50% accuracy.

b. Correct for the slant and skewness of handwritten documents.

c. Ability to read 8 ½ by 11 page document containing 250 words in 13 seconds.

d. Ability to compensate and account for letter's height and width disproportionality.

e. Compensate and account for misplaced dots associated with letters i.e. Sheen, Te, Ghaaf, etc.

f. Compensate and account for the horizontal or vertical script overlap.

Prepare and develop a preliminary user's manual.

Assumptions for Phase I:

a. The Arabic handwriting style shall be variations of Ruq'ah script and not Nastaliq, Naskh ,Muhaqeqq, Thuluth, Diwani or Royal Diwani.

b. Handwritten scripts will have a height excursion of 1.35cm +/- 20%.

c. Handwritten scripts can easily be ready by a native Arabic speaking individual with high school education.

d. There are no diacritic in the script.

e. Scripts are legible, however the words may not be distinctly separated.

f. Sample documents may contain Arabic printed text, Latin handwritten scripts, printed text or photos images as well as written Arabic scripts. We are concerned only with the Arabic written script portion of the document.

g- The AHOCR software module shall use imagery documents/files. Such documents are assumed to be clean and free from any contamination and noise that otherwise could affect the accuracy and correct recognition of the Arabic handwriting scripts.

PHASE II: Phase II would be a detailed execution of Phase I plans and design with aims to develop a fully functioning and matured Optical Character Recognition (OCR) prototype system to accurately read and recognize Arabic handwriting scripts. The OCR engine can be rule based/probabilistic or a combination of both. Under this phase, the bidder shall develop and deliver a system to perform functionalities and specified under Phase I, develop test plans and methodology to evaluate the performance of the OCR as well as to demonstrate and validate its full functionalities and capabilities. The prototype should be matured enough to attract commercial venture capital for full product release. Develop and deliver the final user's manual. Phase II assumptions will be the same as Phase I.

PHASE III: Commercialization of a fully automated AHOCR has a large and diversified market applications. Technologies derived from Phase II can be used as a basis to produce tools/products for wide usage in post offices in Arabic speaking countries, law enforcement agencies, academic and educational institutions. In addition, the core technology developed under this effort is applicable and supports developing OCR for other Middle Eastern Languages, (Farsi/Pashto/Urdu) handwritings. Functionalities and capabilities such as word spotting and short test recognition of off-line AHOCR technology can be transitioned to DoD and non DoD intelligence organizations, law enforcement agencies and department of Home Land Security.
From the Government side, the most probable organization that will be interested and be willing to provide additional funds for Phase III are the intelligence community at Ft. Huachuca AZ and potentially sister agencies and law enforcement agencies.

REFERENCES: 1) Arabic Handwriting Recognition by Peter Burrow of School of Informatics University of Edinburgh-

http://www.inf.ed.ac.uk/publications/thesis/online/IM040241.pdf
2) Automatic Recognition Of Handwritten Arabic Characters Using Their Geometrical Features-by Maged Mohamed Mahmoud Fahmy
http://www.ici.ro/ici/revista/sic2001_2/art1.htm
3) An Offline Arabic Handwriting Recognition System by Abjad Hawwaz
http://www.actapress.com/Reference.aspx?paperId=20440
4) Arabic and Chinese Handwriting Recognition to a two-day Summit on Arabic and Chinese Handwriting Recognition (SACH'06) University of Maryland.
http://lamp.cfar.umd.edu/meetings/SACH06/index.htm
5) The International Arab Journal of Information Technology
http://www.iajit.org/ABSTRACTS-1.htm

KEYWORDS: OCR recogniton of Arabic script, Off line cursive handwriting, Word Spotting, Word Recognition, Optical Character Recognition, OCR accuracy, OCR speed,

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A07-096 TITLE: Applied Innovative Nano-Materials Technology for High Energy Rechargeable Batteries, for Soldier Systems for Extended Missions in Combat Environments

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: Advance nano-material technology for high energy, light, rechargeable secondary battery cells in cost-effective, safe configurations for demanding electrical requirements of soldier-portable equipments and vehicular electrical systems over extended mission intervals.

DESCRIPTION: Innovative exploitation, extension and application of emerging research in nano-technology materials to form higher energy density rechargeable electrical battery cells, suitable for assembly to supply electrical energy exhibiting manifest improvement of their electrical charge/energy capacity in terms of ampere-hours/ watt-hours resulting in extended duration of service per charging cycle. These cells should be configurable to deliver electrical power in form, size, weight, fit and function to span a gamut of the electrical requirements of soldier-portable equipments, e.g. BB-2590 batteries, and vehicular electric power systems, e.g. 6TMF storage, lead-calcium flooded-acid and the newer Hawker (Lead-Tin) AGM (Absorbed Glass Mat) batteries, in extended, e.g. 24-72 hrs, and stressful tactical combat mission scenarios.

PHASE I: Develop and demonstrate prototype battery cells from nano materials. The nano material cells developed should manifest perceptibly higher electrical energy storage density and capacity over conventional state of the art battery cell materials. The developmental cells should characteristically augur their feasibility to be prototypical fundamental components in terms of voltage and current, cost, size, weight, safety, and strategic/logistic availability for the formation of rechargeable electrical energy storage systems, i.e. secondary batteries, to furnish electrical energy to equipments and platforms in extended combat environments and missions.

PHASE II: Using results from Phase I construct and demonstrate the operation of prototype nano material battery configurations in common army tactical secondary battery applications.

PHASE III: Transition the prototype designs into viable standardized competitive cost effective secondary battery product for sale in the military or private sector markets. In particular The Phase II demonstrated prototypical nano technological battery designs will be packaged to transition into viable standardized competitive cost effective dual use secondary battery products for sale to both the military and private sector markets. Thusly, the prototypes developed and perfected in Phase II would be readily evolved into a family of marketable secondary rechargeable battery configurations. The models offered will be configured to conform to the commonly specified electrical power source requirements for a gamut of devices and systems with parallel power requirements that are used in both in military equipments and their COTS counterparts ranging from radios, weapon targeting, detection, surveillance and control devices, note book computers, to vehicular platform electrical power sources with appropriate functionality and conformability. They will readily be targeted to a well defined domain of rechargeable battery applications commonly used both in military and consumer electronics and common commercial vehicular battery specifications.

REFERENCES: 1) Synthesis of High Capacity Sn/MOx Nano Composite Anode Materials for Lithium Rechargeable Batteries, T/J Technologies Inc., Ann Arbor, Michigan, http://www.tjtechnologies.com/research/batteries/
2) Building a Better Battery" By John Hockenberry, Wired Magazine, Issue 14.11 - November 2006, http://www.wired.com/wired/archive/14.11/battery.html?pg=3&topic=battery&topic_set=
3) Alcoa AFL Automotive and Altair Nanotechnologies to Jointly Develop High Performance Battery Pack System; Nano-Titanate Battery Has Key Advantages over Conventional Lithium Batteries, BUSINESS WIRE, Sept. 6, 2006 http://www.alcoaclevelandnegotiations.com/global/en/news/news_detail.asp?pageID=20060906005633en&newsYear=2006
4) Nanotubes and antimatter: energy resupply for the future battlefield: in the first of three articles on scientific advances at the atomic, molecular, and photonic levels, the authors discuss the potential for greatly reducing, or even eliminating, the energy supply chain.
From: Army Logistician | Date: July 1, 2005 | Author: Scharett, David E. | More results for: author:[Garrison;Robert;E.]
5) Army Logistician (Designer Materials: Changing the Future of Logistics): what do carbon nanohorns, photonic band gap materials, electroactive polymers, and electrospun second skin have to do with logistics? They very well may provide the Army with lightweight, reliable systems that revolutionize how logisticians support the warfighter.
6) Army Logistician | Date: September 1, 2005 | Author: Garrison, Robert E. | More results for: author:[Garrison;Robert;E.]
7) Biotemplated Multilayer Structure for Nanoscale Energy Storage Units, http://pdf.aiaa.org/preview/CDReadyMIECEC05_1090/PV2005_5582.pdf, 3rd International Energy Conversion Engineering Conference, 15 - 18 August 2005, San Francisco, California, AIAA 2005-5582, American Institute of Aeronautics and Astronautics, S. Chu, National Institute of Aerospace, Hampton, VA; S. Choi, G. King, P. Lillehei, and J. Elliott, NASA Langley Research Center, Hampton, VA; J. Kim and Y. Park, Science and Technology Corporation, Hampton, VA; and G. Watt, Brigham Young University, Provo, UT
8) Patent Title: Method of Producing Barium Titanate (a Method of Processing Ceramic Type Ferroelectric Materials).Patent 2,985,506 Patented May 23, 1961, United States Patent Office 2,985,506, Sam DiVita et al

KEYWORDS: energy technology, batteries, (electrical, electrical energy, manufacturing processes, manufacturing materials, nanotech materials

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A07-097 TITLE: Multi-fuel Burner for Stirling Engine based on Innovative Component Development

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To design and develop an advanced multi-fuel capable burner and electronic controls subsystem for integration onto a Stirling mule (engine / alternator / controls) without sacrificing weight or power density.

DESCRIPTION: There is an urgent need for tactical power sources both for direct power applications and battery charging. These power sources need to be capable of operation on existing military fuels (DF-2 and JP-8) in order to meet logistics requirements. The power sources may also be operated close to the front battle lines, where low acoustic signature is critical. As a result, these power sources must be small, lightweight, energy-dense, and operate with low acoustic signature. In response to this need, the U.S. Army has issued several generic Operational Requirements Documents (ORDs) describing basic requirements for tactical power sources. These ORDs do not require specific power source technologies; however, Stirling technology is one of several technologies that may be suitable for these power needs. A major challenge for the introduction of Stirling based systems within the military is the lack of a JP-8 burner and associated controls. With an answer to this challenge, a power system in the 400 – 750 Watt range with reduced signature that can enable communication and tactical operations center support activities in the forward areas can be realized.

Stirling power systems in the 400-2000 W range have made significant progress over the past few years. One potential advantage of Stirling engine power sources is multi-fuel capability, yet to date no single system has demonstrated the capability to switch between heavy liquid, light liquid and gaseous fuels. This topic shall focus on innovative component development of advanced burner and electronic controls subsystems without sacrifice to power density and size / weight targets. The Burner development shall enable operational and functional compatibility with gaseous fuels, such as propane, light liquids, such as gasoline, and heavy liquids, such as diesel. The controls development shall enable an integrated multi-fuel capable system, including balance of plant. The innovative and unique components will then be integrated back into the current Stirling mule (engine / alternator / controls) demonstrating a clear advantage in system versatility, without sacrifice to weight or power density. The end deliverable would be a multi-fuel capable Stirling engine-driven power system that provides (objectives/thresholds) 700/400 W of electric power, is less than 25/35 kg dry weight, and has a system efficiency of 20/14%. Development efforts shall include burner development, fuel delivery components, and controls development. The design focus shall address a rugged and reliable system.

The following conceptual research, development and demonstration tasks described should be aimed at addressing or contributing to improvements in the areas of reduced fuel consumption and increased system efficiency as expressed in the Tactical Electric Power (TEP) Operational Requirements Document (ORD) for future power systems.

PHASE I: The investigation shall explore burner concepts, designs and materials towards development of a multi-fuel (un-treated heavy fuels, light liquid and gaseous fuels compatible) burner design for a 700 / 400 (objective/threshold) Watt (electrical) free piston Stirling engine. The objective is an overall burner efficiency of 85% / 75%, an operational goal of 3000/1000 hours with reliable fast start, sulfur tolerance. The design shall address and demonstrate operational compatibility with a temperature range of -30C to +55C. The burner is to be designed to minimize weight, with an objective goal of less than 3 kg for the burner assembly. The design shall consider reduction of maintenance, automation of operation, and robustness with regard to operations in battlefield environments. The effort shall look to study designs which increase efficiency of heat recuperation, improve thermal efficiency, minimize soot and coke deposits during full and partial load operation, minimize parasitic losses, and do not require catalytic combustor materials.

The effort shall demonstrate a proof of concept prototype multi-fuel burner to validate the requirements.

PHASE II: Design, develop and demonstrate proof of concept integrated burner system with controls and Balance of Plant (BOP) for validation with a 700 / 400 Watt (electrical) Stirling power system. Effort shall incorporate improvements identified in the Phase I effort to operational and performance limits delineated in the objective above. The proof of concept system must be demonstrated have the ability to switch “on-the-fly” between propane, gasoline, DF-2, and JP-8, through the military environmental conditions described above.

PHASE III: Commercial Migration of Phase II proof of concept design. Finalize development of a scaleable JP-8 Burner subsystem for tactical electric power sources in the 700/400 W range. Identify target markets for the device and an industry partner for production of the device. Develop partnerships with individual companies and Platform PMs (such as PM-FSS) for rapid fielding of results into the FCS by FY12.

The potential for commercialization is considered high. Both the military and the commercial sector will benefit from successful results. The external combustion enables the use of various fuels. The design would require only a burner change thus making the design more attractive to the commercial market for applications in recreational vehicles / cabins and emergency vehicles / rescue stations as a compact source for combined heat and power output. For the military, the projected design will ensure smaller, lighter systems that take up less room on a given platform. Lightweight systems will ensure greater ease of installation and enhanced mobility for the tactical forces.

REFERENCES: 1) 42nd Power Sources Conference in Philadelphia, PA; 15 June 2006 : 250-300 Watt Silent Clean Power with Free Piston Stirling Engine Micropower Platform by Jason Targoff, Phillip Carbone, Allan Chertok, Paul McTaggart (TIAX LLC).
2) 42nd Power Sources Conference in Philadelphia, PA; 15 June 2006 : JP-8 Combuster for a 35-W Stirling Engine by Subir Roychoudhury (Precision Combustion Inc).
3) 42nd Power Sources Conference in Philadelphia, PA; 15 June 2006 : Free-Piston Stirling Application for Small Tactical Electric Power Sources by Matthew Makowsky (US Army CERDEC.

KEYWORDS: Stirling Power System; JP-8 Burner and controls, battery recharge, Silent Watch, and tactical shelters

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A07-098 TITLE: High Performance Uncooled Focal Plane Arrays

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: To develop and demonstrate innovative low-cost, low power, high performance uncooled infrared focal plane arrays (FPA).

DESCRIPTION: To develop and demonstrate innovative low-cost, high performance uncooled infrared focal plane arrays (FPA). The goal is to develop a low cost, small size, low weight, low power, FPA with NEDT of 20 mK, pixel pitch of 17 micrometers, time constant of 5 milliseconds, at F-number of F/1, illuminated at room temperature (300 K) over the spectral bandwidth between 8 um and 12 um, capable of either 30 or 60 Hertz frame rate with a format of 1280x960. The imager is to operate with no or minimal cooling. The Government is interested in two separate lines of development: (1) Replacement of the traditional electronic readout to eliminate noise contributions traditionally arising from electrically biased detectors relating to Johnson noise, 1/f and from Readout sources, (2) to develop and demonstrate detector technology with adjustable time constant and or reset capabilities. With respect to #2, the current technology is limited in conversion sensitivity by the temperature coefficient of resistance (TCR) of about 2.5% and by a combination of noise sources, and traditional designs lead to a bridge leg combination acting as a simple first order thermal filter. The government is looking for technologies that will provide sensitivity improvements and faster response times resulting from combinations of large improvements in conversion sensitivity, reductions in noise, adjustable control by electrical or mechanical means of the time constant and responsivity, reset to preset initial conditions and potential protection against excessively hot sources. Any proposal shall address either development option 1 or development option 2.

Development option 1: Current uncooled IR technology is about NEDT of 35 mK, pixel pitch of 17 to 25 micrometers, time constant 10 milliseconds, F-number of F/1, illuminated at 300 K over the spectral bandwidth between 8 um and 12 um. The current technology is limited in conversion sensitivity by the temperature coefficient of resistance (TCR) of about 2.5% and a combination of noise sources arising from the use of bolometer detectors that are sampled or biased with an electric current. The government is looking for technologies that will provide large improvements in conversion sensitivity and noise that will lead to the desired goal including the elimination of electrically biased and sampled bolometer readout combination. Encouraged is optically read/sampled detectors that address minimizing Shot noise or other noise inherent in the optical probe beam to make direct viewing or collection with a CCD array without large well capacities feasible. Development option 2: Current uncooled IR technology provides an NEDT of 35mK, pixel pitch of 17 to 25 micrometers, time constant of 10 milliseconds, F-number of F/1, illuminated at 300K over a spectral bandwidth of 8 to 12 micrometers. The goal of this program is to develop a detector technology for use in a 1280x960 FPA operating at room temperature (300K), capable of either 30 or 60 Hertz frame rate that is low cost, low weight, and low power where the Detectors shall meet or exceed the following: NEDT of 20mK or less, pixel pitch of 17 micrometers, system time constant of less than equal to 5 milliseconds, F-number of F/1.4, illuminated and operating at room temperature (300K) over the spectral bandwidth of 8 to 12 micrometers. Noise Equivalent Differential Temperature (NEDT) is noise divided by Responsivity. A limiting component of Responsivity is the conversion sensitivity (a) which may be defined as (1/x)(dx/dT). In the case of a resistor, “x” is the resistance of the detector. For vanadium oxide, a has been reported as about 2.5%. The government is looking for technologies that can provide improved performance resulting from better conversion sensitivity, adjustable time constant and responsivity by electrical or mechanical means, reset ability to limit memory or any combinations thereof and allows for trading sensitivity for response speed under control of the user.

PHASE I: Develomental option 1: Demonstrate the technical feasibility of the proposed approaches through design and analysis. The feasibility study must include analysis of noise contributions from the proposed readout method or method of interrogating or measuring the detector’s response. Additionally, analysis projecting nonuniformity and nonuniformity corrections sufficient to enable full use of the 20 mK NeTD shall be provided. Test strucures or small format arrays to demonstrate the design concepts are highly desirable in the phase I effort.

Development option 2: Demonstrate the technical feasibility of the proposed approaches through design and analysis that meets or exceeds the stated goal in the above description. The feasibility study must include analysis of noise contributions from any Readout Integrate Circuit or any other proposed readout method or method of interrogating or measuring the detector’s response. Additionally, analysis projecting nonuniformity and nonuniformity corrections sufficient to enable full use of the 20 mK NeTD shall be provided. Detectors in Test structures to demonstrate the design concepts are highly desirable in the phase I effort.

PHASE II: Development Option1: Using the results of the phase I effort, build, demonstrate and deliver a focal plane array with support electronics so as to make an imaging camera. Demonstrate a clear path to low cost production.

Development option 2: Using the results of phase I effort, build, deliver and demonstrate detectors in a focal plane array format of not less than 16x16 that meets or exceeds the goals specified in the above description, with test electronics, that achieve high conversion sensitivity with low noise. It is highly desirable that these arrays be imaging arrays. Demonstrate a clear path to low cost production.

PHASE III: The commercialization of this technology is expected to provide low cost, high performance imagers for potential uses in a variety of commercial applications including transportation, security/law enforcement, medical imaging, border patrol, and homeland security as well as military applications such as night vision devices. Success of this SBIR will have direct impact on such programs as Thermal Weapons Sight bridge program and TWS III (TWS is managed by PEO Soldier, TWS II is a $500M procurement of 640x480 25 um uncooled sights) by reducing the cost, size, weight, and power of such manportable imagers because much more senstive and smaller detectors allow extending performance and range with larger array formats and or smaller optics and smaller batteries.

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KEYWORDS: infrared, camera, uncooled, Focal Plane array, optical read, microbolometer, cantilever

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A07-099 TITLE: Commercial Wireless Denial of Service (DoS) Mitigation Techniques

TECHNOLOGY AREAS: Electronics

OBJECTIVE: To develop and demonstrate denial of service (DoS) mitigation techniques for commercial wireless technologies, specifically 802.11g and 802.15.4.

DESCRIPTION: Accurate, secure, and reliable communication transmissions are necessary for the Advanced Network Centric Warfare (NCW) systems. These systems are critical to the successful implementation of the Army’s future force. Two specific communications standards that are of strong interest are the 802.11g and 802.15.4 IEEE standards. However, for the multitude of Army devices that could benefit from these standards, there exists a need to better guarantee and protect the information flow between any two devices. Specifically, the need for better protection against exploitable denial of service attacks is at the heart of the issue.

The implementation of the IEEE 802.15.4 standard introduces some serious denial of service opportunities. Although the IEEE specification calls for vast security considerations, there is no mention of DoS attacks and possible counter-measures to a malicious intruder. For example, the 802.15.4 specification does not consider security features on an acknowledgment packet. In principle, if a sender is waiting for an ACK from the intended recipient, an intruder could jam the ACK transmission and the sender’s message would go unacknowledged for the duration of this DoS attack. Alternately, an intruder could selectively jam a signal, and then forge an ACK back to the original sender of the message. The sender will process this ACK as an authentic acknowledgment and the original message will not be received. It has also been demonstrated that an attacker could disrupt the MAC layer replay protection mechanism by injecting a well crafted packet into the transmission [3].

Operating in the same ISM frequency band is the 802.11g standard. Although not as susceptible to the easily exploitable 802.11b standard, 802.11g is still open to certain types of DoS attacks. For example, there has been research looking into interference from nearby Bluetooth operating devices [4].

The developed work will be particularly useful in support of PM RUS (Robotic Unattended Sensors) and PM WIN-T (Warfighter Information Network – Tactical) in regards to implementing the 802.15.4 or 802.11g standards into future systems.

PHASE I: Develop new mitigation concepts and quantitative assessment techniques for DoS issues in these commercial technologies. Specifically identify the DoS opportunities and highlight the advantages of the new concepts over the existing communications standards. Present applicability of approach to sensor networks. A detailed report is expected at the conclusion of the Phase I effort fleshing out the work and concepts developed after six months. Emphasize innovative approaches that enhance the mitigation of denial of service attacks. Establish performance goals and capabilities. Additionally, it would be helpful to present a proof of concept software demonstration if time and resources allow. If the Phase I bridge option is exercised, some proof of concept demonstration is a requirement.

PHASE II: Based on the Phase I effort, the contractor shall further develop and incorporate the developed concepts and techniques into prototypes. Demonstrate and asses the prototype in terms of meeting the performance goals and capabilities established during Phase I. A required Phase II deliverable shall be the mitigation techniques implemented in software.

PHASE III: Utilizing the concepts and prototypes developed during Phase I and Phase II, develop a working set of commercially deployable devices for use by DoD and commercial customers. Transfer results into commercially viable products.

The developed technology would be beneficial to any organization that utilizes 802.15.4 or 802.11g devices for communications. For example, banks and utility companies that may use wireless technologies and depend upon reliable transmissions would show great interest in this technology. There exists a significant gap in technology whenever the information exchange between devices can be compromised by a denial of service attack.

The developed technology would prove quite beneficial to the future warfighter. Network-Centric warfare (NCW) is quickly becoming the focus of the DoD. In this realm, it is absolutely critical to identify and prevent any activities that would compromise the security and integrity of our systems. PM RUS and PM WIN-T have both expressed initial interest in the pursuit of this topic area.

REFERENCES: 1) IEEE Standard 802.15.4-2006: IEEE Standard for Information technology- Telecommunications and information exchange between systems- Local and metropolitan area networks- Specific requirements Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs)
2) IEEE Standard 802.11g-2003: IEEE standard for information technology- telecommunications and information exchange between systems- local and metropolitan area networks- specific requirements Part II: wireless LAN medium access control (MAC) and physical layer (PHY) specifications
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KEYWORDS: Denial of Service, DoS, Zigbee, 802.11, 802.15.4, interference

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A07-100 TITLE: Mobility to 802.16j - Mobile Multi-hop Relay Base Stations

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: Architect, design and develop adaptations for 802.16j (Mobile Multi-Hop Relay) base stations for on-the-move applications

DESCRIPTION: The IEEE 802.16-2004 standard is defined to have both ends of the link (transmitter and the receiver) stationary. The recent emergence of the IEEE 802.16j standard is similar to traditional cellular systems by adding “mobility” with handovers of Subscriber Stations (SS’s) to occur between fixed base stations (BS) locations. Currently the 802.16j specification is being developed with the addition of mobile, nomadic, and fixed relay stations however BS’s are still to be preplanned and fixed. The added dimension of mobile base stations further complicates the problem by adding issues such Radio Frequency (RF) confliction, often unreliable backbone for coordination, and addressing schemes. Due to the nature of the tactical military, preplanned base stations locations with tall towers and directionally optimized antennas is highly unlikely. Therefore in order for the tactical military to leverage commercial wireless technologies, these technologies must be adapted for a tactical environment. However, for the military to take full advantage of the cost savings and the mass productions associated with using commercial wireless technologies, these adaptations must be made at a minimum or added such that they are above the mass produced chipsets.

PHASE I: Define a design, methodology and algorithm set that will allow for mobile users and mobile base stations with transparent user handoffs between mobile base stations. The result of Phase I must be a high level system design showing the proposed approach. The design should incorporate mobility management Issues such as frequency deconfliction, required backhaul performance, node addressing methodology, the amount of coordination required between base stations to support handovers, and a list of 802.16j modifications/enhancements required for implementation.

PHASE II: Complete the design, development, and demonstration base station on-the-move capability.

PHASE III: Commercial Applications – Mobile Wireless Communications networks, Public Safety, disaster relief and public safety markets. Military Applications –WIN-T LAW.

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1) “IEEE 802 Tutorial: 802.16 Mobile Multihop Relay,” IEEE 802.16 contribution 802.16mmr-06/006, Denver CO, March, 2006
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4) S. Spoenlein, “Military Usage of 802.xx: Potential Applications”, 2006 Armed Forces Communications and Electronics Association Conference”, September 2006, Atlantic City NJ

KEYWORDS: WiMAX, 802.16, 802.16j, Mobile Multi-hop Relay, Wireless Communications, On-the-Move communications, Commercial Wireless

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A07-101 TITLE: Low Profile Smart Multiple Beam Forming Antenna for KU-Band

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop an affordable, airworthy, low profile, high performance, smart multiple beam forming antenna covering the KU-band, which will advance the state-of-the-art in low profile antenna technology.

DESCRIPTION: A directional beam forming antenna can provide increased gain, frequency re-use, noise/interference mitigation, and other beneficial capabilities, making it a good candidate solution for fulfilling the demanding needs of high data-rate/bandwidth communication on the battlefield. The antenna developed under this SBIR shall provide two simultaneous beams in the KU-band, which can facilitate communication between to two independently moving nodes. The system must be easily adaptable and/or reconfigurable to function with a variety of beam forming and/or tracking methodologies and/or protocols, currently in development in both the military and commercial realms.. The system must be airworthy, conforming to all applicable military standards for installation on an Unmanned Aerial Vehicle (UAV), rotary, or fixed-winged military aircraft. Size, weight, power consumption (SWAP), and aerodynamic drag coefficient must be as small as possible. Equal in importance to the designed antenna’s technical features and performance, shall be its ease of manufacture and affordable overall cost. The means by which each of these requirements are planned to be achieved must be articulated. Either the presentation of a singular antenna concept with justification for its selection, or multiple possible concepts with the tradeoffs of each explained, may be presented in the Phase I SBIR proposal. If multiple concepts are to be considered, the best approach must be arrived at, justified, and characterized by the end of Phase I.

PHASE I: Feasibility analysis and proof of concept. Study and development of proposed solution Modeling and Simulation (M&S) based methods. Laboratory and/or breadboard development and demonstration of initial concepts, or particular portions thereof, would be encouraged if feasible.

PHASE II: Development and delivery of an airworthy prototype, suitable for installation and test on a UAV or sub-sonic aircraft. Prototype completed in a substantial fashion, satisfying all general and military standards for obtaining an Air Worthiness Release (AWR), and Technology Readiness Level (TRL) 6. Identify suitable paths toward commercialization.

PHASE III: A multiple beam forming antenna in the KU band has many potential applications, both in the military and commercial realms. Military applications could include the Warfighter Information Network - Tactical (WIN-T) program, or any system requiring high data rate communications in the antenna's band of operation. Satellite communications and television broadcasting industries in the private sector may also benefit from the technology, as well as any entity (automotive, aviation, etc.) desiring "on-the-move" KU-band connectivity. Phase III entails full scale commercialization of the system, with final refinement of the airworthy prototype system developed in Phase II, and preparation for bringing it to market in a substantial fashion. Prospective avenues for commercialization previously identified in Phase II will be fully pursued, with government topic sponsors continuing efforts to identify viable programs of record to utilize the technology. The small business shall also pursue its own commercialization and investment options/sources outside of government. Success of Phase III shall be indicated by a state of the art, highly practical, and widely sought after product, which is readily accessible in all possible markets.

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KEYWORDS: Antenna, KU-Band, Multiple Beam, Beam Forming, Smart, WIN-T, Airborne

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A07-102 TITLE: Cross-Layer Architectures, Semantics and Strategies (CLASS)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

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

OBJECTIVE: Define, design and develop cross layer design architectures and strategies for wireless mobile ad-hoc networks that provide highly optimized network performance as perceived by the end user.

DESCRIPTION: A systematic study of cross-layer design problems, combined with the fundamentally different communication paradigms presented by wireless networks, is necessary to understand what areas of performance improvements are possible, the level of performance improvements gained through cross-layer design, and help define the communication architectures of the future. In addition, since security architectures may dictate the level of cross layer interactions that can take place, an analysis of ways to work with various security architectures for full cross layer design is necessary. There are multiple architecture and implementation concepts in literature for cross-layer design. Example cross layer architecture concepts include but are not limited to the following: upward information flow, downward information flow, back and forth information flow, merging of adjacent layers, design coupling, and vertical calibration. Some example implementation choices include direct interfaces, use of a shared database, or moving completely away from the stack concept and going to a more abstract heap model. The amount of cross-layer information that can impact network performance also needs to be understood further. Several studies have shown that a level of cross layer interaction, for example joint MAC/Routing design, can offer as much as a 7x improvement in channel capacity, but an analysis of application through physical layer cross layer design has not been thoroughly conducted, to include and understanding of potential conflicting optimizations amongst different protocol layers or modules. Since the type and amount of cross layer information impacting performance could be protocol, environment and system dependent, the development of a design tool is necessary that can assess which architecture, implementation methods, level and type of cross-layer information are most adequate or able to provide greater performance improvements to wireless networks. The design tool should accept information to include but not limited to the following: network performance goals and constraints, system parameters, system architecture and protocols, numbers of nodes, locations of nodes, and RF environment and transmission parameters. The resulting output should provide an optimal cross-layer architecture and relevant cross layer information necessary to vastly improve system performance to meet desired performance goals within defined constraints.

PHASE I: Define cross layer design architectures and strategies for wireless mobile ad-hoc networks that provide highly optimized network performance as perceived by the end user. The Phase I effort shall include an analysis of alternative cross layer design architectures and implementations and determine what parameters that can be shared have the largest impact in improving performance.

The result of Phase I must include a high level system design and analysis of alternative cross layer architectures and implementation strategies and a thorough understanding of the level of information that can and should be shared in cross layer designs that offer the greatest performance improvements over conventional network protocol stacks. Development and delivery of models and simulations or other methods to analyze the performance is encouraged.

PHASE II: Design, develop and demonstrate a design tool that can assess which architecture, implementation method, level and type of cross-layer information capable of providing greater performance improvements to wireless networks that can be integrated into a larger ad-hoc network design software suite shall be conducted.

PHASE III DUAL USE COMMERCIALIZATION: Commercial Applications – Mobile Wireless Communications networks, Wireless Sensor Networks. Military Applications – Mobile Ad-Hoc Network Design tools, Future Communications architectures for Tactical Networks.

REFERENCES: 1) "Cross-Layer Design: A Survey and the Road Ahead", IEEE Communications Magazine, December 2005, Vol. 43, No. 12

2) Cross-Layer Protocol Engineering for Wireless Mobile Networks: Part 2, IEEE Communications Magazine, January 2006, Vol. 44, No. 1

3) Proceedings from NATO IST RTG-12 WORKSHOP Cross-Layer Issues in the Design of Tactical Mobile Ad Hoc Wireless Networks: Integration of Communication and Networking Functions to Support Optimal Information Management, June 2-3, 2004 Naval Research Laboratory Washington, DC.

KEYWORDS: Cross-Layer Architecture and Design, Mobile Ad-Hoc Networking, Network Design, Network Science

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A07-103 TITLE: Intelligent Software Agents for Autonomous Intelligence, Surveillance, and Reconnaissance (ISR) Analysis

TECHNOLOGY AREAS: Electronics

OBJECTIVE: To develop tools and techniques which analyze information in an efficient and autonomous manner to produce actionable intelligence for the Warfighter within tactically useful timelines.

DESCRIPTION: This topic addresses the challenges associated with processing overwhelming amounts of intelligence data produced in modern net-centric operations. Specifically, this topic addresses operator efficiency by informing the tactical Warfighter of relevant changes to the battle space without overwhelming the available data bandwidth or adding to existing analyst workloads.

With an ever growing number of real-time tactical sensors, finding information relevant to a current mission objectives and context is becoming more difficult and time consuming. The challenge is to provide today's Warfighter with the prioritized and filtered information required to prosecute time critical targets. Intelligence gathering operations are characterized by systems and processes executing Tasking, Processing, Exploitation and Dissemination (TPED) and Task, Post, Process and Use (TPPU). TPED and TPPU operations are complex within a given sensor system and this complexity is magnified many times in net-centric environments such as Distributed Common Ground System - Army (DCGS-A) and Future Combat System (FCS). Disparate sensors producing heterogeneous information can easily overwhelm and confuse an intelligence analyst. Intelligence information reporting today is often characterized by conflicting, unfiltered and overwhelming amounts of data.

The focus of this research is on innovative agent-based semantic reasoning which provides tactically relevant ISR information based on current mission objectives and context. Automated information filtering should be performed based on specific tactical objectives, mission timing and area of interest. In addition filtering complex data sets, the amount of detail provided and method of representation should also be determined so the Warfighter is informed without being overwhelmed. For example, an agent within DCGS-A could be notified of a mission plan and objectives along with geo-spatial and temporal information. The agent would continually monitor Warfighter location, status and sensor data, to determine the type and priority of data needed to counter potentially lethal situations.

Projects such as the Cognitive Agent Architecture (Cougaar) show promise in the deployment of large scale agent-based systems but specific research is needed to handle the enormous volume of data in tactical situations. Technology of interest to this research may include the application of Bayesian filters, neural networks or information ontologies in agents operating within a framework such as Cougaar. This research should be guided by the ability to provide the Army Warfighter with the right information at the right level of detail so that situational understanding is enhanced without being inundated with data.

PHASE I: Develop the requirements, general usage scenarios and candidate architecture for an autonomous multi-intelligence analysis capability. Evaluate the feasibility of the innovation and approach for a selected legacy system, such as DCGS-A or FCS.

PHASE II: Capture specific operational scenarios within the intelligence domain. Develop a prototype implementation of the system for use on a selected system, such as DCGS-A or FCS.

PHASE III: The amount of electronic information being produced today is outpacing our ability to intelligently analyze it. The objective of this research is to significantly reduce military intelligence analyst overloading and increase the speed of information filtering and prioritization which has resulted/will result from the overwhelming amount of data being produced by current and future net-centric environments. Systems such as Guardrail Common Sensor, Airborne Reconnaissance Low, DCGS-A, and FCS will benefit from automated tools and processes that reduce the analyst workload and increase comprehension of large complex data sets. Likewise, any commercial organization with large, complex or dynamic data stores would benefit from the use of autonomous intelligence analysis tools to identify new market trends and increase the speed at which products are brought to the market.

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2. Future Combat Systems; http://www.army.mil/fcs/
3. Distributed Common Ground System – Army; http://www.monmouth.army.mil/peoiew/dcgsa/
4. Agent-Based Engineering, the Web, and Intelligence; http://www-cdr.stanford.edu/NextLink/Expert.html

KEYWORDS: Information Dissemination, Prioritization, Filtering, Abstraction; Intelligent Autonomous Software

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A07-104 TITLE: Low-Cost Tactical/Logistic Vehicle Real-Time Route Planning

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Development of an affordable map display and navigation utility for tactical and logistic vehicles that has real-time routing capability which is based on access to available threat/hazard information to support routine mission and emergency situations.

DESCRIPTION: The map display system featuring a fully functional real-time route planning capability for tactical and logistic vehicles in urban and suburban terrain. It shall be capable of generating multiple safe routes in real-time serving to support both routine and emergency situations ("Get Out of Dodge"). Hot buttons will enable the system to compute safe routes back to the base, supporting ongoing missions or rescue operations. This concept shall leverage existing route planning capabilities found in commercial automobile navigation systems, but, will be enhanced to provide multiple routes, accessing real-time threat reports to plan around known hazards, and also accept user input to support in the re-planning of a route. To avoid locals from being familiar with commonly planned routes the system will advise the users to use different safe routes selected randomly.

Availability of this capability to as many tactical and logistic vehicles as possible, is a key issue. To accomplish this, the designed system will use available off the shelf componentry including GPS receiver, datalink, map databases, displays, input device, and a computer processor.

The capability will be designed for compatibility with most GPS receivers that are utilized in Army vehicles today. The primary GPS receiver for application within vehicles is currently the PM GPS product Ground Based GPS Receiver Application Module (GB-GRAM) and will be used for this application. However, other receivers will be considered for compatibility, to include interoperability with either ICD-GPS-153 or NMEA capabile GPS receivers.

Interfacing to a datalink within the vehicle will enable access to a database at the Tactical Operations Center, providing threat and other hazard information used to support real-time route planning. The datalink will also serve to support situation awareness to the user, depicting operating friendlies. During Phase I, surveys to understand available datalinks from the platforms to the TOC will be identified.

Human/Processor interaction technology will be developed to support this capability. Symbologies for depicting the situation and routing will be developed. Different display and input devices will be evaluated/demonstrated to determine optimal configurations for tactical and logistic platforms. A fold-down display is envisioned to be mounted on the passenger_s side or center console area of a tactical vehicle, and shall provide the capability to also display situational awareness information and the common operational picture overlaid on a variety of mapping products.

This capability is described in the following TRADOC Force Operating Capabilities and Force Capability Gaps:

Force Operating Capabilities (FOCs)

The following TRADOC Force Operating Capabilities address the need for Higher levels of Battlefield Visualization, Route Planning, Hazard Avoidance, Obstacle Crossing, and Real-time Dissemination of Reported Obstacles; FOC-01-01: Command and Control, FOC-01-04: Decision and Planning Support, FOC-03-01: Mobility, FOC-03-02: Operations in Urban and Complex Terrain, FOC-06-01: Provide Assured Mobility, FOC-06-06: Understand the Battlespace Environment, and FOC-07-01: Protect Personel

Future Force Capability Gaps

The TRADOC Future Force Capability Gaps (3) Enhanced Platform / Group Protection and (6) Ability to Detect and IdentifyFull Range of Obstacles require the ability to mitigate hostile actions and ability to report and disseminate information about obstacle ballistic effects.

Current Force Capability Gap

The TRADOC Current Force Capability Gap (5) Ability to Conduct Joint Urban Operations requires an ability to traverse complex urban topology.

PHASE I: The primary goal of Phase I will be to research and design a demonstration system, system architecture configuration designs for the tactical and logistic platforms, determination of the use of datalinks and the TOC databases, and selection of route planning algorithms that will support real-time routing. Tradeoffs will be analyzed via modeling and simulation.

PHASE II: Develop and demonstrate a prototype system in an urban/suburban environment under realistic conditions using simulated threats and hazards. Exit criteria will be that the system provide the user with valid multiple safe routes for both routine operation and in emergency situations.

PHASE III: This system will be applied to a broad range of military tactical and logistic vehicles, where this function will support routine mission operations, emergency routing, and rescue and evacuation. Well planned routing for vehicles in routine operations will result in efficiencies that result in resource, personnel utilization and fuel savings. Safe routing taking consideration of known threats will reduce overall casualties to roadside insurrections and an increase in morale.
Likely funding sources for maturing the military application include PM Navigation, PM GPS, and PM Joint Light Tactical Vehicle. Installations could be accomplished by tactical and logistic vehicle developers, or in a kit installed by units themselves. Additionally, there are several homeland defense applications that require vehicle route planning in urban/suburban terrain. Such applications extend from emergency relief vehicles supporting large disasters and on to public law enforcement and medical transport vehicles for both routine and emergency operation. Use of this capability in the evacuation of mass trauma casualties by providing realtime routing to a large number of different hospitals would greatly reduce transportation time and thereby improve overall survival rates.

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KEYWORDS: GPS, position, navigation, route planning, tactical vehicle, situational awareness

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A07-105 TITLE: Connectivity, Continuity, and Data Initialization for BC Services

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: This topic will address the operational problem of net-centric data initialization and flow of information essential to maintain Battle Command (BC) Continuity of Operations (COOPS). This effort will invoke Task-Organization (TO) aware intelligent agents to search and discover BC services needed by the user and his decision support environment and to establish and maintain connectivity and continuity for collaboration and interoperability at a desired quality of service (QoS).

DESCRIPTION: A holistic approach is needed to enable dynamic connectivity and continuity of operations for BC Services to include policy-based proactive Data Initialization and Flow Orchestration required for establishing applications and services states-of-readiness (SoRs) using protocols above the Network layer. This includes support for end-to-end data transport and exchange mechanisms, session continuity and associated enterprise and domain policies, presentation context mediation and ultimately persistent awareness and understanding of the BC system state of readiness. An advanced initialization process will need to be able to invoke Missions and Tasks and Task-Organization (TO) aware intelligent agents to search and discover BC services needed by the user and his/her decision support environment and to establish and maintain connectivity and continuity of Quality of Service (QoS).

Automated proactive initialization of operational, system and technical data is a key to rapid deployment and employment of forces in highly fluid situations at all spectra of conflicts. An innovative solution is sought to provide near-term and long term improvements to the initialization process. Currently, initialization is a highly manual process both in creating the data sets as well as in distributing the required data sets to the appropriate target node to be federated. A comprehensive System-of-System (SoS) approach is needed to develop an initialization concept and strategy. Enabling mechanisms and a viable suite of technologies are required to minimize the downtime of a SoS federate as well as to accelerate and attain a high level of operational readiness. Initialization is a multi-phase process that at a high level may be decomposed into two phases: Connectivity and Federation. Connectivity includes the attainment of end-to-end transport-readiness above and beyond the network level of readiness with a known QoS. This effort should assume the tactical on-the-move (OTM) environment and the availability of ad-hoc self-organizing, self-healing networking capabilities to achieve network-readiness but not necessarily applications/presentation/session and transport-readiness. The initialization process of the network to include, link and physical levels of readiness is essential for the overall initialization of the Connectivity Phase. The resulting network-readiness status should be defined but will be assumed to be "a given" to the higher level initialization processes which belong to the Federation Phase. This effort should therefore focus on the transport, session, presentation and application services and mechanisms in operational and or training environments.

PHASE I: Based upon the proposed approach, the concept for data initialization will be investigated fleshed, refined and coordinated to support a representative Army tactical environment consistent with the evolving Battle Command migration plan. A reference architecture 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 initialization 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 initialization 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 be subjected to initialization. Initialization should be supported by a mixed initiative of users and tools with flexibility to utilize available initialization or other relevant databases and scenario data.

PHASE III: As a phase III effort, the initialization approach, algorithms and technologies will be componentized and productized to support 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 addition, Phase III effort will be productized to enhance Army testbeds and exercises and training Programs such as Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR)On-the-Move (OTM) Testbed (Fort Dix, NJ), Battle Command Training Program (Fort Leavenworth, KS) and Central Technical Support Facility (CTSF)(Fort Hood, TX)

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KEYWORDS: Initialization, Connectivity, Federation, Agents, Services, Frameworks, Scenario Generator

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A07-106 TITLE: Optimized Fusion Techniques for Signals Intelligence Collection Management

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a Signals Intelligence (SIGINT) unique solution of collection management and fusion of signals intelligence data as a ‘front end’ to the Distributed Common Ground Station-Army (DCGS-A) software package.

DESCRIPTION: While many fusion algorithms exist for manipulation and collection management of most types of data collected from sensors on the battlefield, little work has been done to date to find the optimized approach to application of fusion principals to the area of SIGINT collection management. SIGINT presents a unique problem in that the very ‘fusing’ of data creates a ‘loss’ of information fidelity that is required to perform the analyst’s mission. Therefore an optimized solution and fusion algorithm approach is required that minimizes data presented to the user and analyst as much as possible yet retains the needed specific characteristics essential to signals identification and direction finding and geo-locations. This center-point of fusion (optimization) will be defined and a fusion algorithm supporting collection management will be developed, tested and delivered to the government. The SIGINT environment requires also being able to manipulate the collected sensor data in such a way that it can be presented at different levels of classification, depending on the user profile and need. Therefore, any fusion algorithm must be able to, as a minimum, sort basic sensor data into 3-levels of security data bases and displays.

Finally this collection management and fusion tool must allow the information to ‘flow’ into the DCGS-A system, and essentially serves as a ‘smart’ filter of data into the DCGS-A architecture, data base, and graphical user interface (GUI) for all SIGINT information.

The approach will be to find the optimum methodology for fusing collected data and displaying it to the users of the data. This includes finding the right level of retention of significant data aspects that can still support the Analyst user without losing the degree of fidelity required to do Specific Emitter Identification (SEI) and other analyst functions.

The technology approaches may include fusion tool analysis and assessment, future fusion gaps and proposed approaches to meeting those gaps. Analysis will include verifiable and quantifiable parameters such as throughput, processing capability and sampling rates, timeliness of data, accuracy and probability of accuracy of data, density of information, etc.

PHASE I: Proposed optimum approach for fusion. Outline an architectural approach for the fusion tools incorporation. Parameters that will measure the successfulness of fusion techniques and tools will be established. Tools to measure fusion methodology ‘goodness’ for the purpose of the SIGINT fusion problem set will be identified.

PHASE II: Implementation and demonstration of the fusion optimization applied to signals intelligent problems. Utilizing the architectural design parameters from Phase I, the final design of the fusion optimization tools will be completed.

PHASE III: Interface of these tools to the DCGS-A as a front end ‘smart’ filter for SIGINT data. Private sector applications include the commercial communications and cellular marketplace. This provides a vital enabling technology for the entire SIGINT community both commercial sector and in the operational field area. As collection of commercial signal information has improved the data required to be processed and understood has increased ten-fold. The criticality of being able to manipulate the data is such as way as to present it in an understandable and manageable way has become evident to all SIGINT users. The transition path of this technology is as stated above and also includes NSA fielded systems, commercial information and industrial voice communicated data. Systems such as TURBULENCE, DCGS-A, PROPHET and TROJAN SPIRIT will directly have insertion paths for this vital technology.

REFERENCES: 1) Laskey B. Kathryn, Wright J. Edward, “Credibility Models for Multi-Source Fusion”, George Mason University, Technical Papers, May 2006
2) LT COL Murphy F. Edward, et al, “Information Operations: Wisdom Warfare for 2025”, Air Force 2025 Symposium, April 1996

KEYWORDS: Signals Intelligence, fusion, multi-level security, smart filter, optimization.

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A07-107 TITLE: Non Cooperative Combat Identification

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics, Weapons

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

OBJECTIVE: Develop and evaluate an innovative noncooperative combat identification system that will reduce fratricide, increase situational awareness and enhance combat effectiveness. This system shall be able to identify foes and neutrals, as well as friendlies.

DESCRIPTION: The contractor shall develop an innovative concept for a non cooperative Combat Identification (ID) system. Joint, Allied and Coalition forces require a combat identification system that will identify foes, as well as friendlies and neutrals. Current Combat ID systems in development require cooperation on the part of the targeted platform. The friendly platform is required to have a device to respond to the interrogating platform in order to be identified. Platforms without a responding device will be identified as unknown. Several cooperative Target ID systems are under investigation or development by the U.S. and their allies.

Various non cooperative techniques could be used to identify friends, foes and neutrals. Many techniques have been tried over the years. In the early nineties, several Non Cooperative Target Recognition (NCTR) techniques were investigated, such as acoustics, Infrared, Radio Frequency and RADAR. Bold Quest, an extension of the Coalition Combat ID Advanced Concepts Technology Demonstration, will occur in late FY 07. The objective of Bold Quest is to assess the military utility of the designated non-cooperative target identification (NCTI) technologies for coalition operations, with the focus on the air to ground mission area.

This topic will focus on the ground to ground target identification mission area. This topic could be expanded to include the ground to air or air to ground mission areas in Phase III, if feasible. The working range of the non cooperative ID system shall be one and a half times the maximum range of the weapon system being interrogated. The system must be small and not weigh more than 15 pounds.

PHASE I: The contractor shall explore different non cooperative techniques that could be used to identify friends, foes and neutrals. The contractor shall perform a feasibility analysis of the design and demonstrate its veracity 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 a prototype.

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 of Non-Cooperative Combat Identification system would be all Future Combat System ground vehicles and all Legacy Ground Platforms. If Phase II is successful, the technology would be developed further and tested by the CERDEC I2WD Directorate. If successful, it would then tranfer to PM Target Identification & Meteorological Systems and PM Future Combat Systems.

REFERENCES:

Mickey McCarter, Identification Friend or Foe, Operations Technology Online, Volume 2 Issue 6, September 13, 2004

LTC Casey Brian and Marie La Touche, "Nine nations kickoff coalition exercise in England", Army Public Affairs, September 2005

"Coalition Combat ID", Global Security.org, November 2005

Jeffrey P. Bialos and Stuart l. Loehl, “The NATO Response Force, Facilitation Coalition Warfare through Technology Transfer and Information Sharing”, September 2005, www.ndu.edu/ctnsp/Def_Tech/DTP%2018%20NATO%20Response%20Force.pdf

“The Sensing Process”, www.au.af.mil/au/awc/awcgate/vistas/sench2.pdf

“Report of the Defense Science Board Task Force on Integrated Fire Support in the Battlespace”, October 2004, www.acq.osd.mil/dsb/reports/2004-10-Integrated_Fire_Support.pdf

“Report of the Defense Science Board Task Force on Combat Identification”, May 1996, www.acq.osd.mil/dsb/reports/combatidentification.pdf

KEYWORDS: fratricide, combat identification, noncooperative, Non Cooperative Target Recognition (NCTR), Non Cooperative Target Identification (NCTI)

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A07-108 TITLE: Human Intelligence (HUMINT) Soft-Target Identification and Tracking

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a set of automated tools to identify and track "significant" individual persons and the organizations that they come together to form, by using Human Intelligence (HUMINT) and other Intelligence such as Communication Intelligence (COMINT) and Imagery Intelligence (IMINT). This effort will allow commanders to target individuals and to understand the organizations exerting influence in his Area of Operation sufficiently to disrupt or attack the organizational infrastructure. HUMINT collection stimulation will be used to support and evaluate the required pattern, link, and trend analysis for the detection of soft target ID and Tracking algorithms being developed.

DESCRIPTION: Current and future operations require more than the prosecution of enemy orders of battle. Exploitation of “soft targets”, namely individuals and the organizations they form, has become important factors for tactical commanders. Automated fusion technology to date has largely focused on “hard targets” (units, their equipment, and facilities) and in a relatively straight-forward processing chain. Soft target exploitation, and the fusion required to support it, will require a tighter integration of fusion steps and unique analytical techniques.

An example: Given a person of interest... we learn of their location at some point in time... what phones could be tied to that time/place... what other phones were called by those... what people are associated with those phones... where do the phones go now... where did that phone go yesterday... does it follow a pattern... where does the person of interest go next... what other people does he associate with... what circle of associates form a functional group... who seems to be the nucleus of that group.. etc.

Exploitation of "soft targets" like individuals and organizations cannot be pursued by the classic correlation approach (Level 1 Fusion) alone. Because we lack sensor systems to uniquely detect them, and have no effective techniques to track them without active tags, we need to work on those entity types in a tightly coupled and iterative correlation/link analysis (Level 1/Level 2 Fusion) concept. To date, this work flow has not been automated and yet the quantity of the data in the real world is overwhelming.

The inputs of this Intelligence Fusion System would be data from Distributed Common Ground Station-Army's Joint Intelligence Operations Center-Iraq such as: Signal Intelligence, Imagery Intelligence, Measurement and Signature Intelligence and Human Intelligence messages. The output would be locations or tracks of High Value Individuals and their associated organizations.

PHASE I: Feasibility study for a capability to detect and track “significant” individuals and their associated organizations. Determine criteria that make an individual “significant”. Prepare a realistic scenario and data requirement to support the task. The scenario should allow collection of other Intelligence in addition to Human Intelligence (HUMINT). The system should include, at a minimum, Communications Intelligence (COMINT) and Imagery Intelligence (IMINT) in the identifying and tracking process.

PHASE II: Design, develop, code, test, and demonstrate a near-real-time system, implementing the approach from Phase I. Perform evaluation of the prototype and provide reporting of the probability of success in the identification of “soft targets”. The system developed should take into account considerations of data volume collected, persons of interest and organization structures, clutter factors and physical environment. Determine Measure Of Performance (MOP) parameters for evaluation purpose. Construct a simulation environment to support HUMINT and the Soft-Target Identification and Tracking process. A report shall document the final approach, implementation, and results of the overall effort.

PHASE III: The completion of this phase will result in a mature software tool set, to include software tools that will help in identifying and tracking significant individuals and their associated organizations using all source data. This tool set could be applied to both military and commercial applications, such as law enforcement and homeland defense. 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. 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). As an example the DCGS-A analysts(s) could use the tool set to track high-value targets within their area of operations.

REFERENCES: 1) http://www.access.gpo.gov/intelligence/int/int023.html
2) http://www.military-information-technology.com/print_article.cfm?DocID=714
3) http://www.globalsecurity.org/intell/systems/ci_humint.htm

KEYWORDS: Data Fusion, Humint processing, link analysis, exploitation, tracking, discrimination, detection.

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A07-109 TITLE: Blue Force Communications Compatible Antenna System

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: Develop an antenna technology that provides broadband frequency coverage while simultaneously allowing operation of Blue Force Communication equipment. Such technology may include, but is not limited to directional and null steerable technology. The intended applications for such technology are mobile mounted and fixed site jamming. The technology should be flexible enough to allow for point-to-point communication either within a convoy of military vehicles or between convoys and fixed sites at known locations.

DESCRIPTION: The Army requires a dynamic/low cost/viable antenna that is capable of determining the frequency of multiple blue force communication signals and then directing multiple antenna pattern nulls towards each of Blue Force Communication antennas.

US Army ground vehicles are relatively small and have multiple antennas in close proximity to each other. Due to the closeness of the antennas, RF systems are starting to interfere with Communication systems on the vehicle. The RF transmitting antennas cause the soldier to have difficulty transmitting and receiving information with their communication equipment.

With the proliferation of RF transmitters the Electromagnetic Environment will only worsen. It is vital that the Blue Force Communications equipment can continue to work with existing and future RF transmitters. If a narrow null in an antenna pattern can be directed towards all of the different antennas on a vehicle, the RF transmitter's signal may be attenuated sufficiently so as not to interfere with communications.

The goal of this program is to develop a low cost system that will allow the soldiers on Army vehicles to use their communication systems while also using RF transmitters. The total cost of the system shall not exceed $5,000 per unit. The antenna system shall be able to be mounted to multiple different Army ground vehicles, be low observable and not protrude above the top of the vehicle by more than 4 feet. The bandwidth of the antenna system shall be between 20 MHz to 6 GHz and be able to null at multiple frequencies at one time. The null should have an attenuation of at least 20dB and have a beam width of no more than 5 degrees.
PHASE I: Feasibility study for a low cost antenna system with the capability to generate nulls and multiple frequency and locations. Perform an analysis of antenna performance parameters. Analyze various antenna geometries. Perform modeling and simulation of antenna technology to estimate performance.

PHASE II: Design, build and demonstrate prototype antenna system for blue force communication compatibility for ground platforms. Develop and document software system if needed.

PHASE III: The completion of this phase would result in a mature technology which would be transitioned to PM CREW for inclusion in the objective multi-band countermeasure system. Concurrently, this technology could be transitioned into a commercial product for use by Homeland Defense and First Responders personnel. Presently, First Responders and other local authorities use various communication systems and require multiple antennae. This design will eliminate the interference between adjacent antennae on the same platform.

REFERENCES: 1) Consumption of Degrees of Freedom in Adaptive Nulling Array Antennas. Accession Number : ADA122389

KEYWORDS: Antenna, Nulling, RF, Blue Force Communications

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A07-110 TITLE: Worldwide Interoperability for Microwave Access (WiMAX) Network Detector and Traffic Analyzer

TECHNOLOGY AREAS: Electronics

OBJECTIVE: The Objective of this effort will be to develop a WiMAX (802.16) wireless network detector capable of detecting and identifying WiMAX networks, Base Stations (BS), and Mobile Stations (MS), and analyzing communications between nodes.

DESCRIPTION: WiMAX is on the verge of standardization and wide-scale deployment. This deployment will allow for low cost, scalable, interoperable, high-throughput and long range wireless communications. These WiMAX networks will allow for enhanced performance and robust quality of service in dealing with traditional network traffic and streaming media such as video and Voice over Internet Protocol (VoIP). While WiMAX radios currently exist, they are inaccessible at the lower layers of the Open Systems Interconnection (OSI) model (Network and Transport). These devices are solely to provide transparent connectivity to a user on a WiMAX network. They are not designed to allow for Network monitoring and troubleshooting. Furthermore, while there are network detectors and traffic analyzers for various types of communications protocols, both wired and wireless, no such device currently exists for the WiMAX protocol. Since WiMAX is such a new and evolving protocol, there has been insufficient work done to determine the potential pitfalls of developing a network detector and analyzer for this standard. However, one such possibility may be that the security measures inherent to 802.16 may not be as easy to circumvent as previous standards for 802.11. This effort will include research and the execution of the best possible way to implement a WiMAX network analyzer (IE usage of existing WiMAX radios as front end receiver or usage of a more generic Software Defined Radio). This capability, once available, will allow for detection, analysis, and monitoring of WiMAX networks as well as communications between BS and MS nodes at the packet level. The features required for the proper analysis of WiMAX data traffic would include real-time packet capture, packet filtering capabilities, stream recreation, network mapping, and appropriate reporting capabilities. Development of this type of capability would allow for a network detection and analysis capability that is currently unavailable and will be required in the near future.

PHASE I: Perform a study of the level of effort required to develop a WiMAX (802.16) detection and analysis software suite. The outcome of this phase will be a report detailing the feasibility of developing this type of software suite.

PHASE II: Develop a WiMAX (802.16 d/e) prototype detector software suite that allows for real-time network discovery, packet capture, packet filtering, stream recreation, mapping, and reporting capabilities. Furthermore, the ability to generate network packets for transmission is also highly desirable. Assumptions that encryption is not enabled is acceptable. The government would, however, also like to understand how much information would be available if encryption were enabled. The outcome of this phase should be a prototype WiMAX software application suite and any associated and relevant documentation capable of demonstrating all stated capabilities.

PHASE III: Completion of this phase would result in a mature WiMAX network analyzer capability. This capability could therefore be successfully integrated into the Network Electronic Warfare ATO to enhance functionality and address emerging threats. Concurrently, this technology could be transitioned into a commercial product for use by security specialists as well as administrators for penetration testing and network management.

REFERENCES: 1) www.wimaxforum.org
2) www.ieee802.org/16
3) www.scs.carleton.ca/~barbeau/Publications/2005/iq2-barbeau.pdf
4) http://www.scs.carleton.ca/~kranakis/Papers/final-madnes.pdf
5) http://www.networkworld.com/columnists/2006/121106-wireless-security.html

KEYWORDS: 802.16, WiMAX, Wireless Communications, Broadband, WirelessMAN

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A07-111 TITLE: Countermeasures for Laser Activated Devices

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: The goal of this topic is to develop countermeasure techniques and a near IR system for the defeat of laser activated devices (LADS) that may be used as optical triggering mechanisms.

DESCRIPTION: Laser activated devices can be used as optical triggers. The goal of this program is to develop proofs of concept and the proposal of a system (or systems) that will provide the US Army with a means for the detection and neutralization of LADS. The program will analyze potential optical threats that can be developed using existing commercial or military hardware and to propose techniques and hardware for their defeat.

PHASE I: Carry out a feasibility study for a Laser Activated Device (LAD) countermeasure system capabilities for detection and/or pre-detonation or jamming (prevent the detonation of) potential LAD triggering mechanisms. Deliverables will be a final report that describes and characterizes the optical threats that were investigated and the technical requirements for the development of a countermeasure system to these threats.

PHASE II: Design and build a prototype LAD countermeasure system suitable for use on either vehicular platforms or unmanned aerial vehicles (UAVs). Develop and test this system against selected targets in the laboratory and field. There will be two deliverables from phase II: 1) a comprehensive final report describing the system design, trade analysis and test results and 2) a working hardware prototype.

PHASE III: In this final phase the developed laser activated countermeasure will have the capability of defeating specific Electro Optic/Infrared threats in a robust field environment. Successful technologies developed under this effort will be transitioned to PM CREW and NAVEOD for inclusion in the objective multi-spectral countermeasure system. The value of the developed countermeasure system/technology will be greatly enhanced by its application to other scenarios both in the military and commercial fields, e.g., application to perimeter defense, inter- and intra-building defense and defense for individual military and commercial personnel.

REFERENCES: 1) C.-L. Fan, T.-H. Yang, Y.-C. Chen and J. Lin, “Effects of Laser Activation on Device Behaviour for Poly-Si Thin-Film Transistors with Different Channel Lengths,” Electronics Letters, March 16, 2006, Vol. 42, No. 6. Electronics Letters online no: 20063793.

2) P. G. McMullin and L. R. Lowry, “Optical Drive Requirements for Laser-Activated Semiconductor Switches,” IEEE Transactions on Electron Devices, Vol. ED-26, No. 10, October 1979, pp. 1469-1472.
3) A. Rosen, P. Stabile, W. Janton, A. Gombar, P. Basile, J. Delmaster, and R. Hurwitz, “Laser-Activated P-I-N Diode Switch For RF Application,” IEEE Transactions on Microwave Theory And Techniques, Vol. 37, No. 8, August 1989, pp. 1255-1257.
4) A. Rosen, P. J. Stabile, Daniel W. Bechtle, W. Janton, A. M. Gombar, J. Mcshea, A. Rosenberg, P. R. Herczfeld, and A. Bahasadri, “Optically Achieved p-i-n Diode Switch Utilizing a Two-Dimensional Laser Array at 808 nm as an Optical Source,” IEEE Transactions on Electron Devices, Vol. 36, No. 2, February 1989, pp. 367-374.

KEYWORDS: active infrared, countermeasures, optical command link, laser activated device, improvised explosive device

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A07-112 TITLE: Activity Behavior Modeling Toolkit (ABMT) for Non-Traditional OPFOR (Opposing Forces)

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: Develop a toolkit for constructing simulation using behavior modeling to represent activities of non-traditional OPFOR (Opposing Forces) to support military / Operation Other Than War (OOTW) experimentation and training exercises

DESCRIPTION: Currently, OPFOR is extended from the enemy on the battlefield to a variety of malicious individuals and organizational groups embedded in the civil society including terrorists, violent extremists, covert threat forces, etc. To meet the challenges of the rapid & evolving changes of the threat environment, the armed forces are shifting their focus of the Tactics Techniques and Procedures (TTP) from the traditional tangible operations to the non-traditional implicit OOTW (fighting terrorism, humanitarian aid, peacekeeping, etc.). The enemy organizations are asymmetric and do not follow a well defined doctrine. Their activities and modes of conducts are blended with the common civilian activities. They are not communicating by military radio but by cellular telephone, walkie-talkie radio, email, telephone, video conferencing and through direct contacts. It is the content and activities that becomes the source of evidence in determining intent.

To support various analysis, experimentation efforts and training exercises, the Army needs modeling tools to represent non-deterministic behaviors of individuals or groups with associated observable characteristics (e.g. physical, movements, patterns, communications signal emissions, electro-magnetic signatures, etc.) that can be mapped and detected/recognized by the various type of Army Intelligence, Surveillance and Reconnaissance (ISR) sensor systems (e.g. Signals Intelligence (SIGINT), Human Intelligence (HUMINT), Measurements & Signature intelligence (MASINT), Moving Target Indicator (MTI), etc.) for further processing, analysis and multi-INT data fusion.

The goal of this SBIR is to improve the existing human behavior modeling capabilities in simulation support for studies, analysis & experimentation on OOTW operations. The main focus is to develop a toolkit of the human behavior modeling for non-traditional Opposing Forces (OPFOR) that exhibits realistic activities and modes of conducts under various operational terrain/environments (e.g. open, mixed, urban). The Activity Behavior Modeling Toolkit (ABMT) shall provide an easy to use GUI to construct building blocks of behaviors conducive and indicative of the various non-traditional OPFOR activities and be able to provide activity behavior assignment to groups or individuals. The control of behavior should correspond to variable communications in means and realistic contents. With the behaviors and information contents available, extended collection can then be emulated for extended periods of activities. The behavior models will be represented at a reasonable level of awareness with the surroundings and have means to interact with/among other human and organizational entities under varying terrain/environmental conditions. The behaviors associated with non-traditional OPFOR should be modeled in generic and extensible modules allowing user construction of specific details and to build a library of activity portfolio. The human behavior models should be sufficiently credible and variable to support run time behavior and/or pattern and link association for trend analysis.

PHASE I: Explore, evaluate and assess the existing modeling solutions & capabilities, tools, techniques & frameworks and propose cost effective means to extend mission / activity behaviors to entities generated by major constructive simulation systems (e.g. OneSAF). Define behavior modes, architecture, and approach for the tool kit design. Example for investigations shall include smuggling activities under foliage in a border crossing and terrorist activities in an urban environment. Define the proposed human behavior models (description and characteristics of the behavioral categories and definitions through selection of the generic behavior components) and their applications in non-traditional OPFOR scenarios. Demonstrate the feasibility and extensibility of the approach. Deliverables: Report of findings and feasibility design documentation.

PHASE II: Design / develop / leverage / expand and describe the conceptual framework of the AMBT to a useful degree of sophistication and providing realistic output to support execution of experiment scenarios for Level 2 and 3 data fusion analysis. Assess the performance based behavior and activity types, its extensiveness and flexibility to adjust for changing non-traditional OPFOR. Focus on individuals, organizations, and civic activities in scenarios of increasing complexity with a build based on current events or at sponsors choosing. Improve on ease of use and flexibility. Deliverables: Prototype software and demonstration, Phase II Report, software documentation/manuals.

PHASE III: Technologies for modeling behavior have a wide variety of application to the military and other government/commercial markets. The ABMT can be further developed and enhanced to become a useful tool for supporting Global War on Terror, Police/Law enforcement efforts, and other homeland security applications where simulation of the behavior of potential threat entities, groups and organizations are needed for support of systems development, testing, training, etc. The effort will provide an enhancement to contstructive simulation more reflective of the modern OOTW operations. It will offer simulation needs in DCGS-A and FCS, Distributed Common Ground Systems - Army and Future Combat Systems.

REFERENCES: 1) Dial-A-Riot: New Simulation Models Crowd Behavior, Training and Simulation Journal, June/July 2006, page 39.
2) Flames Cognition Models, www.Ternion.com
3) "Virtual sensors in a constructive and Live World", Donold Stoner and Richard Patch, http://www.modelbenders.com/papers/02F-SIW-009.pdf
4) Developing Thinking OPFORs for JCATS, Soar Technology, http://www.soartech.com/projects/13%20TOF.pdf

KEYWORDS: OOTW (Operations Other Than War), HUMINT (Human Intelligence), Social Networks, Behavior Modeling, Constructive Simulation

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A07-113 TITLE: Innovative Electronic Counter-Counter Measure Techniques

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 novel processing algorithms that can be incorporated into current or next generation ground based radars such as the current Firefinder family of radars or development systems such as Multi-Mission Radar (MMR) and EQ-36. The effort proposed should postulate several novel Electronic Countermeasure (ECM) waveforms, show their impact against a notional radar and present viable Electronic Counter-Counter Measure (ECCM) techniques. Ultimate goal is to demonstrate capability through field testing with ground based radars

DESCRIPTION: The army requires a dynamic/low cost/viable capability to counter the effects of Electronic Countermeasures against ground based radars. Radars are increasingly being deployed in urban and other exposed environments that allow hostile forces to operate within close proximity. Examples of such deployments are FIREFINDER systems and air traffic control radars in various cities in Iraq, and perimeter surveillance radars at forward operating positions. Such exposed radar deployments allow relatively low power ECMs operating at short ranges to be used effectively. Additionally, by being located close to the radar, the ECMs can capture each pulse, determine its phase and modulation, create coherent interference and inject it through the radar's sidelobes or even through the mainlobe.

There are techniques that are suitable for nulling most intentional interference; however, currently available PC capabilities may allow sophisticated ECM waveforms to be generated at a relatively low cost, especially if the properties of each transmit pulse have been measured.

PHASE I: Conduct study of potential processing algorithms that can be used in current or next-generation ground based radars to counter advanced ECM threats. Begin a study to develop software for algorithms and initiation of Electronic Counter-Counter Measures (ECCM).

PHASE II: Design, develop and document software/hardware prototypes to perform ECCM capability against potential ECM threats. This phase should include a working prototype that can be demonstrated on at least one specific army radar, which will be determined in cooperation with the contractor.

PHASE III: Mature ECCM technologies, could be successfully applied to army and commercial ground-based radars systems either as an adjunct processor to an army ground based system or within the processor architecture of the radar itself. A modular hardware/software product package, customizable for use on many platforms could be a useful addition to current army radars such as the MMR, EQ-36, and the Firefinder family of radars, as well as, for air traffic control and homeland security.

REFERENCES:
1) http://www.globalsecurity.org/military/library/policy/army/fm/6-121/fm612_5.htm
2) http://ieeexplore.ieee.org/iel3/62/7138/00286787.pdf?tp=&arnumber=286787&isnumber=7138

KEYWORDS: Electronic Counter-Counter Measures (ECCM), Radar, Firefinder, Defeat ECM waveforms initiate countermeasures

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A07-114 TITLE: Low-Cost, Multi-Channel Arbitrary Waveform Generator

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop a ruggedized, low-cost, high power, multi-channel, expandable Arbitrary Waveform Generator capable of providing up to ten RF signals. Each channel should support a signal having up to a 5 MHz instantaneous bandwidth and should be capable of transmitting this signal anywhere within the 20 MHz to 6 GHz spectrum at a peak power level of 5 Watts per channel.

DESCRIPTION: To support ongoing research, development, and testing efforts, the US Army has need for a low-cost, expandable, multi-channel arbitrary waveform generator with the following characteristics. In its base configuration this system should be capable of generating a single channel, while the fully populated configuration should be able to generate up to 10 independent channels. The system should operate on 12VDC/24VDC power from a vehicle or battery pack. System configuration should be handled via Ethernet by a laptop computer or other portable device. Once configured, the Waveform Generator should operate in standalone mode (i.e. without the laptop). Each channel should be capable of producing a signal with an instantaneous bandwidth of at most 5 MHz with at least 14-bits of resolution. Each channel should be capable of storing and playing out a digital baseband signal of duration one minute or less. The channel should be able to switch frequency in less than 10 microseconds to any frequency within the operating band. Channel configuration should be very flexible. Configurable parameters for each channel should include: hopping sequence, repetition number, clock speed, and power level. A Graphical User Interface should allow the operator to quickly configure each channel and load waveforms. The control software should auto-detect the number of channels available for use. The system should be capable of operating in harsh environments over a temperature range of 0 degrees C to 55 degrees C while meeting both shock and vibration specification appropriate for HMMWVs. The fully populated system should cost less than $5,000.

PHASE I: Conduct trade studies, design and simulate the performance of an individual channel. Ensure all environmental specification can be met. Develop a system architecture and system specification allowing for up to 10 individual channels in a single system. Develop a specification for the Graphical User Interface (GUI). Deliverables at the completion of this task should include a detailed technical report on the feasibility of achieving the described design objectives, or alternatively, the best cost to performance value attainable based on current technology. This should include the design architecture and specification of the systems.

PHASE II: Develop a proof of concept prototype of a 10 channel system. This prototype should be capable of fully demonstrating the performance of the system and should fully meet all specifications. Deliverables at the completion of this phase should include 1 prototype system with accompanying documentation, source code and training material

PHASE III: The completion of this phase would result in a mature technology, which could be transitioned to programs such as the Urban SABER ATO, STARGRAZER, SANDSTORM and WARLOCK to assist in the development and testing of their Electronic Surveillance, Electronic Warfare (ES/EW) systems. Concurrently, this technology could be transitioned into a commercial product for use by Homeland Security/Defense as well as other DOD Research and Development entities.

REFERENCES: 1) Creating Arbitrary Waveforms Using Direct Digital Synthesis (DDS)
2) http://www.home.agilent.com/agilent/editorial.jspx?cc=US&lc=eng&ckey=451721&nid=-536902257.536883183.02&id=451721
Flash-ROM-Based Multichannel Arbitrary-Waveform Generator
3) http://www.elecdesign.com/Articles/Index.cfm?AD=1&ArticleID=6220
4) Generating Frequency Agile and Custom Waveforms
http://www.highfrequencyelectronics.com/Archives/Feb06/HFE0206_Jungerman.pdf

KEYWORDS: Arbitrary Waveform Generator, Electronic Support

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A07-115 TITLE: W-Band Circular Electrically Scanned Array

TECHNOLOGY AREAS: Electronics

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

OBJECTIVE: Develop a W-Band Circular Electrically Scanned Array (CESA) for use in current and future military surveillance and communications applications.

DESCRIPTION: The inception of Future Combat Systems requirements for Platoon level unmanned surveillance craft – collectively known as Organic Aerial Vehicles (OAVs) – has created a requirement for extremely lightweight and compact surveillance solutions. Since many of the current OAV concept designs are a Vertical Takeoff and Landing (VTOL) crafts utilizing a ducted fan propulsion technique (i.e. the Lift Augmented Ducted Fan (LADF)), integrating a radar or communications relay system onto the craft must be done somewhat unconventionally. The development of a ring-shaped (or similar) CESA would allow for the array to be mounted outside of the ducted fan design (or perhaps conformally to the airframe). This CESA design would greatly reduce the amount of moving parts in the system, thus reducing weight and power requirements. Integration of a CESA design on an OAV would allow for a greater range of capabilities for the OAV system.

The goal of this program is to develop a cost effective, circular electronically scanned array that operates in the W-Band of the radio frequency (RF) spectrum in order to facilitate the performance required by FCS Class-II UAV systems. Due to the necessary integration with OAVs the system should be less than10 lbs in weight including all necessary RF signal transport and interface cabling to a transmitter/receiver and processor. The instantaneous bandwidth, sidelobe levels, and beam agility, etc. should be sufficient for both multiple access communications techniques and extremely high resolution SAR and GMTI radar modes. Determination of these parametrics will be left to the phase I study. Sub-1 inch SAR modes are of interest as well as Micro-Doppler GMTI of targets (especially dismounts). Modes such as these will enable identification and classification of intent of targets of interest. Control of the array should be sufficient to form multiple beams (possibly for separate, simultaneous modes) around the entire 360 degrees. The array should also allow for scanning in the elevation direction if possible; the degree of elevation agility may be left for the study and simulations.

PHASE I: Feasibility study into the development and subsequent performance of a W-Band CESA. The performance should be considered for both radar and communications applications. Extensive antenna modeling and analysis will be required to prove the feasibility in terms of both azimuth and elevation beam steering performance (i.e. beam agility, pointing accuracies, antenna pattern degradation, sidelobe characteristics, etc.). The methods for integrating such a system into the current OAV designs should also be investigated. All model results to include assumptions and appropriate equations, and analysis developed for the study will be delivered to the government in a final report discussing the viability of a CESA design at W-Band.

PHASE II: Design, build and demonstrate a prototype W-Band Radio Frequency CESA and a functioning breadboard radar back-end to facilitate tower and vehicular testing of the array against the targets of interest. The system shall also be demonstrated in a communications mode of operation for high bandwidth communications links. The system should at least prove its ability to collect high fidelity (sub-1 inch) Synthetic Aperture Radar (SAR) images as well as Micro Doppler Ground Moving Target Indication (GMTI). This integration, testing and data collection effort will also facilitate the development of necessary algorithms for radar processing (i.e. adaptive processing for circular arrays), target intent to Identification, and communications (i.e. Code Division Multiple Access (CDMA), etc.). All developed models, analysis, and test data shall be supplied with the final report.

PHASE III: The completion of this phase would result in a mature technology, which could be successfully applied to both military and commercial applications to include security in law enforcement, homeland defense, border patrol, property monitoring, etc.

The W-Band CESA technology can be placed in conjunction with EO/IR in a common aperture payload setup on OAV's and other small FCS Class II UAV systems allowing for high fidelity target detection/tracking and cross-cueing of sensors. The use of this technology can also be used in commercial automobile collision avoidance systems and automatic cruise control. The technology can be adapted to allow for high bandwidth communications using a collection of OAV's to set up an ad-hoc communications network on the battlefield or a law enforcement environment.

REFERENCES: 1) Hansen, H.J.; Kulessa, A.S.; Brooker, G.M.; "Millimetre-wave radars in targeting and data linking operations," Radar Conference, 2003. Proceedings of the International, 3-5 Sept. 2003 Page(s):230 – 234.
2) Ruggieri, M.; De Fina, S.; Pratesi, M.; Saggese, E.; Bonifazi, C.; "The W-band data collection experiment of the DAVID mission," Aerospace and Electronic Systems, IEEE Transactions on Volume 38, Issue 4, Oct. 2002 Page(s):1377 – 1387.
3) Dainelli, V.; Limiti, E.; Ruggieri, M.; "Innovative Technologies for the Developments of W-band Radars and Communication Payloads," Aerospace Conference, 2006 IEEE 04-11 March 2006 Page(s):1 – 7.
4) Dainelli, C.; Fern, M.; De Fazio, A.; Ricci, L.; Ruggieni, M.; "W band communication link, design and on ground experimentation," Aerospace, 2005 IEEE Conference, 5-12 March 2005 Page(s):920 – 926.

KEYWORDS: W-Band, Transmitter, Receiver, OAV, Sensor, Radar, Communications Link, Circular Array, Electronically Scanned Array.

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A07-116 TITLE: Smart Interviewing Tool

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: Develop a software application that guides human intelligence (HUMINT) collectors in identifying reliable sources and obtaining truthful information during interviews of sources.

DESCRIPTION: Intelligence gathering operations conducted by ground troops in Iraq are moving away from large-scale sweeps to more focused, detective-like investigations. A typical scenario finds HUMINT collectors making inferences ('Who did this?') from evidence at the scene of an event (such as an IED attack) and from interviews with witnesses or other sources who might be able to shed light on the event. Given the many of motivations for sources to lie, fabricate, or provide dis-information, soldiers face a major challenge in determining which sources are accurate and reliable, and which leads are worth pursuing. This is a common problem in many investigative fields, made more difficult for ground troops in Iraq by barriers in language and culture and a general lack of forensic s (no CSI teams). Significant innovation and creativity are required in developing tools that will enable rapid (while the interview is ongoing) evaluation of source accuracy and truthfulness under these challenging conditions.

There are two main approaches to solving this problem. One involves various forms of lie-detector tests; such are being considered elsewhere. The approach of interest to this topic involves rapidly assessing the internal consistency of an individual's answers and comparing any statements to information from other sources in order to corroborate or refute those statements, and allow for asking of follow-on questions. The focus of this topic is thus a software toolset that will support making timely decisions about source reliability and the likely truth of statements that sources provide. Innovation and creativity are required in developing tools that will: a) express contextually relevant relationships between a given source and other persons, b) alert the collector to apparent contradictions among reports given by the same or different sources, c) provide a rating of a given source's reliability and clearly indicate the basis for the rating, d) provide tools for easy entry of information about a source and information collected such as: source reliability, pertinence of information, conflicting information and rationale, information credibility and rationale, contextual factors surrounding the information collected that are deemed important by the collector such as apparent motivation of the source, and so on, and e) recommends questions during an interview that would help resolve contradictions and highlight gaps in the information being provided. This task is made more challenging by the general free-form text format in which interviews are conducted.

PHASE I: Perform a feasibility study for a laptop-based toolset that will provide a real-time assessment of the reliability of a source based upon an analysis of any statements being made, and that will suggest specific questions to improve the assessment and obtain truthful responses. Develop accuracy and speed metrics to evaluate options against existing methods for dealing with this set of problems. Analyze system requirements and generate system design alternatives. Evaluate the design options from Phase I and recommend a design for implementation in Phase II.

PHASE II: Build and demonstrate a prototype toolset hosted on a laptop computer as a stand-alone application. The desired system will perform properly using free text as input data. Performance should be consistent with speed and accuracy metrics established in Phase I. As an alternative approach, the system may be exercised with a) structured format data obtained by having run the same free text through an entity extraction tool (the government would provide the extracted output or provide an entity extraction tool license as Government Furnished Equipment to be returned when the contract ends) or b) data using common structured format such as U.S. Message Text Format (USMTF) reports. Evaluate the prototype against the metrics using multiple individuals covering a wide range of investigative and interviewing experience.

PHASE III: Develop the software toolset as a web-based server application. The web-based version will have military transition paths are to: a) the Army's Advanced REsearch Solutions - Fused Intelligence with Speed and Trust (ARES-FIST) Program; b) the Army's Soft Target Exploitation and Fusion ATO Program; and c) the Army's Human Domain Work Station as part of Distributed Common Ground System - Army. Some commercial applications would be police investigation, FBI criminal investigations and insurance claims adjustments.

REFERENCES: 1) U.S. Newspapers reporting accounts of U.S. military operations involving the collection and analysis of Human Intelligence (HUMINT), and Military Intelligence Professional Bulletin.
2) Military Intelligence Professional Bulletin http://www.fas.org/irp/agency/army/mipb/index.html
3) FM 2-91.4, 6/30/05, Intelligence Support to Operations in the Urban Environment http://www.army.mil/usapa/doctrine/30_Series_Collection_1.html

KEYWORDS: source reliability, information credibility and consistency, Counter-Intelligence (CI) and Human Intelligence (HUMINT) collection support

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A07-117 TITLE: Standoff Explosives Detection

TECHNOLOGY AREAS: Electronics

OBJECTIVE: To develop explosives detection sensors capable of detecting and identifying explosives and explosive related compounds (ERC's) associated with surface and shallow buried improvised explosive devices (IED's) and landmines at standoff distances from 30 meters to 250 meters from the detection sensor.

DESCRIPTION: The Countermine Technology Branch, of NVESD's Science and Technology Division, has an interest in technologies for the standoff detection of landmines and improvised explosive devices. The explosives and ERC's associated with these devices may be TNT, DNT, PETN, RDX, HMX, etc. The standoff explosives detection sensor must selectively identify the presence of either the main-charge explosive, or the explosive detonator, or trace amounts of explosives nearby the device. The standoff explosives detection sensor must be highly selective to avoid detecting interfering compounds in the complex chemical environment (clutter). There are three (3) scenarios of interest, shown as follows. The offeror may select either one, or more, of the following three (3) scenarios to address in their proposal.

Scenario 1. The standoff explosives sensor shall confirm the presence of a landmine or an IED that is detected initially by other means. The amount of explosive may be from 300g to 20kg. The minimum standoff distance is 30 meters (with a desired standoff distance of 250 meters); and the minimum identification time is 60 seconds. Longer standoff detection distances and shorter times are desirable. The explosive material may be encased in a steel or other metal container of up to 4 mm in thickness. In addition the larger explosive devices explosive may be buried under 12 cm of rocks or soil.

Scenario 2. The standoff explosives detection sensor shall provide standoff detection of vehicle borne threats. Standoff distances from the sensor are 30 meters to 250 meters. The amount of explosive would be from 150 to 400kg. The time to scan an average sized car must be less than 60 sec. The vehicle could be unoccupied. The ability to scan a moving occupied vehicle would be of even greater interest.

Scenario 3. The standoff explosives detection sensor shall serve as the primary standoff detection sensor--in contrast to the confirmatory standoff explosives detection in scenario one, for targets such as landmines, or IEDs, at standoff distances of 30 m or more. For this case the IED device may be covered by rocks or other material. The standoff explosives detection sensor must scan a 4m wide path and be capable of moving at speeds greater than 3 kph.

PHASE I: This proof of feasibility phase will focus on laboratory and, if possible, limited field investigation of the landmine/IED standoff explosives detection as a potential candidate for application in a tactical system. The sensitivity of the standoff explosives detection technique will be determined in the laboratory. Phase I will include a demonstration to experimentally confirm the lab results and analyses by utilizing a variety of appropriate explosive or ERC vapors generated in the laboratory. Considering the timeframe for a Phase I award (six months, not including the possible Phase I Option), it is critical to demonstrate sound laboratory success and at least generate a detailed plan for prototyping and field testing during Phase II for the Phase I to be considered successful.

PHASE II: The purpose of this phase is to design and fabricate a brassboard standoff explosives detection data acquisition system and to use this brassboard system to experimentally confirm the detection capability under varied conditions and undergo demonstration of a prototype at either contractor test facilities or at Army test facilities. The location of the demonstration will be the contractor's choice. 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, probability of detection, 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.

PHASE III: This technology has numerous applications in asymmetric warfare, airport security, border security, etc. The technologies emerging from this SBIR effort, "Standoff Explosives Detection," would transition to a 6.2 program known as "Sensors for Explosives Detection" (SED). CERDEC NVESD, at Ft. Belvoir, VA, will manage this technology, under the SED program (TRL 4/5). If the 6.2-level standoff explosives detection technology meets program performance metrics, it would likely transition to NVESD's Countermine Division for continued prototype--6.3-level, development (TRL 6 and higher). Testing of the prototype system and platform integration will be done at an Army test facility.The PM-CCS would likely manage the 6.4-level technology. Another accelerated development path would be based on the technology maturity after it emerges from a SBIR phase II. That is, the Rapid Equipping Force (REF) or JIEDDO could take this technology for rapid deployment to the overseas theater.

REFERENCES: 1) "Existing and Potential Standoff Explosives Detection Techniques." Board of Chemical Sciences and Technology; Division on Earth and Life Studies; National Academy of Sciences. 2004. ISBN: 0-309-09130-6
2) Yinon J., and Zitrin S. "Modern Methods and Applications in Analysis of Explosives". John Wiley & Sons, West Sussex, England 1993.

KEYWORDS: Standoff explosives detection, IED detection, landmine detection

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A07-118 TITLE: Visible and Near Infra-Red (VNIR) – Short Wavelength Infrared (SWIR) Hyperspectral Sensor

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 is to develop a compact VNIR – SWIR hyperspectral sensor.

DESCRIPTION: This primary use for this sensor will be in the areas of anomaly detection, countermine research, and camouflage concealment and detection. Targets will be located at relatively close range (< 1km). The sensor must be adaptable to either ground to ground operations or low altitude aerial surveillance operations. The sensor must have the ability to acquire spectral information from 500 nm to 2200 nm. In addition, an enhanced spectral range of 400nm to 2500nm is preferable, even if the performance in the extended range is slightly degraded. It is preferred that the sensor be able to switch between a day mode in which full hyperspectral information (>100 bands) is acquired, and a night mode where multispectral information is acquired under lunar or man made illumination. The sensor should have the ability to detect spatial or spectral anomalies in real time by comparing real time imagery with a set of user input spectral or spatial target definitions. The sensor should have a display capable of identifying targets of interest in real time in a method that does not confuse the user. The sensor should have the ability to save full spectral data for offline analysis that is tagged with meta information such as time, GPS, pointing direction, and meteorological information. In addition, the user should have the option of saving the real time target detection information. Finally, the sensor and its supporting hardware should be man portable and not physically extended or overly heavy.

From buried land mine detection to basic chemical analysis, the possible applications for hyperspectral imagery are just beginning to be explored. Thus far, several prototype hyperspectral systems have been produced, each with its own strengths and weaknesses. This project will focus on the creation of a VNIR-SWIR hyperspectral sensor. The Army is seeking an innovative, low cost, compact way to obtain a multi/hyperspectral data over a relatively wide spectral range. By providing one or all functions of imaging, spectral and temporal data, a single reconnaissance sensor system can support automated counter mine algorithms, aided target cuing, Aided Target Recognition (AiTR) of difficult targets, and anomaly detection and identification in complex/urban areas. This will enable the warfighter to surgically attack foes and provide spectral analysis of potential threat areas for counter CCCDD.

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

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

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

Potential government users may include the Department of Defense, Department of Agriculture, and the various intelligence agencies. As the SBIR is being run through the Army, the main user of the initial research will be Army research organizations such as the U.S. Army Night Vision and Electronic Sensors Directorate and the U.S. Army Research Lab. The initial research will be focused towards target detection, discrimination, countermine, urban warfare, and camouflage detection. Future avenues of research will include these areas, but will be expanded as needed.

REFERENCES: 1) C.Simi, J. Parish, E. Winter, R. Dixon, C. LaSota, and M. Williams, "Night Vision Imaging Spectrometer (NVIS) Performance Parameters and their Impact on Various Detection Algorithms," Algorithms for Multispectral, Hyperspectral, and Ultraspectral Imagery VI, Proceedings of SPIE, 4049, pp. 218-229, (2000).
2) M. Winter, "Fast Autonomous Spectral End-member Determination in Hyperspectral Data," Proceedings of the Thirteenth International Conference on Applied Geologic Remote Sensing, Vol. II, pp. 337-344, Vancouver, B.C., Canada, (1999).
3) C. Simi, W. Tennent, et. al., "Compact Army Spectral Sensor (COMPASS)," IRIA-MSS Proceedings of the 2000 Specialty Group on Passive Sensors, Vol. 1, (March 2000).
4) H. Gumbel, "System Considerations for Hyper/Ultra spectroradiometric Sensors," Proceedings of SPIE, 2821, pp. 138–170, (1996).
5) A.T. Pritt, Jr., P.N. Kupferman, S.J. Young, and R.A. Keller, "Imaging LWIR Spectrometers for Remote Sensing Applications," Proceedings of SPIE, 3063, pp. 138–149, (1997).
6) J.E Murguria, T.D. Reeves, J.M. Mooney, W.S. Ewing, F.D. Sheperd, "A compact Visible/Near Infrared Hyperspectral Imager" Proceedings of SPIE Vol 4208 (2000): pp. 457-468

KEYWORDS: Hyperspectral, temporal, imaging sensor, spectral, spectrometer, IR, SWIR, VNIR, countermine, anomaly detection, spectral matching

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A07-119 TITLE: 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 shortwave infrared (SWIR) silicon-germanium based imaging camera. The goal is to develop a low cost, small in size and weight, low power, man-portable, solid-state silicon and/or germanium imaging sensor as a video based technology. The imager is to operate at 30Hz frame rate minimum (60Hz frame rate desired), with no or minimum cooling.

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 Intesified Charge-Coupled Device (I2CCD), Midwave Infrared (MWIR) and Longwave Infrared (LWIR) for cave and urban assault missions. Conventional silicon CCDs and 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 an uncooled, mega-pixel, low cost, low power, man-portable solid state Silicon-Germanium (Si-Ge) sensor/imager operating at normal video rates. To achieve required performance the solid state Si-Ge sensor/imager should be of 1k X 1k format (minimum), 10um pitch or less, 30 Hz operation minimum with 60Hz operation desired, a spectral bandwidth that includes 1.0 – 1.6um, and optics providing a minimum of 55 degree FOV. The sensor performance should be approaching that of lattice matched InGaAs with a limiting noise floor that will allow a specific detectivity (D*) approaching 10^12 cm·Hz½/W.

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 man-portable solid state silicon-germanium imager/camera system with significant response from 1.0 – 1.6um. 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. This technology has potential for the development of next generation digital night vision devices as an inexpensive covert device that has application in cave and urban assault operations. If Phase II is successful, the technology would be developed further and tested by the CERDEC NVESD Directorate and incorporated into Soldier Mobility Vision Systems Advanced Technology Objective (ATO). If successful, it could then transfer to PM Night Vision or PM Soldier.

REFERENCES: 1) Konstantatos et al. "Ultrasensitive Solution-Cast Quantum Dot Photodetectors." Nature, 0 2006|doi:10.1038/nature04855, 2006.
2) Ettenberg, M. A little night vision. Adv. Imaging 20, 29–32, 2005.

KEYWORDS: shortwave infrared, germanium imager, digital imaging sensors, camera, manportable, solid state sensors

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A07-120 TITLE: Body Wearable Diversity Antenna Systems for Increased Antenna Performance

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Communication degradation due to multipath causes low throughput and decreased range. Investigate diversity antenna technologies for body wearable antenna systems to combat the problem of poor antenna reception due to multipath. Determine if diversity offers distinct advantage over current body wearable antenna systems.

DESCRIPTION: Current body wearable antenna systems are being designed under the Tactical Networking Communications Antennas ATO for the Land Warrior/Ground Soldier Systems Soldier ensembles to support wideband (225-1000 MHz) and broadband (1350-2700) MHz communications. These frequency bands are particularly vulnerable to signal cancellations due to multipath. Diversity techniques employed with these antennas may decrease multipath and thereby increase the overall link system gain. Improved system gain translates into higher throughputs, increased range and more flexible use of the Army's tactical radio systems.

Some diversity antenna technologies that may be applicable to body wearable antenna systems are:
a. switching diversity - switching from one antenna element to another and selecting the best signal
b. spatial diversity - processing the signals from different antenna elements to put them in phase and add them together.
c. beam diversity - using different antenna shapes (different radiation patterns)
d. polarization diversity - achieving low correlation factor (high isolation) between antenna elements.

To determine if diversity offers a distinct advantage over current body wearable antenna systems, real world challenges must be addressed in the implementation of a diversity antenna system. One of the biggest challenges with a diversity system will be interfacing with the current and/or future Army communication systems. Diversity antenna systems often require digitized circuitry to switch between antennas or signal processing within the radio to compare the two signals. This circuitry and signal processing has not been incorporated into current or future army communication systems so some external circuitry or processing may be necessary for implementation. The size, weight and cost are also real world challenges for body wearable systems. These too must be compared to the current body wearable antenna system.

PHASE I: The Phase I effort will result in an analysis of link performance with and without diversity, a paper study to determine if diversity offers distinct advantage over current body wearable antenna systems and an antenna diversity topology design.

PHASE II: Phase II will result in the delivery of an engineering prototype of a body wearable diversity antenna system with the capability to interconnect to a current or future force manpack army communication system. The prototype will be able to both transmit and receive. A finalized report will detail the diversity system design, performance parameters and areas or opportunities for improvement on the design.

PHASE III: Body wearable diversity antenna systems have applications in both the commercial and military markets. For military applications, this product will directly support the Tactical Networking Communications Antennas ATO for the Land Warrior/Ground Soldier Systems Soldier ensembles. Commercially, local Emergency Medical Services, Fire and Police forces, and federal forces such as the FBI, Home Land Security, CIA, and IRS can use this body wearable system for covert operations and search/rescue missions.

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KEYWORDS: diversity, antenna, wearable, multipath, communication

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A07-121 TITLE: Fabrication of Highly Conductive High Aspect Ratio Nanoflakes for Infrared Obscurant Applications

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

OBJECTIVE: To develop a process to produce at high volume individual highly conductive nanoflakes.

DESCRIPTION: The US Army seeks conductive nanoflakes, with conductivity at or near that of copper. The nanoflakes should have a thickness of 20-50 nanometers and a face diameter of 5-10 microns. These conductive nanoparticles are excellent screeners of infrared radiation and can be used in advanced infrared countermeasure devices, e.g. smoke grenades and smoke pots.

PHASE I: Develop a process to produce 500 to 1000 grams of conductive nanoflakes with thickness of 20-50 nanometers and a face diameter of 5-10 microns. The material will be evaluated in a large aerosol chamber to determine its infrared screening performance. The material must exhibit high extinction values (greater than 8 m2/g) either across the full infrared spectrum or peak in the 3 to 5 micron region or 8 to 12 micron region of the infrared spectrum.

PHASE II: Scale-up nanoflakes process to produce 25 kilogram samples. Perform aerosol chamber test to measure the infrared shielding performance and to characterize the flakes.
Demonstrate that it is feasible to commercially produce conductive high aspect ratio nanoflakes.

PHASE III: These advanced nanoparticles will be used in current infrared smoke grenades, such as the XM76 and XM81, and give enhanced obscuring capabilities for the warfighter. These particles can be used to block all regions in the infrared and only leave a small window (an unblocked infrared region) open for the US Army FLIRs to see through. Other potential military applications include Electromagnetic Interference (EMI) shielding, vehicle parts and combat uniforms. Industrial applications for conductive nanoflakes include electronics, fuel cells and batteries. Conductive nanoflakes can also be used in “taser smoke” applications. The need for conductive nanoflakes in industry is growing with advancement in the technology.

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KEYWORDS: Conductive, nanoflakes, nanoparticle, infrared

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A07-122 TITLE: Enhanced Standoff Detection of Personnel Intrusions using Seismic Sensors

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop seismic personnel detection system incorporating innovative signal processing that extends detection range and discriminates against non-threat seismic sources. Significantly increased detection range over current Commercial Off-The Shelf (COTS) and military seismic sensors enables greater spatial coverage with fewer sensors, as demonstrated with Phase II sensor system that also discriminates personnel movement from seismic clutter of urban areas.

DESCRIPTION: COTS and military seismic sensor systems for unit protection detect personnel at maximum ranges that are significantly less than what is feasible. Results from intruder trials in rural Enfield, NH and at Yuma Proving Ground, AZ emphasize that characteristic features of personnel movement are apparent in raw seismic data at distances much greater (up to 10x) than the detection ranges currently attainable with unattended seismic sensors (Lacombe et al., 2006; Peck et al., 2006). Increasing detection ranges through innovative algorithm development would extend standoff threat detection attainable with sensors outside occupied positions and, through greater sensor spacing, reduce the number of seismic sensors and deployment time required to secure a perimeter. Algorithm development for enhanced standoff detection also would incorporate innovations to enable reliable sensor operation in seismically cluttered environments, such as normal traffic outside a base camp entrance.

To ensure universality of use regardless of soil type, state of the ground (frozen/thawed, dry/wet) or ground cover (vegetation or snow), the seismic sensor developed for personnel detection must be independent of or adjustable to ambient site conditions. Full utilization of seismic intrusion detection requires a high probability of detecting footsteps against various backgrounds of culturally-induced seismic noise. Current sensors are rendered inoperative at fairly low seismic noise levels; this is a legacy of their development to remotely monitor unoccupied sites. Seismic detection now is directed at tactical operations and expedient security at fixed installations, which typically means battery operation, small size, direct burial and wireless communication of alarms from sensor to monitoring point. An advance over current sensors would be wireless communication to the sensor for such purposes as sensitivity adjustment or algorithm selection based on ambient site conditions. The Phase II prototype seismic sensor system will incorporate an innovative personnel detection algorithm with COTS hardware for sensing, signal processing and communication.

The seismic sensor system must reliably discriminate against seismic signals generated by idling or moving vehicles, and against footstep-generated signals originating from non-threat sectors. With the latter, seismic signals arriving from user-specified sectors are excluded from alarm generation; this feature makes feasible deploying seismic sensors in proximity to legitimate personnel activity, such as a base camp, while still maintaining a detection capability for intruders operating outside the camp perimeter.

PHASE I: Phase I focuses on detection methodologies. Major classes of candidate methodologies are identified and tested against CRREL-provided seismic data to assess their effectiveness in terms of personnel detection range and avoidance of nuisance alarms due to vehicle activity. The data represent sensor operation under benign conditions with low level cultural activity and only slight masking of the target footsteps. The poorer performing methodologies are eliminated, and a plan for more rigorously evaluating the remaining candidates under Phase II is developed.

Deliverables are a report on the elimination testing of the detection methodologies, a plan for further evaluation under Phase II, and design concepts for both discrimination against non-target seismic sources and ensuring detection capability under variable ground conditions.

PHASE II: Phase II develops, demonstrates and validates a signal processing concept and a prototype sensor for personnel detection that meet the detection range requirements set in Phase I. Detection methodology is finalized following testing against seismic data of moving personnel in semi-urban and urban settings, using trial data obtained from scenarios approved by the project monitor. Phase I design concepts are implemented and tested. A prototype personnel seismic sensor system is constructed, tested and demonstrated. The detection capabilities of single and networked sensors are documented.

Deliverables are a prototype sensor system with personnel detection algorithms, and a report on its test and evaluation in stand-alone and networked modes.

PHASE III: After commercialization of the seismic sensor system, seismic detection of personnel movement will no longer be restricted to seismically quiet areas without vehicle or other cultural activity. The seismic sensor system could fill a gap in the sensor options for comprehensive installation security available to an agency, such as the U.S. Army Corps of Engineers Electronic Security Systems (ESS) Mandatory Center of Expertise, when developing protective designs for military and civilian facilities in urban settings. The personnel detection sensor will enable covert, expedient, standoff detection of threat activity against military installations and critical infrastructure in areas with high seismic clutter. [ESS concurs with this statement.]

The seismic sensor system will be represented in decision aids for sensor selection and sensor deployment that are developed from Adaptive Protection research conducted in conjunction with ATO IV.EN.2005.04, Modular Protective Systems for Future Force Assets. Unit Protection and Forward Operating Base force protection in seismically cluttered environments will have an operational advantage of detection coverage in areas denied to troop observation or patrolling.

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Peck, L.; Gagnon, J.; Lacombe, J. (2006). Seismic detection of personnel:
Field trials with REMBASS-II and Qual-Tron sensors. ERDC/CRREL TR-06-4.

KEYWORDS: Sensor, seismic sensing, footstep detection, personnel detection, seismic signatures, standoff

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A07-123 TITLE: Novel Representations of Elevation Data

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop novel representations of terrain elevation data, which reduce the burden of storage, transmission, manipulation, and/or display of the data. The government also desires software to transform existing representations of elevation data to and from the novel representation.

DESCRIPTION: The problem:
Urban warfare poses unique challenges for the Future Combat System (FCS) and other army systems, which need high-fidelity knowledge of the shape of the Battlespace. Dense networks of elevation data are needed to represent the complex shape of an urban landscape. Today there are sensors that can supply high-resolution elevation data, but the size of the data sets make the data difficult to transmit, store, manipulate, and display. (Registration, production, editing, and validation of elevation data are difficult problems, as well, but these are not addressed in this solicitation.)

The shape of the terrain is an important component of the Battlespace. Applications like line-of sight or drive through in an urban area need high-resolution terrain data to answer such questions as: is one building or two? Can a vehicle pass between two buildings? Is there a passage way between buildings? How high are the buildings? What can I see from a given location? Data of this fidelity is costly to store and transmit.

The State of the Art:
The current state of the art is to represent elevation data in a digital elevation model (DEM). The most common military representation of elevation data is Digital Terrain Elevation Data (DTED). In DTED, elevations are recorded at a rectangular grid of points. Only the z-value of the point is stored in the DEM, and the x-y location of the point is determined by the storage location of the point within the DEM, along with meta data parameters. DTED Level 2 is available over much of the world; a cell of DTED Level 2 contains about 1.6 mega bytes of data. Light Detection And Ranging (LIDAR) DEM's exist over selected areas; a one-meter LIDAR DEM, covering the same area as a cell of DTED Level 2, could contain 900 times as much data as DTED Level 2, even if the LIDAR is not floating point.

The New Idea:
The Government seeks alternative representations of elevation data which reduce the burden of storage, transmission, manipulation, and/or display, yet, when expanded, accurately represent the shape of the terrain. The government also desires software to transform existing representations of elevation data to and from the novel representation. The software must accept elevation matrices as input; additional input might be a sensor representation such as a LIDAR point cloud from nadir or terrestrial-based. The government desires metrics which measure the effectiveness of the novel representation.
Currently transmission of the data is via external hard drives which require hand carrying the data or mailing the data.

The software should be able to fuse DEMs of different densities, retaining the fidelity of each input DEM, but not incurring the cost of representing both DEMs at the same density.

The representation should be capable of expansion to a DEM, if a DEM is desired. Possibly, the representation can admit expansion to a user-selected fidelity and over a user-selected x-y extent. Elevations matrices can be either integer or floating point format.

An example of an alternative representation of DEM's is a triangulated irregular network (TIN). This solicitation is looking for novel representations of DEM's, not for TIN's.

Likewise, this solicitation is not looking for novel sensor designs.

If proposals use terminology like "three-dimensional" or "two-dimensional", the Government requests that these terms be used in compliance with the spirit of ISO19107, "Geographic information – Spatial schema".

Impact:
To avoid confusion, we should mention two areas that are not directly related to this work. This BAA is not about finding a better display format for the Modeling and Simulation community. Also, this BAA is not about feature extraction. However, any user of high-resolution elevation data will benefit from this novel representation.

An efficient representation of elevation data will better meet the needs of FCS and other Army systems. An efficient representation of elevation data will benefit all users of these data, just as users of imagery benefit from a format like JPEG. A better representation of elevation data will improve the transmission of these data for applications such as Mission Planning, Intelligence Preparation of the Battlefield, and Dismounted Maneuver. Planning, rehearsal, and execution of military operations will be enhanced by a better representation of the urban battlefield. With an improved representation, high-resolution elevation data can be transmitted to the soldier in the field.

PHASE I: Complete a research plan and demonstrate the feasibility of this plan. The research plan will include identification of input data, methodology of solving the problem, plan for developing metrics of success, and a schedule. The contractor will develop a plan to test their software.

PHASE II: Follow the research plan of Phase I to develop one or more representations of elevation data, together with software that transforms existing representations of elevation data to and from the new representation. Develop and demonstrate metrics that quantify the effectiveness of the representation.

PHASE III: Phase III will result in a commercially-available/supported software suitable for use on a desktop or in a service-oriented architecture. Rapid access to compact elevation data will support data exchange in bandwidth-constrained environments and the generation of decision aids such as intervisibility, slope, aspect, and shaded relief products.

The software will be used by military geospatial analysts requiring elevation data for analysis. Upon successful demonstration of this capability in the Joint Geospatial Enterprise Services demonstration, this transition would be funded by the target programs. Next it will be integrated in components of the Distributed Common Ground Station - Army (DCGS-A) and elements of the Future Combat Systems.

The software, which will be designed to be compatible with commercial Geographic Information Systems (GIS) software (e.g., ARC GIS) could also be used in a variety of non-military applications requiring access to compact elevation data, including homeland security, emergency management, urban planning, and architectural design. Technology transfer to commercial users will be primarily through professional papers, trade shows, coordination and integration with GIS software vendors, and traditional commercial marketing channels.

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2) ISO19107:2003 Geographic Information – Spatial Schema
http://www.iso.ch/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=26012&ICS1=35

KEYWORDS: Elevation, DEM, DTED, Compression, Urban Battlespace

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A07-124 TITLE: Geospatial Database Generation Agents

TECHNOLOGY AREAS: Information Systems, Battlespace

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To develop software agents to automatically create and update geospatial databases by mining open source text, tables, and non-spatial databases.

DESCRIPTION: This topic will develop the technology to populate the geometry and attribution of geospatial databases with information mined from open source text, tables, and non-spatial databases. As an example, the National Geospatial-Intelligence Agency's (NGA) Geographic Names Data Base (GNDB) includes the names and locations of populated places, but does not include population information. The software developed under this effort would be able to search the web for sources of population information, mine and evaluate the information, and add the details to the GNDB.

There are a number of technical challenges required to solve this problem for which new research is required. The solution must contain an intelligent spider to locate relevant geospatial text sources, a spatio-temporal parsing component to extract and validate place names and times, a text parsing component to identify the specific information of interest, a coordination component to associate places with the relevant information, a reasoning component to weigh potentially conflicting sources, and a data management component to store and transform the disparate data.

The software developed under this topic would be able to address a wide variety of questions, not just the population example cited above. It would be able to locate and extract other cultural information, such as political structure, religious affiliation, and ethnicity, as well as terrain information, such as elevation, area, or land use. It would also be able to identify relationships, such as finding all the features of a specific type within or near another feature, i.e., all the villages in a specific province or all the hospitals in a town.

PHASE I: In Phase I, the Contractor will design the concept, develop approaches, and demonstrate the software components required for a geospatial database generation agent. All aspects of the problem, from locating and extracting the information, managing conflicting data, and updating the database will be exercised. The Contractor will add population data to the NGA gazetteer for populated places in a small country.

PHASE II: In Phase II, the Contractor will integrate the software components and refine the technical approach. The contractor will demonstrate a prototype application integrated as a standalone application and web service. The demonstration will address a broader class of applications, including creating a names database by capturing the names and locations of places, adding population data to a large country using the NGA gazetteer, finding additional variant names for places in the NGA gazetteer, identifying related places of interest to a town, and listing the hospitals in a province.

PHASE III: In Phase III, the Contractor will productize the software as a standalone application and web service and integrate it with other commercial geographic information system (GIS) applications.

This software is applicable to intelligence, cultural, and engineer-related applications in the Army. It is especially relevant to military intelligence systems, such as the Army's Distributed Common Ground System (DCGS-A) and the Special Forces' Asymmetrical Software Kit (ASK). With the proposed capability, these systems could rapidly assemble new geospatial intelligence which is not available in traditional Department of Defense geospatial databases. They will have the agility to generate structured feature, attribute, and relationship information to support geospatial analysis on a rapidly changing battlefield.

The same technology would be applicable to the diverse GIS community, which is responsible for collecting and managing dynamic geospatial data in similar environments. Specific sectors would include Homeland Security, Law Enforcement, Public Safety, Business Intelligence, and Demographics.

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KEYWORDS: Named Entity Extraction, Geoparsing, Data Mining, Agents

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A07-125 TITLE: Passive Imaging Millimeter Wave Polarimeter System

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: Design and construct passive MMW polarimeter system providing video imagery for each of the four Stokes parameters and the brightness temperature. The system must have low power requirements, and be compact and lightweight with the potential of fitting on a tactical Unmanned Aerial Vehicle (UAV) for mapping terrain features.

DESCRIPTION: A capability to rapidly identify, map, and classify natural and manmade terrain features such as state of the ground and disturbed soil in cluttered backgrounds is one of the soldier's most difficult challenges. Potential surfaces and materials requiring location and identification to promote situational awareness and provide for mission and tactical planning may be in the open or obscured by foliage, camouflage, or other man-made or natural materials. Most passive millimeter wave (MMW) sensing systems seek only the brightness temperature of objects at the sensor's frequency that provides some detection discrimination. However, non-imaging passive MMW polarimeters have demonstrated that the Stokes parameters can provide valuable additional information allowing objects to be characterized, identified, and discriminated from backgrounds (Stokes, 1852). This is especially important when features are partially obscured by vegetation or weather, are imbedded within complex backgrounds, or where brightness temperature alone is insufficient for detection or characterization because there is little contrast between the object of interest and the background (Schroth, et al, 1998; Kutuza and Zagorin, 1998).
Small, non-imaging polarimeters operating in the 35 GHz to 95 GHz range providing the four Stokes parameters have been developed. These sensors are sufficiently small to fly on a tactical UAV. However, these instruments only provide point information – they are not imagers. Imaging and video capabilities that provide the four Stokes parameters and brightness temperature are important because shape and position are also critical identification tools. Battlespace terrain features, materials and conditions not identifiable in non-polarized visual or MMW images may become clearly visible in one or more MMW Stokes parameters. In addition, as with multispectral imagery, Stokes parameters may be manipulated (for example, by ratioing the second and first Stokes parameters) to obtain even more information retrieval capability.
Small, robust microwave imaging MMW polarimeter systems that are capable of being mounted on tactical and larger UAVs, and helicopters, that map and identify natural and manmade terrain features and state of the ground, are not available. Innovative, small airborne microwave imaging polarimeters that map terrain Stokes parameters are needed for creating maps for mission and tactical planning. Such a system should be relatively inexpensive, require low power, occupy a small volume in the aircraft nose or leading edge of a wing, and be lightweight. Antennas should have a form factor that will allow mounting on a small aircraft and yet have a capability for imaging from a moving platform (Lahtinen et al, 2003). This will require innovative antenna technology to fit a small aircraft and yet passively collect sufficient energy to provide usable resolution and frame rates.

PHASE I: Develop and document theory and engineering plans that will demonstrate the feasibility and capability of designing and fabricating an imaging polarimeter that will provide real-time video of the four Stokes parameters from a small moving platform such as a tactical UAV. Develop detailed analyses and simulations of expected performance video imaging natural and manmade terrain features, state of the ground, disturbed soil and other characteristics. A system should provide resolution and frame rates sufficient for surveillance and reconnaissance use. Highlight innovations. Preferred frequencies are 30-40 GHz and 89-95 GHz. The system should provide four Stokes parameters and brightness temperature. Deliverable should be a report and briefing containing theory, simulation, engineering design and operational specifications. A functioning breadboard laboratory demonstration of the proposed design would be a significant plus.

PHASE II: Produce operating prototype video imaging polarimeter system based upon Phase I theory, design, and simulation. Prototype should have a near-production form factor for flying on tactical UAV. System should be constructed and demonstrated in a near-operational environment by flying on a small aircraft, and all specifications should be tested, demonstrated, and verified with government participation. A unit should be provided to the government for testing. Required Phase II deliverables will include documentation that system performs to design specifications and a report describing capability.

PHASE III: The proposed MMW polarimeter imaging system will enhance RSTA sensor designs and detection capabilities by affording enhanced target and background characterization thru the four Stokes parameters. Operationally, the proposed system would be a small manned or unmanned air platform payload operating alone or complimenting onboard electro-optical or other MMW sensors. The polarimeter imaging system would, for example, compliment the fielded optical Buckeye System, and would provide independent image identification capabilities related to urban and change detection mapping mission. Because the proposed system addresses TRADOC's Future Force Capability Gap 6 – Enhanced Collection, Exploitation, and Dissemination it has been endorsed by PEO IEW&S which could transition the technology into operational use, specifically through the Reconnaissance, Surveillance and Target Acquisition (RSTA) program.

Since Stokes Parameter imaging also provides unique characterization of non-military objects and backgrounds there are numerous civilian applications within border patrol, search and rescue, law enforcement, and geology, land use, urban planning, and agricultural assessment mission areas.

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KEYWORDS: microwave radiometer, polarimeter, Stokes parameter, UAV, imaging, video, mapping, terrain, disturbed soil, millimeter wave

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A07-126 TITLE: Optimal Intervisibility Site Selection

TECHNOLOGY AREAS: Information Systems, Battlespace

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: To develop intervisibility software that optimizes the locations of observers/sensors for maximized coverage.

DESCRIPTION: This topic develops the technology to maximize visual coverage of specific areas of interest in the battlespace, while minimizing the number of assets required for that coverage.

The software will solve two specific problems: 1) find and locate the minimum number of observers/sensors for complete coverage over an area of interest (AOI), and 2) given N observers/sensors, find the maximum coverage of the area of interest and locate the positions of the N observers/sensors. A Digital Elevation Model (DEM) containing the elevation of the earth's surface, vegetation, and manmade structures will serve as the basis for the analysis.

The user should be able to specify excluded observer/sensor locations as well as whether the observers/sensors can be located inside the AOI, outside the AOI, or both inside and outside the AOI. Observers/sensors will be defined at a minimum by their height, horizontal and vertical azimuths, and range. The user should be able to specify the characteristics of each observer/sensor in the list of N observer/sensors.

This problem is particularly difficult, because it is time-consuming to compute the visibility at every location on a DEM and geomorphometric indicators are imperfect identifiers of points of maximum visibility. In addition, given the potentially combinatorially large number of locations observing an area of interest, it is challenging to find the optimal combinations of sensor/observer locations.

This research will require innovative solutions to reduce the search space for selecting candidate observer/sensor locations, to improve techniques for rapidly calculating line-of-sight, and to develop heuristics for selecting the appropriate combinations of observer/sensors.

PHASE I: In Phase I, the Contractor will design the concept, develop approaches, and demonstrate the software components required to 1) find and locate the minimum number of observers/sensors for complete coverage over an area of interest, and 2) given N observers/sensors, find the maximum coverage of the area of interest and locate the positions of the N observers/sensors. The Contractor will test and demonstrate the concept on two small DEMs (1200 x 1200 matrices of elevations) representing urban and open terrain. The DEMs will be stored in a standalone file.

PHASE II: In Phase II, the Contractor will integrate the software components and refine the technical approach. The contractor will establish performance parameters through experiments and demonstrate a prototype application integrated with the Commercial Joint Mapping Toolkit environment as a standalone application and web service. The tests will be done on large DEMs (12000 X 12000 matrices of elevations) representing urban and open terrain. The DEMs will be stored in a commercial relational database.

PHASE III: In Phase III, the Contractor will productize the software as a standalone application and web service that operates in the Commercial Joint Mapping Toolkit (CJMTK) environment and integrate it with other commercial geographic information system (GIS) applications.

This software is relevant to mission planning and line-of-sight applications in the Army, especially those associated with the Army's Distributed Common Ground System (DCGS-A). The same technology is essential for border monitoring and infrastructure protection related to Homeland Security, as well as antennae siting for the telecommunications industry.

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KEYWORDS: Visibility, Intervisibility, Digital Elevation Model (DEM), Viewshed, Optimization, Multi-Observer Siting

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A07-127 TITLE: Spatio-temporal data modeling

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a spatio-temporal data model that models transition, mutation and movement, while preserving the historical information of an entity or process.

DESCRIPTION: The Global War on Terrorism and Peace Keeping and Stability missions have created a need for modeling the dynamic nature of the geospatial environment in a database. Mapping agencies are no longer the sole source of geospatial data for the Army geospatial analyst. Geospatial data can be captured from cell phones, PDAs, and terrestrial sensors and used in geospatial analysis. Ephemeral phenomena such as demonstrations, refugee migration routes, or funeral processions can now be represented in a spatial information system rather than as a hardcopy map overlay. Cell phone and text messaging technology can quickly spread information about these real time events and quickly change their nature. It is crucial that the Army has a method by which temporal information can be stored and used for prediction and analysis.

Vector-based Geographical Information Systems (GISs) are increasingly being used to store, display and analyze non-traditional geospatial information. The GIS has progressed from a system containing cartographic data to a system containing geospatial information. This is a shift from representing physical objects, such as buildings, to representing temporal and non-temporal objects and phenomena. A temporal object, such as a check point, has historical value, and would be maintained in the database beyond its expiry. Other phenomena being mapped range from terrestrial sensor readings to cultural events, such as pilgrimage routes.

It can be said that geospatial information consists of theme, location and time. Theme describes the phenomenon or object being observed, location describes the place of observation, and time describes the moment of observation. A geospatial object may undergo eight possible spatio-temporal changes. These consist of: 1) no change, 2) change in geometry, 3) change in topology, 4) change in attribute, 5) change in geometry, topology and attribute, 6) change in topology and attribute, 7) change in geometry and attribute, and 8) change in topology and geometry. Maintaining these changes in the GIS database facilitates broader query and analysis, and is the goal of this solicitation.

The chosen modeling technique should manage transition, mutation and movement. Transitional changes describe an entity as it moves from one form of depiction to another, for example, from a point representation to an area representation. Mutation would describe a feature that changes so much that it no longer resembles itself and must be reclassified. For example, a demonstration could become a riot. An example of feature movement is the migration of refugees. In all these examples it is important to maintain the genealogy of the feature because it provides historical information and context.

We are seeking an innovative solution that will efficiently model the transition, mutation and movement of spatio-temporal data while effectively preserving the historical data.

PHASE I: The contractor shall accomplish the following research goals: 1) develop and demonstrate a prototype data model that effectively models spatio-temporal data in a GIS, 2) demonstrate that the model supports various concepts of time, such as valid time and transaction time, 3) demonstrate that the model supports the geometry, attribute and topology changes that can occur to a feature over time, 4) document the findings in a report.

PHASE II: The contractor shall accomplish the following research goals: 1) refine the model developed in Phase I, 2) provide a robust spatio-temporal query language, 3) demonstrate the value of the model by performing complex spatio-temporal querying and analysis, 4) create a logical data model and a mechanism to generate a spatio-temporal database schema from the logical data model, 5) test and optimize the model for maximal performance on a large

GIS database. The contractor will provide a report documenting the modeling method; document the results of experiments and any new discovered knowledge or limitations of the model. In addition, the contractor will perform a demonstration of the versatility and robustness of the model.

PHASE III: This SBIR would result in a spatio-temporal data model for vector data, which would provide benefits in the civil and military communities by providing a mechanism for performing spatio-temporal querying and analysis. Static, mobile and airborne sensors provide data that is temporal in nature. The ability to model this data in a temporal geospatial database is powerful. Current analysis that discovers spatial trends can be extended to support valid time. This capability supports the Distributed Common Ground System – Army (DCGS-A) by allowing systems, such as the Digital Topographic Support System (DTSS) to use sensor data to augment their analysis.

This SBIR would provide benefits in the commercial sector in areas such as environmental monitoring and impact assessment, resource management, decision support, and transportation scheduling.

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KEYWORDS: Spatio-temporal, geospatial, data modeling, GIS, feature data

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A07-128 TITLE: Functionalization of Carbon Nanotubes into Materials with High Compressive Strengths

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective is a new process by which typically hydrophobic carbon fullerenes can be integrated into matrix materials such as concrete and ceramics with minimal loss in the intrinsic tensile strength and conductivity of carbon-based fullerenes. Accomplishment of this objective will lead to new high-performance smart materials for civil and military applications.

DESCRIPTION: The functionalization of carbon nanotubes is used to refer to innovative means or processes whereby the unique properties of the graphene lattice are translated up to a macroscopic material level. The resulting composite should be chemically and mechanically stable and the elements should function together synergistically. When possible, details should be provided as to how the carbon nanotubes participate in the synthesis and failure of the matrix material. The project scope here includes demonstration of a novel functionalization strategy resulting in a new and desirable high-performance material. Potential civil and military benefits are far reaching but obvious examples include new armor panels for vehicles and soldiers or super light-weight and high strength deployable structures for shelter and infrastructure.

To conserve cost, proposers should focus on small-scale testing and evaluation. The first phase will focus on developing and defining a composite material concept which functionalizes carbon nanotubes. At the end of Phase I the proposers should have an initial plan to produce and refine the material and its fabrication process for Phase II preparation. Polymer-based solutions are only sought if they represent a novel and innovative approach. Concretes or similar mixtures should address a solution that deals with known issues such as hydrophobic interaction. End product costs are of less concern than material performance as commercial cost of fullerenes has fallen drastically in recent years. Improved material properties are not limited to strength, but could also include heat resistance or transfer, toughness, superelasticity, and self healing / sensing, for example.

Proposers should cite, demonstrate, or describe an innovative approach to either production of novel fullerene based raw material suitable for functionalization, or a functionalization strategy based on commercially supplied carbon nanotubes. Possible functionalization strategies could take many possible routes as demonstrated by the variety of published research. As an example theoretical and laboratory studies have included: twisting and knotting of "nanoforests", sidewall bonding, dispersed nanotube-polymer composites, bundles or interlocked assemblages, and correction for hydrophobic behavior for inclusion in mixtures such as concrete. Laboratory testing, prior research and/or molecular simulation should be utilized to demonstrate potential material property improvements and fabrication routes prior to Phase II initiation.

PHASE I: Task will focus on the material formulation and feasibility demonstration.
The contractor shall develop the material and demonstrate the required capabilities by conducting necessary laboratory tests.

PHASE II: Task will address the development and evaluation of structural components using the construction material developed in Phase I. Material refinement and subscale validation will be performed in the latter stages of Phase II.

PHASE III: There exists a huge application potential for new high performance materials in the commercial and military arenas, e.g., bridges, buildings, dams, tunnels, roadways, structural armor panels.

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2) T.S. Gates , G.M. Odegard , S.J.V. Frankland , T.C. Clancy, Computational materials: Multi-scale modeling and simulation of nanostructured materials, Composites Science and Technology 65(2005) 2416–2434
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KEYWORDS: impact-resistant, vibration damping, carbon nanotube, composite material, lightweight, new materials, smart material, structural composites, armor units

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A07-129 TITLE: Next Generation Urban Encroachment Models

TECHNOLOGY AREAS: Materials/Processes, Human Systems

OBJECTIVE: Conduct research that will allow the creation of new urban growth models that take into account the 1) attractiveness effect of all parcels on all parcels, 2) prediction of new highways and roads, and 3) estimated future values of value for military, urban, agriculture, and habitat. Current urban growth models are heavily used by cities and states to predict the impact of proposed regional plans on future induced land-use patterns. Adding the ability to predict the construction of new roads will significantly improve the use and impact of these models in dual-use applications.

DESCRIPTION: The Army anticipates a continued development of weapon and vehicle technologies that require ever larger training and testing areas. The urban growth around installations caused, in part, by the economic engine of the installation continues to threaten current missions, let alone future missions and training/testing requirements. To protect Army investments in training and testing areas, participation in local regional planning is becoming more important. Army regional planners need better tools to project the changing urban, and exurban, and rural landscapes that develop in response to regional plans. Current regional growth models need to be improved to better predict future human settlement patterns, including the developement of road systems, that take into account economic changes and developments in the cost and capability of transportation and communication infrastructures.

PHASE I: Current urban growth models require that road and highway construction to be explicitly provided as inputs. Research is required to predict the formation of new roads and highways as a function of transportation needs between points and the economic wherewithall to construct or widen roads/highways. Therefore, in phase one, design and develop a prototype for a next generation regional growth model that can predict future road networks, residential areas, commercial areas, and open space. Publish the design and validate the ability of the model to predict future land patterns and road/highway networks.

PHASE II: Fully develop, demonstrate and validate a regional growth model that predicts the development of current urban patterns over the previous thirty years using input representing thirthy-year old land use patterns, regional economic strength, and communication and transportation technologies. Finalize, validate, and document the capability.

PHASE III: There are three primary applications of the developed technology. First, it will benefit OSD/OEA sponsored joint land use studies (JLUS) that involve joint installation and local municipality planning. Second it will help with the development and defense of Army Compatible Use Buffer (ACUB) proposals. Third, it will provide the Army and OSD with better metrics to complete future Congressional 320/366 reports on urban encroachment on military installations and training areas.

REFERENCES: 1) The Landuse Evolution and Impact Assessment Model (LEAM): http://www.leam.uiuc.edu
2) LEAMram™: Land use Evolution and impact Assessment Model Residential Attractiveness Model: http://www.cecer.army.mil/td/tips/pub/details.cfm?PUBID=5256&TOP=1
3) Fort Knox Trend Analysis, Encroachment Study, and Perimeter Expansion Opportunities in Support of Military Training: http://www.cecer.army.mil/td/tips/pub/details.cfm?PUBID=5628&TOP=1
4) Development of Input Maps for the military Land use Evolution and Assessment Model (mLEAM) Land Use Change (LUC) Simulation Model: http://www.cecer.army.mil/td/tips/pub/details.cfm?PUBID=4936&TOP=1

KEYWORDS: urban growth, encroachment, simulation,

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A07-130 TITLE: <u>Microcontainment System for Photolytically Induced Delivery of Biocide Against Biological Agents</u>

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: The objective is to develop and demonstrate a microcontainment system that can rapidly release biocides to neutralize biowarfare agents when photolytically triggered.

DESCRIPTION: Conventional neutralization technologies rely on large quantities of biocide, such as chlorine dioxide, to be infused into a contaminated facility. However, there is a significant delay between the time of detection and the time that decontamination is conducted. Real-time neutralization of biological warfare agents before multiplication will reduce casualties and insure uninterrupted mission performance under a biological warfare attack. Furthermore, the non-availability of buildings during decontamination is costly and can severely impact the execution of critical missions. Currently there is no real-time micro-delivery system to release biocides for on-demand neutralization of biowarfare agents (BWA), when triggered by the presence of a BWA. Currently used photo-activated release containment systems rely on the use of encapsulated hydrophilic materials in which a lamellar phase change or increase in permeability is induced by absorption of 630-820 nm light. These systems are ideal for drug delivery in biological systems, since they release their contents slowly. However, neutralization of

BWAs requires very rapid release of biocide. Therefore, there is a need to develop micro-containment systems that can be photolytically triggered to deliver on-demand biocides, such as chlorine, which can neutralize biowarfare agents (BWAs) in real-time (i.e, less than 10 seconds).

PHASE I: Develop a micro-containment system for photolytically triggered release of biocides to neutralize biowarfare agents in buildings. Design the micro-containment biocidal delivery system for incorporation in Heating, Ventilation, and Air Conditioning (HVAC) filters and HVAC walls coatings on wall or ceilings of buildings to neutralize spores, bacteria, and viruses using simulants for the biowarfare agents, such as anthrax, in a laboratory setting. Neutralizing biocide could be released from nanocapsules when triggered photolytically, by an external BWA sensor. The biowarfare agent simulants that need to be investigated in a multiplexed situation include at least one from each of the four classes of biowarfare agents: (1) Bacterial spores (2) viruses (3) vegetative bacteria, and (4) bacterial toxins. The technology should have the potential to achieve "kill ratios of at least 99%.

PHASE II: Develop and test, in a relevant environment, biowarfare agent neutralization technology on HVAC filters, and other HVAC surfaces, using a micro-containment system in which the biocide can be released, when photolytically triggered by an external BWA sensor, and can achieve kill ratio greater than 99%.

PHASE III: Future biowarfare agent release could occur in military or civilian buildings such as mailrooms, where packages are received and handled. Thus, this technology has dual use applications: (1) in military systems, particularly in HVAC systems of military buildings on an Installation to protect against BWA attack; (2) In other government buildings, e.g., in Post Office Buildings, and in commercial building HVAC systems, which could be impacted by a terrorist act. The most likely customer and sources of funding will be the U. S. Army Assistant Chief of Staff for Installation Management (ACSIM) and the Army Installation Management Command (IMCOM) for transition and procurement. The technology will be transitioned by the private sector for chemical/biological protection of facilities.

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KEYWORDS: Biological Warfare Agent, biocide, photolytic triggering, microcontainment system, on-demand release

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A07-131 TITLE: Spatio-Temporal Evidential Reasoning

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To develop spatio-temporal evidential reasoning techniques to discover relationships, patterns and connections between diverse sources of spatial and/or temporal data, and to predict and create useful information and evidential models.

DESCRIPTION: Key scientific challenges revolve around the discovery and quantification of relationships between differing information sources with spatial and/or temporal components. Combining the information found in the increasing number of geospatial, cultural, and temporal data sources available provides an opportunity for advanced pattern analysis, recognition, prediction and other inferential methods and approaches. However, little use has been made of the relationships that might exist among all data sources over a particular location and at different times. Relationships can be viewed as vertical, examining all data over a single location, or horizontal, looking at spatio-temporal relationships, such as spatial adjacency or temporal adjacency, that exist in one or more data attributes. There are also significant gaps in attributes for some data sets which can be filled in by evidential or other models. Spatio-temporal evidential reasoning seeks to discover both the vertical and horizontal relationships that exist between various sources of spatially and temporally referenced data and to use these relationships to discover significant patterns and draw optimal inferences given the available evidence.

Military analysts require tools which provide the greatest possible understanding of the battlespace. Advanced models and methods are needed to move beyond the detection and understanding of patterns which are apparent through visual clues or through application of standard geographic information systems (GIS) and statistical methods. These models must also integrate natural and man-made feature information with available temporal and cultural/societal information. In the cognitive hierarchy, spatio-temporal evidential reasoning provides both added value to existing limited data and a value to different decision choices that must be made given the available evidence. The results of this research will also support common homeland defense/homeland security forecasting and predictive analysis needs.

It is anticipated that positive results will support common military and homeland security forecasting and predictive analysis needs, and improve situational awareness through the application of more sophisticated approaches. It is a very straightforward process to group and display certain types of adversary activities in time and space using basic statistical and GIS tools. Uncovering the non-apparent relationships which might drive particular patterns of activity requires the application of advanced methodologies. For example, it would not be immediately obvious that a change in the infrastructure (such as the electrical grid) would influence certain types of adversary activity at certain times, or that a sequence of seemingly unrelated activities over time would provide clues to allow analysts to infer the existence of previously undetected or poorly defined man-made or natural features.

The Army seeks a contractor to investigate methods and to develop software to perform spatio-temporal evidential reasoning so that it can be quickly and efficiently integrated into Army systems. Emphasis is placed on information networks which are useful to decision-making by the intelligence community.

The contractor must have the ability to interface with a GIS to ensure compatibility with both the commercial sector and with existing military systems.

PHASE I: The contractor will accomplish the following research goals: 1: develop and demonstrate prototype software components that predict the presence or absence of significant events such as stationary or mobile attacks; 2: demonstrate the accuracy of the predicted events. The contractor will provide a report documenting the evidential reasoning algorithms, document the results of experiments and any new discovered knowledge, and discuss the accuracy of the predicted events. In addition, the contractor will demonstrate the software components to perform the evidential reasoning.

PHASE II: The contractor will refine and enhance the Phase I development to create an integrated prototype spatio-temporal evidential reasoning software. At the conclusion of Phase II, the contractor will demonstrate and deliver mature, robust spatio-temporal evidential reasoning software that is interoperable with a commercial GIS. This software will demonstrate new tools which can perform on complex data sets. Algorithms and methodologies will be documented so that they can be integrated into Army systems.

PHASE III: This SBIR would result in a technology with broad applications in the civil and military communities by providing a reasoning tool for making decisions from multiple data sources.

In the military sector this tool would be embeddable into systems such as intelligence analysis workstations, command and control, or weapons targeting. More specifically, such a tool could be incorporated into the Distributed Common Ground Systems – Army (DCGS-A) or into either the Survivability Subsystem or the Autonomous Navigation Subsystem of the Future Combat Systems (FCS).

In the commercial sector this tool could be used for emergency management (e.g. FEMA), homeland security and law enforcement, disease outbreak monitoring, and dynamic simulations such as various climate change scenarios.

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KEYWORDS: spatio-temporal, evidential reasoning

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A07-132 TITLE: Automated Condition Based Maintenance

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: The objective of this research proposal is to generate 3-dimensional terrain mission profiles of expected U.S. Army deployment areas. These in-theater 3-dimensional terrain mission profiles (profiles of expected paths tactical and combat vehicles will deploy over) will be used in high fidelity dynamic durability models to predict vehicle component failures. The mission profiles will be extracted from mission planning tools (Environmental Systems Research Institute (ESRI) software) that generate maneuver networks for vehicle routing and logistic. The vehicle paths will require micro-surface terrain inferencing to achieve the level of terrain fidelity necessary to conduct adequate vehicle durability analysis.

DESCRIPTION: The following quote from Defense Update describes the current CBM concept. “The US Army will field a comprehensive "enterprise level" maintenance information system for its ground combat vehicle fleet. The system will integrate existing test and diagnostic equipment to develop fleet wide logistic and situational awareness, implementing modern Condition Based Maintenance service that will enhance the operation and effectiveness of the tactical and combat vehicles of the current force.” The current CBM is focused on real-time monitoring of vehicle components for situational awareness of feet maintenance driven by embedded sensors and external tests. This is the backbone of CBM but not everything necessary to create a successful CBM system. Another area of CBM is the forecasting of expected maintenance issues for planning and projection of the Army logistic footprint. This proposed research would develop a methodology using current research mission planning tools in the Battlespace Terrain Reasoning and Awareness (BTRA) Commercial Joint Mapping Tool Kit (BTRA is a current ERDC ATO and CJMTK is an ESRI software product) to forecast CBM issues and offer products that can be used in high fidelity models for durability analysis. The current shortfall to this forecasting ability is the micro-surface terrain. The micro-surface terrain that creates the high-frequency vehicle vibrations and discrete impacts on the vehicle’s suspension is missing from typical mission planning terrain information used in the BTRA-CJMTK software. This proposal will develop adequate micro-surface terrain inferencing tools to populate standard mission planning terrain information for CBM analysis.

PHASE I: Determine the best approach for cost-effectiveness and product development to collect micro-surface terrain elevation profiles that will be used to create micro-surface terrain inferencing algorithms. In order to generate statistically correct 3-dimensional terrain mission profiles of expected U.S. Army deployment areas, it is necessary to develop a ground truth data based that will be used to generate the micro-surface terrain inferencing algorithms. This phase will determine the adequate resolution of the terrain data and the appropriate method for collecting the terrain information suitable for the development of the micro-surface terrain inferencing algorithms. Since the final product of this SBIR are tools for the BTRA-CJMTK software environments, it will be necessary to gain a detailed knowledge of ESRI software products and how they are used in military mission planning.

PHASE II: If the knowledge gained in phase I of this SBIR is adequate to indicate that ground truth data can be collected cost-effectively and in a meaningful manner sufficient to develop terrain inferencing algorithms, then significant field work will be necessary in this phase. The field work will be focused on collecting adequate terrain information to create the micro-surface terrain inferencing algorithms, but it will also create classes of terrain types used in mission planning represented by primary and secondary roads, trails and cross-country. The inferencing algorithms will be used to statistically populate the extracted mission profiles from the BTRA-CJMTK software with high fidelity terrain information. The phase II product will be software tools implementing the inferencing algorithms designed for the ERSI software environment. These software tools will also automate the vehicle mission profile extraction for use in high fidelity vehicle design software packages such as Dynamic Analysis and Design Software (DADS) and Advanced Dynamics Analysis of Mechanical Systems (ADAMS) which are the front end to standard durability analysis methods. Validation of the inferred terrain types will be made to typical terrain types from historical vehicle test programs. This data is available and applicable to these software tools.

PHASE III: This SBIR research has a good chance to be commercialized through Geospatial Information System (GIS) software. To accurately determine vibration on commercial or military vehicles the high fidelity terrain profile of the vehicles' path is required. This is seldom known except when testing on proving grounds and even then it's an expensive requirement to measure a high fidelity terrain profile. This is used not only for durability analysis but for power and energy development of hybrid vehicles and fuel consumption predictions. The US Army Engineer Research and Development Center is currently developing the BTRA- Battle Command (BC) ATO software package using the CJMTK. This ESRI software environment forecasts in-theater maneuver networks over tactical deployed locations. The products of this SBIR will be integrated into the BTRA-BC CJMTK to assist in forecasting CBM issues during mission planning. These SBIR tools will also be available through the CJMTK for extracting mission profiles for high fidelity vehicle design analysis by The US Army Tank-Automotive Research, Development and Engineering Center (TARDEC) and commercial companies such as General Dynamics Land System.

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KEYWORDS: Condition Based Maintenance, Durability, Mission Planning, Vehicle Modeling, Terrain Inferencing, Maneuver Support, Geospatial Information System

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A07-133 TITLE: Bandwidth Management in QoS Environments Using Wireless Network State Information

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: To provide layer 2 wireless network state information to higher protocol layers, so IP Quality of Service (QoS), transport, and/or application functions can adapt their behavior based on available wireless network/link metrics. To produce mechanisms for providing relevant, timely, and actionable information from layer 2, so the higher layers can self-adjust IP packet handling, data workflow, synchronization, and consumption guided by the network traffic conditions and operational contexts between networked entities.

DESCRIPTION: Ensuring sufficient communications Quality of Service (QoS) levels for mission critical applications is a significant challenge in tactical networks. The predominant approach to address QoS requirements in both military and commercial networks consists of combinations of: network-level enforcement mechanisms that deny or delay lower priority traffic; network-level enhancement/mitigation mechanisms that incrementally improve performance of higher priority traffic or mitigate the impact of lower performance on higher priority traffic; and, contracts/policies that inform human end-users of the QoS distinctions between various applications, connection points, and hours of operations.

An inherent limitation of these current QoS approaches is that they are specifically geared for operation in wireline and/or fixed bandwidth networks and can be limited when applied to tactical wireless (i.e. MANET) networks. These tactical networks, due to mobility, terrain, distance between neighbors etc. have an ever-changing wireless network topology with wireless neighbors also adjusting their individual link rates/bandwidth as propagation conditions vary.

Today's wireline-based end-to-end QoS solutions include individual IP QoS domains, with each domain's QoS capabilities principally executed at the IP layer via DiffServ-based, or for some application services, IntServ-based solutions. The general solution consists of IP QoS domain-edge functions that include traffic marking, policing and shaping and IP QoS domain-core functions that consist of the per-hop behavior packet scheduling functions for the individual service class queues.

The IP QoS network designs, based on the above model, operate at the IP layer, and since static, fixed bandwidth links are assumed, no cross-layer information is required from the layers below (i.e. layer 2) to the IP or higher layers (i.e. transport, application) to manage overall QoS. Due to the topology and link dynamics of a tactical wireless network, information on these dynamics would help drive the IP packet scheduling policies and/or transport/application configuration and performance.

The objective of this SBIR is to empower the IP layer, transport layer, and/or applications with relevant, timely, and actionable information from the wireless link/MAC layer (layer 2), so some level of informed judgment can be applied to shape those network and higher layer policies.

The technology described within this topic is soliciting Research & Development - i.e., projects involving a degree of technical risk- rather than procurement.

Phase I: Phase I will be a technical analysis and feasibility study to determine an appropriate demonstration scenario and environment to demonstrate the innovative solution prototype during Phase II. The offerer will identify the specific technical barriers that will need to be overcome in building the prototype, characterizations of the barrier's relative risk and complexity, as well as proposed approaches to address them. The feasibility study will also provide a technical and operational walkthrough of the proposed prototype's design approach, composition, operational behavior, and design assumptions. The feasibility study should also define the presumed operational scenario for demonstrating the effectiveness and value of the prototype.

Phase II: The scope of the Phase II prototype will be to execute and demonstrate a solution that will enable wireless network layer 2 information to be used to manage QoS, transport, and/or application policies. The solution may include external network agents or external hardware (including software). Solutions that can adapt layer 2 information as relevant to wireless networks and/or applications are desirable.

This final work product should be supported by any other documentation necessary for the government to make a well-informed Phase III decision.

Phase III: During this phase, the Phase II software and/or hardware deliverables shall be implemented, integrated, tested, and certified for Army operation. The Phase III business implementation plan approved by the government shall be developed and delivered via documented hardware and software (both executable and disclosure of source code) along with all necessary documentation and testing, compatibility, and performance results.

The end-state demonstrated prototypes being researched within this topic will have dual-use value in commercial and government application. Potential commercial market applications for this innovation include any wireless data network (i.e. MANETs) supporting organizations with applications with demanding QoS requirements. This includes “first-responder” applications as well as emerging multimedia markets. The vendor is responsible for marketing its demonstrated prototypes for further development and maturation for potential Post-Phase II transition and integration opportunities including actual military Programs of Record and any dual-use applications to other government and industry business areas.

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KEYWORDS: QoS, MANET, Layer 2, Wireless, Mobile Networking, Link Layer,ad-hoc networking

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A07-134 TITLE: Small Aperture X-Band Antenna (SAXBA)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: This project is to demonstrate a small form factor (less than one cubic foot), low cost, vehicular military satellite antenna to provide situational awareness and other command and control capabilities to mobile tactical users at platoon and above

DESCRIPTION: Providing Situational Awareness (SA) in a non-linear battlefield is critical to effective command and control. The Army’s recent experience in IRAQ and Afghanistan demonstrates that command and control of mobile and widely dispersed forces is very challenging. Satellite communications are a critical component of the battlefield communications strategy; however, existing satellite antenna technologies for mobile and On-the-Move (OTM) operations are limited and very expensive. The antennas and tracking mechanisms for these systems also carry a significant size, weight, power, and logistical burden.

The Army is very interested in obtaining a Small Aperture X-band Antenna (SAXBA) that is capable of sustaining OTM communications. This SAXBA solution must also utilize an electronic antenna in order to eliminate the need for a mechanical tracking mechanism, which would enable these systems to be more reliable, and require less power and maintenance support. A strong preference will be give to systems that are significantly less expensive than existing technologies so that more vehicles can be equipped with OTM satellite capability.

Another inherent limitation of current mobile SA systems is the reliance on commercial satellite bands for extended operations. These commercial systems lack security, assured access and jam resistance. These limitations significantly affect military operations since the essential beyond line of sight communications is costly, less secure and subject to service denial.

Development of an affordable, small form factor, OTM X-band capability will enable the Army, Homeland Defense, and other government organizations to deploy OTM satellite communications to tactical vehicles.

The objective of this SBIR is to demonstrate a low cost antenna at cost points that favorably compare to commercial systems and provide the security and interference tolerance that is required in the modern non-linear battlefield.

PHASE I: Phase I will be technical analysis and feasibility study to determine an appropriate demonstration scenario and environment to demonstrate the innovative solution prototype during Phase II. The offerer will identify the specific technical barriers that will need to be overcome in building the prototype, characterizations of the barrier's relative risk and complexity, as well as proposed approaches to address them. The feasibility study will also provide a technical and operational walkthrough of the proposed prototype's design approach, composition, operational behavior, and design assumptions. The feasibility study should also define the presumed operational scenario for demonstrating the effectiveness and value of the prototype.

PHASE II: The scope of the Phase II prototype will be to execute and demonstrate a solution that will support a common forward data rate (from satellite to the vehicle antenna) of 16 kb/s and a reverse satellite link data rate (from the antenna to the satellite) of 8 kb/s with up to 5 simultaneous users, while traveling at 40 mph.

This final work product should be supported by any other documentation necessary for the government to make a well-informed Phase III decision.

PHASE III: During this phase, the Phase II hardware and software deliverables shall be implemented, integrated, tested, and certified for Army operation. The Phase III business implementation plan approved by the government shall be developed and delivered via hardware components and any documented software (both executable and disclosure of source code) along with all necessary documentation and testing, compatibility, and performance results.

The end-state demonstrated prototypes being researched within this topic will have dual-use value in commercial and government application. Potential commercial market applications for this innovation include Homeland Defense, first-responders, and local and Federal government organizations. The vendor is responsible for marketing its demonstrated prototypes for further development and maturation for potential Post-Phase II transition and integration opportunities including actual military Programs of Record and any dual-use applications to other government and industry business areas.

REFERENCES: 1) "The Army Future Force: Decisive 21st Century Land Power", August 2003, USA TRADOC, http://www.army.mil/thewayahead/acpdownloads/Future%20Force%20Blg%2003%20Final1.pdf
2) "Technology challenges for satellite communications on-the-move", 2001, Gouker, Battle Command Battle Labs – Gorgon, http://www.gordon.army.mil/AC/Summer/Summer%2001/satmove.htm
3) "Joint Vision 2020", 2000, Joint Chiefs of Staff, http://www.dtic.mil/jointvision/jvpub2.htm

KEYWORDS: Satellite, X-Band, On-the-move, OTM, antenna, satellite On-The-Move, SOTM

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A07-135 TITLE: MEMS Enhanced Laser Spectrometer for Ultra-sensitive Toxic Chemical Detection

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

OBJECTIVE: Develop a miniature, MEMS enhanced tunable laser spectrometer sensor for broad range detection and identification of Chemical Warfare Agents and Toxic Industrial Chemicals (TICs).

DESCRIPTION: The Joint Services have the need for a miniature, highly sensitive and yet highly specific (low false alarm) sensor for detection of toxic industrial chemicals. Infrared absorption spectroscopy has proven to be a very useful tool in the detection and precise identification of airborne chemicals. Pattern recognition is used to compare the infrared spectrum of library molecules against the infrared spectra of airborne contaminants. Infrared spectroscopy has been used to detect chemicals at extremely low concentrations with detection limits comparable to standard methods such as ion mobility spectrometry (IMS) and surface acoustic wave spectroscopy (SAWS). Infrared spectroscopy also holds the promise of very low false alarm rates due to the spectral pattern matching over a large number of spectral bins. Infrared spectrometers can also provide quantitative information regarding cloud concentrations. Infrared spectrometers have rapid response and clear-down times, which provide utility in cloud tracking or dynamic monitoring experiments.

However, current infrared spectrometers are large and expensive or small and relatively insensitive. The size, weight, and power requirements of current infrared spectrometers have limited their utility in field environments.

In recent years there has been much activity in developing tunable laser based infrared absorption spectrometers which are capable of extreme sensitivity and spectral resolution. They have enabled IR absorption measurements over relatively long paths (in multipass cells) and exhibit spectral resolution easily capable of discriminating isotopic species. An appropriately designed system could be configured for high sensitivity in detecting Chemical Warfare Agents and TICs in the environment. Further application of the technology to bio-aerosol detection may also be possible. There may even be potential for short-range standoff operation. The problems of adequate tuning range, wavelength monitoring and stability while managed in larger systems, represent a challenge in miniaturized devices which could be amenable to MEMS solution. A miniature tunable laser IR absorption spectrometer would be extremely small and consume much less energy than the extant units. Miniature lasers with MEMS monitoring should allow for compact devices more amenable to substantial cost reduction.

The goal of this program is to develop an extremely sensitive miniature sensor system with very low false alarm rates that is approximately 1800 cm3 or less in size, including power supply. The sensor should run on standard batteries without an outside power source.

PHASE I: Design a tunable laser based infrared chemical sensor. The initial brassboard design should include selection of laser(s), analysis to indicate adequate spectral coverage for the defined military threats, selected TICs and military interferents. Modeling of anticipated sensitivity and the limiting source of noise should be addressed.

PHASE II: Fabricate the laser diode based chemical sensor. While the brassboard developed in Phase I need not meet all size and weight constraints, a definitive and practical analysis indicating the path from brassboard to prototype should be defined with weight, power and size limit goals by major subsystem. Measure the sensitivity to selected simulants and establish the limiting noise source. Using a recognition algorithm of choice, determine the variance possible in wavelength and amplitude vs. false alarm rate.

PHASE III: Prototype will undergo testing and analysis against a wide range of chemicals in order to define operational parameters and to determine if the device will meet operational requirements as defined by the Joint Chemical and Biological Defense Program. There are numerous environmental applications for a small ultrasensitive, chemical detector/identifier. A rugged, ultrasensitive and flexible chemical detector will benefit the manufacturing community by providing very finely tuned monitoring of chemical processes and associated emissions. Also, first responders such as Civil Support Teams (CST) and local fire departments have a critical need for a relatively inexpensive but versatile and rugged sensor that can be transported to the field to test for possible contamination of various chemicals to include CW agents. The potential for short-range standoff capability enhances this utility.

REFERENCES: 1) J. Reid, M. El-Sherbiny, B. K. Garside, and E. A. Ballik, "Sensitivity limits of a tunable diode laser spectrometer, with application to the detection of NO2 at the 100-ppt level," Appl. Opt. 19, 3349- (1980).
2) D.D. Nelson, J.H. Shorter, J.B. McManus, M.S. Zahniser, “Sub-part-per-billion detection of nitric oxide in air using a thermoelectrically cooled mid-infrared quantum cascade laser spectrometer”, Journal Applied Physics B: Lasers and Optics, Issue Volume 75, Numbers 2-3 / September, 2002, Pages 343-350.
3) J. Podolske and M. Loewenstein, "Airborne tunable diode laser spectrometer for trace-gas measurement in the lower stratosphere," Appl. Opt. 32, 5324- (1993).
4) M. Nägele, M.W. Sigrist, “Mobile laser spectrometer with novel resonant multipass photoacoustic cell for trace-gas sensing”, Journal Applied Physics B: Lasers and Optics, Issue Volume 70, Number 6 / June, 2000, Pages 895-901

KEYWORDS: Chemical detection, tunable laser, MEMS, Infrared spectrum, IR

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A07-136 TITLE: Technology for Detection of Chemicals in Extreme Environmental Conditions

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: JPEO Chemical and Biological Defense

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

OBJECTIVE: To develop a field rugged colorimetric sensor for passive detection of chemicals to include chemical agents.

DESCRIPTION: Colorimetric technology has been used and accepted for detecting Toxic Industrial Chemicals (TICs) and Chemical Warfare Agents (CWAs) in vapor or liquid form. Some advantages of colorimetric technology are low cost, easy to use, and requires no external power source (e.g. battery). A major drawback of most current colorimetric technologies is the inability to withstand 'real-world' ambient operating conditions (including heat, humidity, water immersion and long-term shelf life in adverse environments), and the inability to quickly detect TICs and CWAs at relevant low concentrations. This topic solicits innovative technology to develop passive (i.e. no active sampling required) colorimetric sensors which meet the following criteria: physical requirements are low-cost (<$3 per sensor), light-weight, require no external power source, physically rugged. Requirements for the user include minimal operator training and be in a configuration easily deployed and used by the war-fighter or personnel equipped in personal protective equipment. Operational requirements include compliant functioning in arctic, tropic, and desert conditions for a minimum of 24 hours, have an in-package shelf life of at least 1-year at ambient temperature, is directly immersible in salt water and fresh water for at least 1 hour without impacting performance following aqueous exposure, can detect TICs/CWAs in vapor phase at PEL levels within 15 minutes or less, and detect TICs/CWAs in vapor form at one-half IDLH levels in 5 minutes or less. It is advantageous for the proposer to have a successful track record of transitioning products from R&D to manufacture for military and/or commercial applications.

PHASE I: Develop and test multiple chemistries for detecting selected high-risk TICs and CWAs. Conduct testing with an array of TICs and CWA simulants in vapor form. The proposer must demonstrate: (i) the successful development of colorimetric chemical sensors to meet the performance requirements listed in the description above for detecting at least five high-risk TICs, and (ii) the current ability to generate, in the laboratory, precise concentrations (validated against analytical methods) of vapors for targeted TICs and CWA simulants.

PHASE II: Incorporate chemistries developed in Phase I into at least three new passive colorimetric sensors (detecting a different TIC or CWA) which meet all of the performance requirements detailed in the description above. Conduct testing and validation with an array of TICs and CWAs in vapor form. Conduct cross-interference and field-interference testing. The result of the Phase II must be a device ready for production/manufacture. Implementing innovative manufacturing methods to reduce unit costs is advantageous.

PHASE III: The device should be available for production at high volumes. Prototypes will undergo testing and analysis against the targeted TICs and CWAs in order to define operational parameters and to determine if the device will meet operational requirements as defined by the Joint Chemical and Biological Defense Program. This system has potential for use in industrial hygiene applications in addition to civil defense fields where colorimetric technology is currently and widely utilized.

REFERENCES: 1) Longworth, T.L. Cajigas, J.C. Barnhouse, J.L., Ong, K.Y.and Procell, S.A. 1999. Testing of Commercially Available Detectors Against Chemical Agents: Summary Report. Soldier and Biological Chemical Command, AMSSB-REN, Aberdeen Proving Ground, MD.
2) Shoji R, Takeuchi T, Kubo I., Atrazine sensor based on molecularly imprinted polymer-modified gold electrode, Anal Chem. 2003 Sep 15;75(18):4882-6.
3) Frye-Mason, G. et al., Novel fluorescence-based integrated sensor for chemical and biological agent detection, Proceedings of SPIE -- Volume 5617, Optically Based Biological and Chemical Sensing for Defence, John C. Carrano, Arturas Zukauskas, Editors, December 2004, pp. 353-363.

KEYWORDS: chemical agent, colorimetric, TIC, CWA, detection

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A07-137 TITLE: Passive Angle Tracking in a Distributed Sensor Environment

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: Identify and develop advanced algorithms and signal processing techniques to address the problem of passive angle tracking in a distributed sensor environment.

DESCRIPTION: Fusion of active radar returns in a distributed sensor environment is well understood and a number of algorithms exist for the various processes associated with this task, including track initiation, measurement-to-track association, track-to-track correlation, and track filtering. However, in hostile operating environments, an adversary will often employ some form of electronic countermeasures in an attempt to deny active track to the air defense system responsible for defending the asset under attack, resulting in the generation of a passive track (angle only) within the system. In these cases, sensor networking can often reduce the effectiveness of the countermeasures because it is difficult to deny track to all sensors in a network if those sensors are sufficiently distributed in location and/or frequency. This can result in the presence of an active track and one or more passive tracks (depending on the number of sensors effectively jammed) within the system unless an effective algorithm exists for fusing the passive data with the active data. Furthermore, if no active track exists, the problem becomes one of properly fusing two or more passive tracks into a single coherent track.

This process of fusing passive tracks to active tracks or other passive tracks is complicated in the distributed sensor environment because of the addition of unit-to-unit alignment errors, time delays in data exchange, and ghosting problems in any but the sparsest operating environments. The investigation must be concerned with the reliable fusion of multiple unit passive tracks into 3D tracks and the proper correlation of these tracks with active tracks as they become available, under various “unfavorable” unit-target alignments and dense target environments.
There is a great deal of interest in the fusion of multiple platform, multiple sensor data to obtain a more accurate and complete track picture than can be obtained using a single sensor. The techniques required for the various data fusion processes (measurement-to-track association, data registration, track state estimation, etc.) are well understood for collections of sensors providing measurements with sufficient observability for the dimensionality of

the desired state estimate (typically three spatial dimensions). One area that has received less attention is the processing of passive angle tracks from multiple units in a distributed sensor network, perhaps because the distributed nature of the problem can make it more difficult for an adversary to deny range to all participants in a sensor network. Yet the problem of range-denied tracks still exists in this domain, if with less frequency than in single unit scenarios, and the problem can be significantly more complex given that many units may be exchanging angle-only data and the extent of the surveillance volume may be larger and encompass greater numbers of targets, thus making for many more potential associations and mis-associations. In sufficiently benign environments, e.g., two units providing passive angle measurements from an appropriately located target, the solution is relatively simple assuming accurate navigation data is available from the measurement platforms. However, the simple passive angle triangulation methodology can quickly be overcome if the geometry of the sensor units and the target are unfavorable and/or the numbers of passive angle targets start to increase.

The challenge to be addressed in this topic is the development of robust algorithms and techniques to allow the proper association of passive angle tracks (jam strobes) from multiple (possibly dissimilar) sensors operating in a distributed sensor environment with decentralized track processing. This association processing may be conducted in the data processing domain, the signal processing domain, or both. It should be robust in the sense that it will work in a wide range of sensor/target geometries, be capable of operation in a multiple jammer environment (deghosting), be relatively insensitive to data timeliness, and operate over a range of data registration and navigation qualities. In addition, the techniques should provide some means of transitioning to single unit operation if the unit motion is sufficient to provide data that is sufficiently observable.

PHASE I: Conduct research, simulation and analysis to demonstrate the feasibility of an algorithm for a variety of sensor networking scenarios. The algorithm must be suitable for operation in a decentralized, distributed environment. Perform analysis to quantify the performance of the proposed techniques using relevant evaluation metrics.

PHASE II: Develop and evaluate a working prototype of the proposed algorithms and/or techniques for passive-angle tracking in a decentralized, distributed sensor network. The solution should be capable of implementation/demonstration in the IAMD Benchmark and will be evaluated using air defense scenarios including stressing target environments.

PHASE III: Transition the technology to the military and commercial markets. This will include the development of a robust process capable of running in real-time in a tactical environment for acheiving SIAP that is approproiate integration into warfighting systems. If successful, the potential source for the Phase III funding could come from SIAP JPEO Tier I and/or Tier II funds to integrate into the IABM being developed by SIAP JPO. Then the final product of IABM will be implemented onto various major weapon systems.
Dual Use Applications: This technology will be useful in any environment that requires object tracking with range-denied data. The capabilities provided by this technology development includes application to commercial air traffic control (especially in Homeland Security applications where previously commercial aircraft may become hostile targets with jamming capability), roadway vehicle tracking (for traffic flow control), and pedestrian tracking.

REFERENCES: 1) Samuel Blackman, Robert Popoli, Design and Analysis of Modern Tracking Systems. Boston, MA: Artech House, 1999.
2) Hammel, S. E., and V. J. Aidala, “Observability Requirements for Three-Dimensional Tracking via Angle Measurements”, IEEE Transactions on Aerospace and Electronic Systems, Vol. AES-21, No. 2, March 1985, pp. 200 – 207.

KEYWORDS: Passive Angle Track Processing, Multiple Target Tracking, Sensor data processing, sensor measurements, algorithms

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A07-138 TITLE: Characterizing Errors in Measurements Manually Extracted from Radar Video for use in Composite Tracking Processes

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Missiles and Space

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

OBJECTIVE: Develop techniques and corresponding algorithms to characterize and process manually generated sensor measurements for use in a distributed, decentralized automatic track processing system.

DESCRIPTION: In certain operational environments, the automatic measurement-to-track association process may have difficulty in properly detecting and associating a measurement to an existing track. This situation may arise because of excessive clutter in the region of the track, target maneuver causing the detection to fall outside the prediction window, or limitations in the measurement-to-track association processing. In these cases, it may be possible for radar operators to manually associate a measurement (seen in the radar video) with the appropriate track, thus increasing the likelihood the sensor will continue to track the target. This same type of technique can also be used for the early initiation of tracks. In this situation the operator may have information that is not available to the automatic tracking system and that permits the early promotion of initial detections to track status. The problem with these manually generated measurements and manually initiated tracks lies in how they are to be integrated with or transitioned to automatic track processing. In the case of automatically generated measurements and tracks, the errors associated with the measurements (and incorporated into the track state estimates) are caused by well-understood, reasonably independent processes that are consistent over time and can be properly modeled within the various automatic estimation routines. Thus, the error covariance matrices associated with the resulting tracks are consistent with the actual errors in the track state estimate. However, for manually associated measurements and manually initiated tracks, the errors are not well-understood, are likely not independent, and are almost certainly not consistent over time. As a result, the covariance matrices associated with these tracks may not be consistent with the actual errors in the track state estimate. This creates a multitude of problems for downstream processing that assumes covariance consistency and so virtually precludes the ability to transition these manual tracks to automatic tracks.

If these manually extracted measurements included properly characterized error estimates, incorporating them into a composite tracking process (i.e. filtering them as associated measurement reports) would be beneficial in maintaining track continuity and in the association processes for the contributing sensor adaptation layers. However, achieving the required accuracy and characterizing the associated error parameters is a significant technical challenge. The measurement extraction is subject to operator error and even assuming there is a theoretically ideal operator, there are other error parameters beyond the radar accuracy itself such as data registration errors and sensor biases that need to be characterized accurately if these measurements are to be meaningful to a composite track filtering process. The operators themselves are also likely to introduce biases that vary from operator to operator (as well as duty shift to duty shift).

The technical objective of this topic is to identify and characterize the error parameters that must be considered, evaluated, and quantified if manually extracted measurements are to be incorporated into an automatic networked sensor track filtering process. Ideally, the information quality of the resulting manually-generated measurements would be comparable to that of automatically associated sensor measurements.

PHASE I: Conduct research, simulation and analysis to demonstrate the feasibility of techniques for the characterization of the errors associated with manual sensor measurement extraction. Develop a proof of concept for incorporation of the manual measurements into the composite track processing of a decentralized distributed sensor networking system and demonstrate the effectiveness of the proposed technique(s) using pertinent evaluation metrics

PHASE II: Develop and evaluate a working prototype of the proposed techniques in Phase I (manual sensor measurement extraction) for incorporation in a decentralized, distributed sensor track processing environment. Build the algorithms in an appropriate language and identify performance evaluation metrics for evaluation. This may require examination of recorded data and/or conduct of experiments with instrumented targets and radar operators. Analyze the data for error characterization to determine whether it is possible to generate consistent error measures for manually extracted measurements.

PHASE III: Commercialization and transition of the technology to military and commercial markets. This will include working with tactical systems that have manual tracking capability and integrating that capability into automatic sensor networking environments that is appropriate integration into warfighting systems. Successful results have potentially transitioned into the SIAP development effort. The potential source for the Phase III effort could be funded with SIAP JPEO Tier 1 or Tier 2 funds in implementing the algorithms and technique into the IABM development effort. The final version of IABM then will be implemented onto various major weapn systems in achieving SIAP capability. For Dual Use Application: the capabilities provided by this technology development include application to air traffic control, ground tracking, and other related applications where it requires human operators providing input to automatic processing systems.

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4) Elbert, Theodore F., Estimation and Control of Systems. Van Nostrand Reinhold Company, New York, 1984. pp. 8 – 89.

KEYWORDS: Manual tracking, radar operator tracking, manual track fusion, radar measurement characterization, error characterization, radar operator performance, radar error estimation, radar error modeling.

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A07-139 TITLE: Portable Digital Field Panoramic x-ray

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To fabricate a portable digital field ready panoramic x-ray that will aid in the diagnosis & treatment of maxillofacial field trauma.

DESCRIPTION: Currently there are two digital panorex machines operating in southwest Asia. The machines are over 248 lbs and require over 1500W of power during operation. These machines are not limited to strictly "dental" use. They are considered the gold-standard for diagnosis of mandibular fractures and can greatly assist in the diagnosis of orbital, zygomaticomaxillary, and Lefort fractures. Head & neck trauma requires significant resources to treat in the field environment. In a 14-month period, 16 percent of 11,287 soldiers airlifted from Iraq or Afghanistan had injuries to the head and neck. The development of a portable field panoramic x-ray would serve as a useful adjunct to the surgeon.

PHASE I: This phase will demonstrate the feasibility of producing a demonstration of the digital field panorex, and demonstrate success in the following criteria: (1) lower energy requirements and ability to function using a slave cable from a HMMMV power source of 100VAC to 240VAC, 50 or 60 Hz; (2) decrease in overall size of the machine; (3) One man carry weight of less than 90 lbs.; (4) ease of assembly in the field; and (5) durability in the field with air drop capability per Army regulations.

PHASE II: For phase II, the deliverables will include (4) four prototype panorex devices that can be portable in the field setting and meet the above cited criteria to be tested in austere environment.

PHASE III: Application to all echelons of military medicine as well as use in civilian trauma centers. Specifically, the Department of the Army could purchase additional units for use in CASH, forward deployed head & neck trauma teams, as well as dental field units. Commercial applications would be seen in smaller out-patients clinics, and in disaster emergency units that assist in Homeland Security.

REFERENCES: 1) "Head & Neck Wounds in soldiers airlifted from Iraq & Afghanistan treated at Landstuhl Regional medical Center". Lt. Col Michaeal S. Xydakis, U.S.A.F., Lt. Col Guillermo Tellez. Sept 20, 2004, Presentation, American Academy of Otolaryngology Head and Neck Surgery annual meeting, New York City.
2) Army Regulation 70-47 "Engineering for Transportability"
3) Army Regulation 71-9 "Material Objectives and requirements"
4) Army Regulation 600-55 "The Army Driver and Operator Standardization Program", has data regarding slave cable and power source for HMMWV.
5) MIL-HDBK-157 "Transportability Criteria"
6) MIL-STD-1366 "Material Transportation System Dimension and Weight Constraints"

KEYWORDS: panorex, digital, maxillofacial, trauma

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A07-140 TITLE: <u>Maintain Dexterity During Cold-Weather Operations</u>

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a lightweight, robust, low-energy, non-flammable, system or method for maintaining fine-motor dexterity of the hands and fingers in resting individuals during cold weather-operations for up to 4 h in ambient temperatures of less than 32°F.

DESCRIPTION: Cold-weather operations pose unique problems with regard to maintaining hand dexterity and performance. Currently, gloves/mittens that maintain comfort and warmth cause dexterity to degrade because of bulky material and loss of tactile sensitivity. If gloves are not used, hand and finger temperatures rapidly decrease during cold exposure, causing a reduction in hand function and manual dexterity. Previous methods to maintain hand dexterity include auxiliary heating of the torso and electrically-heated gloves. These methods, however, have drawbacks for the dismounted soldier. Torso heating required a relatively large power supply and heated gloves do not improve dexterity back to levels observed when bare-handed due to glove stiffness and materiels used. Burning of liquid fuels (butane, propane) has also been used to provide heat, but this method increases the fire risk and potentially can cause severe burns. Currently there is no system or method to maintain dexterity during cold-weather field operations that has low-power requirements and is non-flammable. The envisioned system or method would employ technology using an innovative engineering and/or physiological approach that enables the resting Warfighter to maintain dexterity at air temperatures < 32°F for > 4 h. Dexterity during cold exposure must be equal to that observed during rest in 70°F air. System requirements include: (1) light-weight; (2) low-power requirements; (3) non-flammable; (4) not interfere with other physiological functions; (5) rugged enough to withstand routine use in military settings, and (6) user friendly technology with the potential to be used in field operations. Military users for this product include snipers, infantrymen, military police, mechanics, and Soldiers conducting NBC operations in cold weather. In the civilian community, the product will maintain dexterity in cold-weather workers (construction and line workers, mechanics) homeland security personnel (hazardous material cleanup in cold weather), and cold-weather recreational athletes (mountain and ice climbers).

PHASE I: The contractor will design and develop innovative concepts and approaches (engineering or physiological) to maintain dexterity during cold air exposure (< 32°F for 4 h) that is equal to the manual dexterity observed during 70°F air exposure. The approach will be supported by documentation of proof-of-concept and data regarding scientific validity of the proposed approach.

The contractor will develop the work plan for subsequent testing in human volunteers. Human testing requires approval by the Human Research Protections Office at the US Army Medical Research and Materiel Command. Phase I should include submission of appropriate and necessary regulatory documents to execute Phase II testing using human subjects.

PHASE II: The contractor will construct and demonstrate the operation of a prototype that maintains manual dexterity during cold exposure. Demonstration of the prototype will require laboratory experiments using human volunteers exposed to cold air (< 32°F) for 4 h. The prototype will also include any hardware/software interfaces that are required for system functionality.

PHASE III: The system or method prototype will be extensively tested in laboratory and field studies to demonstrate a reliable and robust solution for military application. The end-state of the Phase III effort will be a product suitable for inclusion into the Military’s cold weather clothing ensembles. It will be used to increase hand dexterity to maximize performance and reduce risk of environmental injuries. Military users for this product include snipers, infantrymen, military police, mechanics, and Soldiers conducting NBC operations in cold weather. In the civilian community, the product will maintain dexterity in cold-weather workers (construction and line workers, mechanics) homeland security personnel (hazardous material cleanup in cold weather), and cold-weather recreational athletes (mountain and ice climbers). The likely transition path after Phase III is through a formal acquisition program such as PM-Soldier, if the TRL level is deemed high enough. If this is not supported formally, then the contractor will need to procure outside funding to continue development.

REFERENCES: 1) Brajkovic, D., M.B. Ducharme, and J. Frim. Influence of localized auxiliary heating on hand comfort during cold exposure. Journal of Applied Physiology, 85: 2054-2065, 1998.
2) Brajkovic, D. and M.B. Ducharme. Finger dexterity, skin temperature, and blood flow during auxiliary heating in the cold. Journal of Applied Physiology, 95: 758-770, 2003.
3) Enander, A. Performance and sensory aspects of work in cold environments: a review. Ergonomics, 27: 365-378, 1984.
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KEYWORDS: cold, dexterity, finger temperature, hand temperature, heating, thermal comfort

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A07-141 TITLE: Human Hydration Status Monitor

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a non-invasive sensor for measuring human body hydration status that is small, requires low power, and is sensitive to dehydration levels >3% total body water

DESCRIPTION: Body water balance (hydration status) depends on the net difference between water gain and water loss. Water gain occurs from consumption (fluids, ingested food) and production (metabolic water), while water losses occur from respiratory, skin, renal and gastrointestinal tract losses. When the combination of work and environmental stress is high, heavy sweating produces net losses (dehydration) in total body water (TBW) which can seriously threaten fluid balance homeostasis, performance, and health (heat injury). Over-aggressive re-hydration can also cause serious health problems such as hyponatremia. Symptoms of hyponatremia mimic those of dehydration-heat exhaustion, which makes diagnosis and treatment difficult. These debilitating performance and health consequences could be exploited by an aggressive enemy.

Hydration status can be assessed using various techniques, but all current technologies vary greatly in their applicability due to methodological limitations such as the necessary circumstances for measurement (reliability), ease and cost of application (simplicity), sensitivity for detecting small, but meaningful changes in hydration status (accuracy) and the type of dehydration anticipated. Although strenuous physical work and/or fluid restriction results in a hyper-osmotic hypovolemia, TBW can also be reduced without the expected tonicity changes in body fluids in some circumstances. Exposure to cold, altitude, and salt-depletion dehydration are a few examples.

Reliable hydration assessment remains a key component for insuring proper hydration in Soldiers performing frequent and intense work, particularly in hot weather. Non-invasive hydration monitoring technologies will allow for better hydration management, thus improving performance, medical triage, and treatment in-theater for fluid-electrolyte imbalances. The same technology might allow rapid and non-invasive evaluation of hydration status in clinical settings (burn and trauma patients, children with gastroenteritis), athletics, and others. Currently there is no valid quantitative measure of body hydration status for field use that is rapid, sensitive, technically simple, and not easily confounded.

The envisioned sensor / tool would employ a technology that is non-invasive or minimally invasive and can measure TBW content. The system must be (1) accurate and reliable for detecting water losses >3% TBW and must be unaffected by (2) skin temperature or moisture, (3) movement or posture, and ideally (4) changes in body fluid tonicity. The technology should eventually be (5) simple, inexpensive, require low power, be light weight, and be hardened for use in field operations. The system could be worn by individual Soldiers (ambulatory unit) or used by medics at the point of treatment or squad leaders during pre-combat checks. Clinical / medical applications for various patient populations are also desirable.

The proposed SBIR does not represent a duplication of research efforts. Existing SBIR efforts related to hydration assessment using salivary osmolality or muscle water content do not meet one or more of the important needs outlined above (#'s 1-5). We are presently unaware of any technology that does meet all of these needs.

PHASE I: The contractor will demonstrate proof-of-concept of the approach to measure TBW content and potential to discriminate small (>3%) reductions in total body water (TBW). This will be supported by documenting the basis for the approach and the human factors acceptability to War Fighters. A prototype system with specifications and data regarding measurement validity and reliability will be required.

PHASE II: Contractor will build 5 working prototypes and supporting hardware/software interfaces for evaluations in laboratory using animal and human models. This will be supported by overall system design document and hardware / software prototype. Animal or human studies will require appropriate Department of Army, Institutional Review Board approvals. This may take 6-9 months.

PHASE III: The sensor / tool will be ruggedized and manufactured to support operational deployment and commercial use. The sensor / tool will be extensively tested in laboratory / field studies to demonstrate accuracy, reliability, and applicability for military operations. The instrument will be used to manage deployed Soldier hydration status to maximize performance and reduce risk of environmental injuries.

The envisioned end-state of this research is a device that could be worn by individual Soldiers (ambulatory unit) or used by medics at the point of treatment / squad leaders during pre-combat checks. The precise transition avenue for the device is presently unknown, but strong military interest in such a technology has been explicit. The Institute of Medicine and the World Health Organization have both identified the scientific importance and relevance of such a device for healthcare, athletics, and industrial settings. The commercialization potential for the technology is therefore very promising. Recent meetings and publications by the International Life Sciences Institute and the American College of Sports Medicine also concur.

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KEYWORDS: dehydration, body water, hydration, hypohydration, water, water balance, assessment, hyponatremia, hyperhydration

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A07-142 TITLE: Development of Improved Therapeutics for Local and Systemic Inflammation

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: The intent of this research topic is to solicit the development of new drug candidate for local and systemic inflammation. There is a clear medical need of improved therapeutics for the treatment of local and systemic inflammation. This is an unexplored area of research and, therefore, is not without technical risks. However, the potential gains will impact enormously on the treatment of trauma and wounds not only in a community medical center, but also in a battlefield setting.

DESCRIPTION: This topic solicitation is proposed to develop improved therapeutics for treatment of inflammation and pain in military personnel experiencing trauma. These agents aim to prevent or reduce the early and chronic inflammatory processes associated with injuries where pain is related to the level of inflammation. Injuries of such nature commonly lead to arthralgia, dental and bone irritation, and myalgia and over time can result in tissue scarring and be debilitating for months or even indefinitely. Therefore, control of inflammation is an important part of treatment that can prevent significant tissue damage and aide in simultaneous attempts at healing, repair and rehabilitation. Currently the major anti-inflammatory agents with analgesic properties include non-steroidal anti-inflammatory drugs (NSAIDs) and the glucocorticoids. NSAIDs and glucocorticoids are used both systemically and locally: oral tablets are commonly used by prescription or over-the-counter (OTC) NSAIDS for systemic inflammation, whereas local inflammation is treated by either topically applied agents or more potent cortisone injections. All are limited by toxicity to the gastrointestinal system or significant metabolic activities with the corticosteroids (i.e. Cushings syndrome). Current debate also exists over the cardiovascular risks associated with the NSAID COX-2 inhibitors. Therefore, there is a great need of new anti-inflammatory agents devoid of these complications and that may potentially be available without a prescription (OTC) enabling easier access for deployed military personnel. There is currently early phases of research exploring possible approaches to alternative anti-inflammatories (PLx Pharma, Inc.), however it is encouraged to receive proposals from all interested parties offering novel approaches in this field keeping these factors in mind.
The responders are encouraged to explore either existing agents modified to be devoid of common adverse affects such as gastrointestinal complications associated with NSAIDs or new agents with activity against the inflammatory pathway commonly associated with arthralgia, myalgia, tendonitis, and dental and bone irritation. Proposals should include institutional assurances that local IRB approvals for any Phase I work can be expedited or that the work plan already has local approval.

PHASE I: The objective of phase I is to identify new therapeutic agent(s) targeted toward inflammation for the proof of concept. In this phase, the methodology to identify targets, rational for designing the effector molecular entities must be elaborated. This phase should include the evaluation of these drug candidates in in vitro cell culture system. Demonstrate the ability to show anti-inflammatory effect of new drug/agent in simple straightforward biological assay.

Use of human cells and tissues and/or vertebrate animals requires approval by the appropriate US Army Medical Research and Materiel Command regulatory office. Phase I should include approval of appropriate regulatory documents necessary to execute Phase II.

PHASE II: Phase II will follow to evaluate any new anti-inflammatory agent/drug candidate that was identified in vitro cell culture system under Phase I. Demonstrate its use in any preclinical animal model of injury associated with inflammation such as arthralgia, dental and bone irritation, myalgia and tendonitis.. The responder should aim for a specificity, efficacy and reproducibility. An experimental plan including the appropriate positive and negative controls should be outlined clearly.

PHASE III: This phase is to perform additional experiments with the lead targeted agent(s)/drug(s) to prepare for FDA review, and approval, and subsequent commercialization. A state of art for developing the agents/drugs including a methodology for using a drug should yield many advances important not only to the civilian but also to the military community. This will be a highly product driven project and the product developed under this topic will have strong patent potential. In addition, the commerciality potential of a product developed under Phase III is expected to be high. This will open a door for small industries to enter into partnerships or licensing agreements with bigger industries in the US as well as overseas. The most likely path for transitioning this research into operational considerations for the military will be with the U.S. Army Medical Research and Material Command to incorporate the product into the medical materiel acquisition strategy through consideration with the programming and prioritization process.

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KEYWORDS: New improved anti-inflammatory drugs, trauma, wound healing, repair, rehabilitation etc.

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A07-143 TITLE: Healthcare Interface Engine To Support Health Level Seven (HL-7), Version 3.0 Data Standard

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop messaging gateway to exchange health data using new International Standards Organization (ISO), Health Level Seven (HL-7) 3.0, Clinical Document Architecture. Leverage Bi-Directional Health Information Exchange (http://www1.va.gov/vadodhealthitsharing/page.cfm?pg=14) demonstrated at HIMSS Integrated Healthcare Environment and Spartanburg Regional Healthcare Center initiative.

DESCRIPTION: As a matter of background, the OMB, GAO, and Congress are continually interested in greater data sharing between the Military Healthcare System (MHS) and the Veterans Healthcare Administration (VHA). A great amount of work has already been accomplished to share patient identification, laboratory, and allergy between these organizations through the Bi-Directional Health Information Exchange (BHIE). The healthcare data from

VHA's Computerized Patient Record System (CPRS) and from the DoD's AHLTA Electronic Health Record will be shared bidirectionally, in real time, and with computable data for use by VA and DoD healthcare providers. The business case is where a common treatment, health care operation, and/or payment relationship exists for the shared patient population between VA and DoD. The solution will be portable to other joint, medical sharing facilities with agreements between VHA and DoD.

A related project, the CHDR initiative, seeks to ensure the interoperability of the DoD Clinical Data Repository (CDR) with the VA Health Data Repository (HDR) by FY 2006. Under CHDR, the DoD and VA are developing the software component that will permit the AHLTA CDR and the HEALTHE Vet HDR to exchange clinical data so that both TRICARE and HealthEVet beneficiaries receive seamless care. A prototype was completed in October 2004, which successfully demonstrated the initial exchange of pharmacy, allergy, and demographics data. The prototype also demonstrated the capacity for agency drug-to-drug interaction screening (based on the integrated DoD/VA medication list) and local (intra-agency) database drug-to-drug allergy interaction screening (based on the integrated DoD/VA allergy list). A contract has been awarded for Phase II, called Production CHDR, which will leverage the lessons learned from the prototype demonstration and include the exchange of patient demographics, outpatient pharmacy (Military Treatment Facility, DoD mail order, and retail pharmacy network data), laboratory, and allergy information. Implementation is anticipated by Spring 2006.

While this work has been promising, the messaging standard used has been HL-7 2.4, which provides only for resolving structural differences between file formats. Further work is required to deal with the real challenge in interoperability: dealing with the semantics and meaning of data between systems. The new ISO HL-7 3.0 standard, which is based on a Reference Information Model (RIM), and its associated Clinical Document Architecture (CDA), release 2, has been designed to deal with the semantic interoperability challenge.

Moreover, this SBIR topic is directly related to the President's April 2004 Executive Order concerning the establishment of the Office of the National Coordinator for Healthcare Information Technology. Per the order, "in fulfilling its responsibilities, the work of the National Coordinator shall be consistent with a vision of developing a nationwide interoperable health information technology infrastructure that:

(a) Ensures that appropriate information to guide medical decisions is available at the time and place of care;

(b) Improves health care quality, reduces medical errors, and advances the delivery of appropriate, evidence-based medical care;

(c) Reduces health care costs resulting from inefficiency, medical errors, inappropriate care, and incomplete information;

(d) Promotes a more effective marketplace, greater competition, and increased choice through the wider availability of accurate information on health care costs, quality, and outcomes;

(e) Improves the coordination of care and information among hospitals, laboratories, physician offices, and other ambulatory care providers through an effective infrastructure for the secure and authorized exchange of health care information; and

(f) Ensures that patients' individually identifiable health information is secure and protected."

Implementing the HL-7 3.0 standard across electronic health records is not only of interest to DoD and the VHA, but is also of interest to newly formed national Regional Health Information Offices (RHIOs). Early prototypes involving data exchange among disparate systems using HL-7 has been demonstrated last year at the Healthcare Information Management and Systems Society (HIMSS) Integrated Healthcare Environment (IHE). Further work and demonstrations are necessary using HL-7 3.0.

This proposal is also related to an FY 06 congressional appropriation to examine innovative technologies in healthcare, using Spartanburg Regional Healthcare Center, SC, as a "Future of the Hospital" demonstration platform. A major part of this initiative is to find ways to electronically exchange records between DoD and civilian facilities. As such, this SBIR will also leverage lessons learned from the Spartanburg initiative.

PHASE I: Phase I activities will center on the selected vendor reviewing the literature to identify the basic constructs and concepts of Health Level Seven, HL-7 3.0, the Reference Information Model (RIM), and the Clinical Document Architecture (CDA), and to understand the work accomplished to date on the BHIE, CHDR, and Spartanburg Regional Health Center Future Hospital initiatives. The analysis will also research alternative methods to achieving semantic interoperability which might employ terminology or ontology mediation services. The analysis will center on how these architectural frameworks can be applied to the current AHLTA BHIE and CHDR data exchange with the VHA. The Phase I vendor will also identify and evaluate EHR integration and/or developmental frameworks, which support the HL-7 3.0 Reference Information Model (RIM), and Clinical Document Architecture, Release 2, such as the Oracle Healthcare Transaction Base (HTB), and competing products. Phase I work will also develop a Concept of Operations, functional and technical requirements, and a system design document for the prototype.

PHASE II: In Phase II, based on the best technologies identified in the Phase I research, the vendor will build a prototype to demonstrate semantic data interoperability of lab, pharmacy, radiology, and clinical encounter notes between DOD and the VHA. The prototype must be shown to be capable of actually interfacing or integrating with the VHA and DOD EHR systems on a global level. The phase II prototype must also be capable of data exchange performance parameters identified in the requirements, as defined by users for certain use cases. Some of these use cases may call for query of data contained in other systems to support near-real time exchange of data to facilitate critical care decisions impacting the life of patients.

The prototype will be demonstrated at in the IHE environment at the annual HIMSS Conference.

PHASE III: In Phase III, the selected vendor will actually integrate the prototype with the DoD AHLTA and VHA VISTA systems, upon sufficient development integration, system integration, system qualification, system acceptance, and operational tests and evaluation. The gateway must also be subjected to joint interoperability testing prior to being put into production. Upon proving itself in the military/VHA environment, the interface engine and gateway could be commercialized for civilian use.

It is critical to understand the commercial potential of this interface engine and messaging gateway which will be based on HL-7 3.0. The ability of this engine to deal with semantic interoperability issues is the greatest challenge faced by civilian physician practices and hospitals, healthcare payers, and State Regional Health Information Offices, as they try to comply with the President's April 2004 Executive Order which urges the development of a National Health Information Network. Per the order, "in fulfilling its responsibilities, the work of the National Coordinator shall be consistent with a vision of developing a nationwide interoperable health information technology infrastructure that:

(a) Ensures that appropriate information to guide medical decisions is available at the time and place of care;

(b) Improves health care quality, reduces medical errors, and advances the delivery of appropriate, evidence-based medical care;

(c) Reduces health care costs resulting from inefficiency, medical errors, inappropriate care, and incomplete information;

(d) Promotes a more effective marketplace, greater competition, and increased choice through the wider availability of accurate information on health care costs, quality, and outcomes;

(e) Improves the coordination of care and information among hospitals, laboratories, physician offices, and other ambulatory care providers through an effective infrastructure for the secure and authorized exchange of health care information; and

(f) Ensures that patients' individually identifiable health information is secure and protected."

The interface engine that comes out of this work can be licensed to commercial electronic health care record vendors and health payors, as well as to State Regional Health Information Offices. While some HL-7 interface engines exist in the marketplace, none can deal with the semantics addressed by HL-7 3.0 and the CDA.

The interface engine might also be adapted to be used by other vertical industries, such as law, to promote the semantic exchange of data.

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3) http://www1.va.gov/vadodhealthitsharing/page.cfm?pg=14
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KEYWORDS: healthcare, semantics, HL-7, electronic health records, EHRs, interoperability, data sharing, DOD, TRICARE, Military Health System, MHS, Veterans Health Administration, VHA, BHIE, CHDR, TATRC, Spartanburg Regional Medical Center, NHIN, RHIO

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A07-144 TITLE: Automated Identification Technology System (AIT) to Identify, Track and Monitor the Condition of Medical Supply Items from Point of Origin to End User

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a universal AIT system to monitor medical materiel from point of origin to end user. The system would identify requisitioned items, would be attached to individual items or packages either at the point of origin or at an intermediate shipping point for shipment to a deployed theater. The data would be picked up by wireless scanners at appropriate nodes and update the system on the status of the shipment. The successful implementation will be compatible with the enterprise systems in use by Defense Medical Logistics, particularly those systems used by deployed forces. The system will provide manifest information to authorized users as items move through the transit system.

DESCRIPTION: At the present time there is no system to monitor the progress of medical shipment to and within the combat theater other than those pallets that are tagged with Radio Frequency Identification (RFID) tags in compliance with the current DoD mandate for tagging pallets and cases. Full implementation of the DoD mandate to tag all pallets and cases of Class VIII (Medical) materiel is not expected to occur before 2008. The DoD mandate not withstanding, most Class VIII shipments are of less than pallet or case quantity and therefore are not subject to this requirement. Many of these medical shipments are time sensitive and are often subject to damage from rough handling and/or environmental exposure. Very often the timely delivery of these items, in good condition, is necessary to save human life or limb or to alleviate human suffering. Currently commercial delivery services, such as FedEx, UPS, DHL, etc., have very efficient and effective systems to monitor the progress of packages throughout their delivery networks and provide real time intransit visibility with a high degree of accuracy.

We are seeking an AIT enabled system to provide tracking/intransit visibility of less than pallet/case quantity medical shipments from the point of origin, or from an intermediate shipping point such as a military medical depot, to the point of use. The selected technology should require minimal human intervention, thus RFID tags are preferred over bar codes alone (bar coding should be provided as a backup for damaged RFID tags). In addition to monitoring the progress of delivery we wish to monitor the condition of sensitive medical shipments in transit. Therefore a technology such as MEMS (Micro Electrical Mechanical Systems) should be combined with the RFID technology to provide alerts to the condition of goods in transit. Early notification of possible damage to essential medical materiel can facilitate the shipment of a replacement item even before the ultimate consignee receives the damaged material. The successful system will be capable of being integrated into the Defense Medical Logistics system(s).

The successful development will go beyond current practice in a number of areas. RFID tags will reduce human intervention and provide more information than is provided by presently used one and two dimensional bar codes. The implementation of MEMS technology sensors within the RFID transponders will permit monitoring the condition of items both in storage and in transit. As a minimum sensors will be available to monitor and report temperature, humidity, vibration and/or shock. In addition the desired result will go beyond current mandates (Wal-Mart, DoD, etc.) by tagging individual items (or small quantities of items) rather than just cases or pallets.

PHASE I: At the least Phase I will develop a system scope and overall architecture and will identify and demonstrate existing hardware which can be used as well as items which will require development. Requirements for interfacing with and supporting Defense Medical Logistics enterprise systems, particularly those used by deployed forces will be identified. Security requirements for use in DoD systems will also be addressed. The successful system will be rugged, portable and will be capable of working in austere environments. Ease of use is also important. Phase I effort will also consider a testing plan and metrics to assure the efficiency and accuracy of the system.

PHASE II: Phase II will result in the testing, evaluation and delivery of a functional prototype of the system described in Phase I. All issues related to interfacing with enterprise systems will be addressed to include security requirements. The Phase II prototype will result in a product ready for final development as a production version in a potential Phase III.

PHASE III: A successful production version of this system will provide significant value to deployed military medical activities. Such a system will be capable of providing combat theatre caregivers a significantly improved logistics support system, thus improving the care given combat casualties and others needing medical care. The technological advances made to provide better logistical support to the health care system can also be applied to the logistics needs of other commodities with sensitive requirements such as subsistence, ordnance, replacement parts, etc. These improvements should also be of value to commercial enterprises and delivery systems where the safe, timely delivery of sensitive items is necessary.

The result of this effort will go well beyond what is current practice in the shipping/delivery industry. The use of RFID transponders will significantly reduce human intervention in the tracking effort since identification tags/labels will not need to be visualized to be read. The combination of MEMS (Micro Electrical Mechanical Systems) sensors with RFID tags has been demonstrated (First reference below) in a number of venues. When applied to shipments these sensor enabled tags are capable of recording and reporting the environmental conditions encountered by items in transit or storage. Tags have already the ability to monitor temperature excursions, shock loads, humidity or moisture conditions, and other parameters. This capability will enable a sense and respond logistics system to better serve its customers by assuring that deliveries will not only be made in a timely manner, but in usable conditions. By knowing that an item in transit has been subjected to conditions beyond acceptable parameters a replacement item can be dispatched to the customer even before the original shipment is received and determined to be unusable. This is clearly a significant benefit for shipments of critical life or limb saving medical supplies and also of critical repair parts. Just as the assurance of the timely delivery, in good condition, of medical supplies, repair parts, ordnance, etc. can help assure mission accomplishment for military customers the ability to deliver commercial commodities to customers timely and in good condition will provide significant added value beyond what is currently available.

Many commercial interests, beyond the shipping industry, that have concern for the conditions their shipments are exposed to include: pharmaceuticals, research and compliance laboratories, instrumentation suppliers, replacement parts suppliers and virtually any industry that ships a commodity that could be damaged in shipment by heat, cold, shock, vibration, humidity, water, chemical exposure, etc. All of these are potential beneficiaries of this effort.

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United States Government Accountability Office, Report to Congressional Committees, September 2005
5) RFID in Healthcare, The Applications, and Obstacles, Are Many
Mary Lou Ingeholm, MS; In K. Mun, PhD; and Seong K. Mun, PhD
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KEYWORDS: RFID, supply chain, sensors, medical logistics, healthcare logistics

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A07-145 TITLE: A Compact, Rugged, Mobile Automated Identification Technology Integrated Warehouse Scanning System for use in a Military Deployed Environment

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop an integrated deployable warehouse wireless RFID scanning system. Scanners would have the ability to connect with parent logistics system(s) to access and exchange system data. The equipment should have clear, compact screens to display system data. Scanners will be used for inventory operations, Quality Assurance/Quality Control (QA/QC), and the daily processing of both inbound and outbound shipments. This system will be rugged, light weight, portable, easily transported and able to be set-up under the most austere conditions as well as improved conditions. The desired outcome is to have a warehouse management system capable of rapid deployment to austere, remote environments that will help manage the daily receipt, inventory management and shipping process of the deployed medical warehouse subject to constrained personnel assets.

DESCRIPTION: Automated Identification Technology (AIT) systems are now emerging which are bringing a high degree of automation to the management and control of inventories in warehouses. This automation significantly reduces human error and improves the accuracy and timeliness of warehouse management operations. These improvements are often accomplished with a reduction of human intervention and a decrease in the size of the workforce needed.

Bar codes have broad acceptance and have been used for many years to help manage inventories and to maintain visibility of goods in transit. Because barcodes require considerable human intervention in their use, with resultant error rates, better technologies have been sought. RFID (and other AIT modalities) is emerging as a leading potential successor, or supplement to barcoding. AIT eliminates or significantly reduces human intervention needed in the scanning process. Wal-Mart and DoD, among others, have instituted mandates requiring the application of RFID tags to all shipments at the pallet and case level. The primary purpose of this initiative in the DoD has been to maintain visibility of goods in transit. Wal-Mart is using the RFID tagging for some inventory management purposes as well. To date these efforts are being accomplished primarily in well established fixed facilities with improved infrastructures.

In order to provide support to the deployed medical forces the medical logistician must also deploy a medical material distribution system. This requires that one or more warehouse operations must be established in the deployed theater. These operations are usually in environments that are austere in both resources and personnel.

We are soliciting the development of a compact, scalable, deployable, accurate, efficient and rugged automated warehouse inventory management system capable of use in an austere setting. The successful system will minimize the requirements for human intervention; will be portable, with the ability to be set up in both conventional structures, expedient shelters, such as tents, and in open areas. It is expected that bar codes and Radio Frequency Identification (RFID), compatible with industry standards and DoD requirements, will be used as the primary technologies.

The successful system will retain traditional layers of redundancy, will scan data and forward them to the activity's central database and will be able to retrieve data from the central database. The system will consist of both mobile and (semi)fixed devices with readable screens to provide system information and data at multiple locations. Easy connectivity among devices is important. WiFi or wireless LAN is the preferred choice, however, where security concerns dictate, hard wired or direct contact means of information transfer may be necessary. The system will be capable of processing receipts, storage operations, including location identification, materiel release orders, shipments and generating inbound and outbound manifests. The system will be compatible with and interface with the Defense Medical Logistics enterprise system(s) supporting the deployed activity.

PHASE I: Phase I will develop the scope and overall architecture of the system and will identify and demonstrate existing hardware and software which can be integrated into the system. Phase I will also identify those items which will require development. Requirements for interfacing with and supporting Defense Medical Logistics enterprise systems, particularly those used by deployed forces, will be identified and addressed. Security requirements for use in DoD systems will also be considered. The successful system will be rugged, portable and will be capable of working in austere environments. Ease of use is important. Phase I effort will also consider a testing plan and metrics to assure the effectiveness and accuracy of the system.

PHASE II: Phase II will result in the testing and delivery of a functional prototype of the system developed in Phase I. All issues related to interfacing with enterprise systems will be address as will the security requirements. Phase II will result in a prototype that will be ready for production in a potential Phase III.

PHASE III: A successful production version of this system will provide significant value to deployed military medical materiel distribution activities. This system will go well beyond what is currently being done by Wal-Mart, and other commercial interests, and by the present DoD mandate, by extending the application of RFID to the sub-pallet level, and even to the item level, and by doing that in an austere, deployed environment. Such a system will be capable of enhancing the logistical support of all combat theatre caregivers. An effective deployable system for the management of field medical logistics warehouse operations can be readily transitioned to the needs of other commodities, especially those with sensitive requirements, such as subsistence, ordnance and replacement parts.

Advancements and innovations developed here will also be of value to commercial warehousing enterprises by improving the range of use of the technology and by improving efficiency. A significant civil application of this system might be in the provision of emergency response to natural or man made disasters. In such situations it is usually necessary to mount significant logistical operations where destroyed or damaged facilities must be supplemented or replaced. A field deployable warehouse management system will permit the rapid establishment of temporary or ad hoc expedient distribution operations.

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4) RFID in Healthcare, The Applications, and Obstacles, Are Many
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KEYWORDS: warehouse management, RFID, supply chain, sensors, medical logistics, healthcare logistics, inventory control, deployed,supply chain

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A07-146 TITLE: An Advanced Medical Robotic System Augmenting Healthcare Capabilities

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop and design an advanced medical mobile teleoperated robotic system to augment the healthcare capabilities of nurses at Department of Defense and Veteran Administration hospitals.

DESCRIPTION: In efforts to keep healthcare costs down in the 1980's and early 1990's, hospitals eliminated nursing positions and tried to increase healthcare efficiency, but often at the expense of the nurses' working conditions, medical experts contend, decreasing their flexibility, increasing their workload and reducing their roles in decision making. Hospitals are currently facing staffing crises, including a shortage of immediate care personnel. While this shortage is being dealt with in creative ways (assistance of medical robots and automated equipment, flexible shift scheduling, on-line auctions of shifts), the trend is expected to worsen – especially in the trained and professional nursing fields. Hospitals face growing pressure to attract and retain their nursing staffs, at the same time as a mounting body of evidence points to short staffing as a leading cause of medical errors and avoidable deaths. A report just released by the Institute of Medicine of the National Academies found that nurse's working conditions were contributing significantly to medical errors. High patient-to-nurse ratios, fatigue on long shifts and mandatory overtime, a lack of experienced staff, and inadequate time to monitor patients have been associated with poor medical results and with higher death rates for patients.

A mobile robotic nurse assistant is highly desired to enhance the efficacy and quality of care nurses can provide by improving their working conditions, and by off-loading some of their most physically demanding duties thereby reducing the potential for medical error. Robotic nurse assistants would increase nurse's work satisfaction, decrease lifting-related injuries, extend the years of effective service nurses could render, all reducing hospitals costs and contributing to a greater solution to the nurse shortage problem. Today's advances in robotic technology can provide human care givers with help in the labor intense hospital or clinical work place, augmenting human physical capabilities and performing some regular, repetitive tasks. A tracked or other type of mobile robotic systems with flexible mechanical structure, advanced dexterous manipulation; and featuring enhanced robot-human interaction and the sensing capabilities required to support the required taskings should be applicable in this development effort. This robot system must be slender in form and yet powerful enough to work in tight spaces while lifting and/or moving heavy loads (e.g. patient laundry). The upper torso profile will be slender in shape in relation to the base. The purpose of which is to facilitate movement by the nurse/operator my minimizing obstruction in a relatively narrow work space environment, e.g. bed side. A critical requirement of the robot manipulators is to, through strength and dexterity, safely and gently, rotate and lift human patients up to 300lbs. The robot system will assist the nurse/operator in moving patients by inserting manipulators beneath the patient and safely and gently lift them from a lying or sitting position. Safe operation in constrained hallways and clinic rooms is a must. Strategies for communications and command and control should include provision for wireless communications or networking, and remote control. The development and implementation of a safe robotic system beyond basic obstacle-avoidance is highly desired.

PHASE I: Conduct research and gather data focused on previous and current work in robotic system development to design a medical mobile robot to augment nurses' capabilities. Provide a detailed report describing the conceptual design as well as different applications of the proposed medical mobile robotic system. 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 a medical mobile robotic system to augment nurse's healthcare capabilities with mobility, dexterous manipulation, and viable interactions. System hardware and software should be able to:

- Navigate in hospital environment in teleoperation mode
- Work safely and robustly with a nurse
- Lift and move patients and heavy loads up to 300 lbs. with dexterous manipulation
- Perform well under direct control and via telepresence
- Automate start-up and self-diagnostics to ensure ease of use by diverse personnel of many skill sets, and within multiple environments

PHASE III: The ultimate goal of this research is to provide a new medical mobile nurses' assistant robot system for use in military and civilian hospitals to enhance healthcare quality and extend staff capabilities. This system will also have the potential for application in other healthcare and allied care facilities including nursing homes, long-term care of the disabled, and rehabilitation centers. With certain modifications this system would also be useful in physical medicine.

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KEYWORDS: Advanced Medical Robotic System, autonomous, teleoperated, dexterous, mobile, nursing assistant

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A07-147 TITLE: Rapid Production System for High Affinity Reagents Recognizing Protein Biomarkers

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Devise and implement a high-throughput system for producing reagents recognizing specified protein biomarkers based solely on sequence information to validate and test toxic exposure /effect biomarkers discovered by the US Army Center for Environmental Health Research (USACEHR) Biomarkers Program.

DESCRIPTION: Beginning solely from protein sequence description, the system should be able to rapidly produce protein recognition reagents with affinity and specificity for their target molecules comparable to that observed with antigen-specific antibodies. Such reagents may be produced by any means, including, but not restricted to, rational design; selection of aptamers or members of antibody or phage display libraries; or facilitated antibody production in an immune cell-based system. However, the time and effort for creation of any secondary reagents, such as synthetic peptides or over-expressed proteins required for selection or antigenic stimulation of immune cells, is considered to be part of the project. The target time frame for reagent generation is no more than 2 weeks. The generated affinity reagents must be usable in a high throughput quantitative assay in a complex biological matrix (preferably serum, but mammalian whole cell extracts may be acceptable) and require sample sizes in a range typical of molecular biological experiments. It must be possible to perform large numbers of quantitative assays simultaneously or near simultaneously in complex biological samples. The effectiveness of the system should be largely independent of the type of organism from which the starting sequence is derived.

PHASE I: The contractor will provide a proof-of-concept demonstration of a high throughput affinity reagent generation system. The demonstration will include nanomolar level quantification of 5-10 proteins in microgram to milligram samples of a complex biological matrix (preferably serum, but mammalian whole cell extract may be acceptable) using the affinity reagents developed in the project. The quantification method demonstration should be designed in such a manner as to allow assessment of cross-reactivity or other interferences. The project demonstration should begin solely with sequence data for proteins of interest and continue through quantitation. Preference will be given to projects that utilize original concepts or represent significant advances over published methods, use methods which minimize the number of steps for reagent production, require minimal sample sizes, and are amenable to miniaturization.

PHASE II: The contractor will continue research to implement and refine high throughput reagent generation using, at least in part, sequences provided by USACEHR. Contractor will provide proof-of-concept of high throughput quantitation in a complex biological matrix (preferably serum, but mammalian whole cell extract may be acceptable) involving 50 to 100 reagents. Sensitivity should be at least picomolar with femtomolar being desirable. At the end of Phase II, the contractor shall provide USACEHR with any reagents developed in the demonstration and two copies of any software or prototype or other devices developed in the course of the SBIR.

PHASE III: The rapid protein recognition reagent generating system is, in effect, a tool for producing new biotechnological tools and will have very general applicability in any setting (whether civilian or military) where a test for a protein of interest is required -- such as diagnostic tests for diseases, or detection systems for the presence of naturally occurring or weaponized disease-causing agents in the environment. Other potential uses for protein recognition reagents (used either singly or in combination) may include monitoring or discovering inapparent disease states, tracking wound healing, creating antitoxins or other therapeutics that function like interfering antibodies (e.g. the anticancer drug, Herceptin, tetanus or snake venom antitoxins), and creating moieties for recognizing or targeting particular cell types (tumor cells, e.g.) or pathogens (e.g., malaria, leishmania) with a chemically linked therapeutic agent.

Potential military users and applications include

US Army Center for Health Promotion and Preventive Medicine: assaying biomarkers of exposure to toxic industrial chemical and materials; assaying contaminants in food and water.

US Army Medical Command field units: assays for exposure to pathogens.

Joint Vaccine Acquisition Program: antitoxins; inactivating vaccines.

Defense Threat Reduction Agency, US Army Medical Research and Material Command Medical, Chemical and Biological Defense Program: detection, inactivation of, interventions for novel or weaponized pathogens.

The most likely Phase III government funding source is the US Army Medical Material Agency.

Creation of even single protein recognition reagents using conventional methods of antigen production and stimulation, and then screening a large number of potential reagents can be a slow, extremely arduous process, costly both financially and terms of the number of animals required for its completion. Hence, the development of a rapid system for protein recognition reagent development and production would provide broad benefits to the civilian and military biomedical and biotechnological communities. However, success will require effective market research for partners capable of commercial production and skilled marketing to ensure the involvement of such partners and to make the availability of the technology known to military and civilian users.

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KEYWORDS: proteomics, protein microarray, toxicology, biomarkers, antigen, antibody, aptamer, molecular methods

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A07-148 TITLE: Integrated Clinical Environment Manager

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a system for coordinating the operation of medical-electrical devices in a patient-centric clinical environment in a manner that provides levels of context-sensitive decision support and device management designated by the clinicians.

DESCRIPTION: The clinical environment is the patient-centered ecosystem comprising the patient, clinicians, medical-electrical (ME) equipment, and "information" about the patient and what the clinicians plan to do to support the patient. The clinical environment follows the patient as the patient changes clinical setting. Settings include, but are not limited to, home, transport, emergency room (ER), operating room (OR), recovery room, and intensive care unit (ICU).

In each of these environments clinicians interact with the patient, with ME equipment supporting the patient, and with each other. The primary clinicians use ME equipment to act upon and understand the patient's condition. More specifically, the ME equipment may monitor and display patient physiological parameters and may also act on the patient in order to control some of those parameters. Clinicians operate their own suites of equipment, derive patient information from them, and communicate verbally among themselves in order to coordinate the various activities that each is performing in the clinical environment. The clinicians interact as a team and share an awareness of the activity, treatment or disease being addressed. Within each clinical environment, the clinicians are aware of the clinical context (e.g. induction of anesthesia in an infant with normal volume status; elderly post-op patient lying in hospital bed at night receiving intravenous pain medication and on supplemental oxygen, etc.)

The state-of-the-clinical-environment is characterized by the values of patient physiological parameters, ME equipment configuration and settings, and status of active clinical procedures. Clinicians act to achieve some goal for the patient using this state information to inform their actions. This process can be represented by a classical feedback control loop. For example, during an OR procedure the anesthesiologist seeks to maintain a patient's vital signs within defined ranges. The ranges of the vital signs are the clinician goals. Patient monitors take measurements of the patient's vital signs and display the results to the clinician. These measurements, the settings and status of the anesthesiology equipment, and the clinician's visual observations of the patient are integrated—in the clinician's head, in the light of past experience—to assess the patient status. This status is compared—again, in the clinician's head—with the goals for the patient. If goals and patient status differ in an appreciable way, the clinician takes action—by adjusting settings of the ME equipment—in order to reduce the difference.

Assessment of overall clinical state, comparison of state to goals, and decisions about how to act to minimize the differences are implicit in every clinical context. Today they are, for the most part, executed manually. Significant benefits, both in safety and efficiency, could be achieved by a system that aided the clinician in performing these functions (ie. clinical associate). A clinical associate acquires and integrates data from ME equipment to provide the clinician with an assessment of the state-of-the-clinical-environment, and the differences with the intended goals. The associate provides a "second set of eyes" and a "second opinion" to the clinician. The clinician retains access to all of the primary information so is free to evaluate the associate's assessment of clinical state and calculated difference from goals, and to utilize this information in an appropriate way. In addition to providing an assessment of clinical state, the associate could suggest actions to the clinician, and even be assigned a level of execution authority in specific areas by the clinician. Assessed differences from desired clinical state would trigger actions by the associate to reduce those differences.

The clinician's associate is intended to provide improved patient safety and procedural efficiency by providing the clinician with 1) a shadow observation and assessment of clinical state—a second set of eyes and a second opinion, and 2) automated loop closure of specifically identified functions—a second set of hands. In all cases the clinician retains ultimate control of the system.

Characteristics of a clinician's associate should include 1) mechanism for gathering and integration of data from medical-electrical devices in the clinical environment, 2) mechanism for assessment of that data in the clinical context to support clinician decision-making, and 3) mechanism for automating actions by the associate as enabled by the clinician.

PHASE I: Conduct research and gather data focused on previous and current work on integration and coordination of ME devices. These baseline data must be collected by a multidisciplinary group comprised of expert clinicians, engineers (i.e. Biomedical, Mechanical, Electrical, and Computer), programmers, and military personnel. Provide a detailed illustrative report describing the conceptual design as well as different applications of a proposed patient centered integrated clinical environment associate. Identify design features and applications that will improve the safety, quality, access and cost of medical care in subsequent phases of this project.

PHASE II: Design, develop and demonstrate a functional prototype of a multi-purpose clinical associate for integrating and coordinating the patient clinical environment including the following advancements. Hardware and software that:

- Provides a method of data logging
- Incorporates device authentication/authorization (digital certificate)
- Maintains data security
- Allows implementation of clinical rules to coordinate ME devices for increased care
- Incorporate fault tolerant computing to ensure patient safety despite system failure
- Automatically optimize network configuration and performance
- Incorporate modular design to allow easy upgrade and replacement
- Automate start up and diagnostics to insure ease of use by diverse personnel within multiple environments
- Incorporate open source software and industrial/government standards as much as possible to permit use with varied ME systems

PHASE III: The ultimate goal of this research is to provide a novel clinical environment management system that centers on the patient and provides the ability to integrate and coordinate various ME devices with clinician support for improved health care. The patient centered clinical associate will improve the safety, access, quality and cost of military and private sector medical care. It is the intent of this R&D to develop a dual-use military and private sector device that can implemented within each healthcare system. As medical device interoperability technologies continue to advance the private sector will also adopt this because it will allow small, specialized ME device manufacturers to integrate with other ME devices into a system that provides increased levels of health care over singular, standalone devices. Cost within the private sector is a major factor in business decisions to implement ME device interoperability technologies. This new patient centered clinical environment management technology can provide a scalable integration and coordination tool that clearly benefits the private sector healthcare equally as well as the DoD in improving the overall Quality of Service (QoS).

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KEYWORDS: Clinical Environment, Patient-centered, Medical Device, Interoperability, Integration, Coordination

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A07-149 TITLE: Multiplexed Assay for the Detection of Wound-related Pathogens

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: MRMC Deputy for Acqusition

OBJECTIVE: We envision a hand-held assay that uses modern molecular and or immunological technology to simultaneously detect and differentiate up to 7 distinct wound-related pathogens/targets in a single reaction using clinical blood or serum samples.

DESCRIPTION: Wound-related pathogens such as Acinetobacter baumanii are a major challenge affecting the care of soldiers injured in Iraq and Afghanistan. The rapid determination if a wound-related pathogen is causing illness is a critical requirement for which no solutions currently exist.

The goal of this SBIR topic is to develop a prototype diagnostic system that is capable of simultaneously detecting and rapidly identifying up to 7 militarily relevant wound-related pathogens/targets from a clinical sample. The 7 targets for this effort include Acinetobacter baumannii-calcoaceticus complex (ABC), Enterobacter cloacae, Pseudomonas aeruginosa, Streptococcus pneumoniae, Streptococcus pyogenes, Staphylococcus aureus, and Methicillin-resistant S. aureus (MRSA).

Currently used diagnostic assays normally only detect a single pathogen or at most several pathogens – as such they only provide limited information (e.g., pathogen "A" is present or not present in a particular sample) that clinicians can use to assist them in the diagnosis of infectious agents causing human disease. The ideal assay would be able to detect the primary pathogens of concern in a particular type of sample. For example, a tissue-swab from a wound could be tested for the presence of infectious agents such as methicillin-resistant Staphylococcus aureus (MRSA), Acinetobacter baumanii, and Pseudomonas aeruginosa (among others).

We envision a hand-held assay that uses modern molecular and or immunological technology to simultaneously detect and differentiate up to 7 distinct wound-related pathogens/targets in a single reaction using clinical blood or serum samples. The assay should have the following characteristics: The assay must be rapid (<30 min), one- or two-step format, stable (storage at 35 degrees C for 2 years) and require no power to operate. The assay should 80% as specific and 80% as sensitive as current gold-standard assays. The assay must be soldier-friendly (i.e., easy to operate), inexpensive, portable, use heat-stable reagents, and have no special storage requirements.

PHASE I: Selected contractor determines the feasibility of the concept by developing a prototype diagnostic assay that has the potential to meet the broad needs discussed in this topic. Contractor conducts initial laboratory evaluation of the prototype device and provides a written report to the Contracting Officer Representative (COR). Contractor should coordinate in advance with the COR for any support required from the Walter Reed Army Institute of Research (WRAIR).

PHASE II: The goal in Phase II is the development of a prototype assay that provides 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. Contractor should coordinate in advance with the COR for any support required from the WRAIR.

PHASE III: The selected contractor carries out studies required to obtain FDA clearance for the assay and commercializes 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 medical organization (such as a Battalion Aid Station, a Combat Support Hospital, or a fixed medical facility) to determine if wound-related pathogens are present in an injured patient. 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 deployable medical forces.

Civilian Use of this Product: Wound-related pathogens are a significant problem for a variety of civilian medical organizations. This assay will have a significant commercial market in both the United States and in various overseas locations.

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KEYWORDS: Diagnostic, Assay, Wound-related, Acinetobacter, MRSA

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A07-150 TITLE: A Multiplexed Assay for the Detection of Pathogens of Military Importance in Sand Flies

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To quickly and accurately determine whether sand flies collected during military deployments are infected with sand fly fever virus (SFFV) or leishmaniasis, two of the leading causes of disease during military operations in the Middle East. We envision a rapid detection assay capable of determining whether sand flies are infected with SFFV or Leishmania parasites.

DESCRIPTION: A. Requirement: To quickly and accurately identify Leishmania and Sand fly fever virus in sand flies. Sand fly-borne pathogens are a leading cause of morbidity in Iraq and Afghanistan – the rapid determination if infected sand flies are present will allow for timely implementation of prevention and control programs to minimize disease in deployed US forces.

B. Desired capability/concept of the final product: We envision a rapid, multiplexed detection assay capable of simultaneously determining whether sand flies are infected with Leishmania or Sand fly fever virus. The assay must be rapid (<30 min), one- or two-step format, and stable (storage at 35 degrees C for 2 years). The assay should be 80% as specific and 80% as sensitive as current gold-standard assays. The assay must be soldier-friendly (i.e., easy to operate), inexpensive, portable, use heat-stable reagents, and have no special storage requirements.

C. Technical Risk: There is a degree of technical risk involved in this project. There are currently no existing assays that meet the requirements outlined in this proposal -- the candidate contractor is expected to use innovation and in-house expertise to develop a prototype that meets the needs of the Department of Defense.

D. Access to Government facilities and supplies: Reagents, positive-control material, infected sand flies, etc. to support this project may be available from the Walter Reed Army Institute of Research. The candidate contractor should coordinate with the Contracting Officer Representative (COR) for any required support prior to the submission of the proposal.

PHASE I: Selected contractor determines the feasibility of the concept by developing a prototype diagnostic assay that has the potential to meet the broad needs discussed in this topic. Contractor conducts initial laboratory evaluation of the prototype device and provides a written report to the COR. Contractor should coordinate in advance with the COR for any support required from the Walter Reed Army Institute of Research (WRAIR) or the U.S. Army Medical Research Institute for Infectious Diseases (USAMRIID).

PHASE II: The goal in Phase II is the development of a prototype assay that provides 80% sensitivity and 80% specificity when compared to current gold standard assays for each Leishmania parasites and Sand fly fever virus. 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) and initial field testing. The selected contractor will also conduct stability testing of the prototype device in Phase II. 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. Contractor should coordinate in advance with the COR for any support required from the WRAIR or USAMRIID.

PHASE III: During this phase the performance of the assay should be evaluated in a variety of field studies that will conclusively demonstrate that the assay meets the requirements of this topic. By the conclusion of this phase the selected contractor will have completed the development of the assay and successfully commercialized the product. The contractor shall provide a report that summarizes the performance of the assay to the Armed Forces Pest Management Board and will request that a National Stock Number (NSN) be assigned. Contractor should coordinate in advance with the COR for any support required from the WRAIR or USAMRIID.

Military Application: Once a NSN has been assigned to the assay, the Armed Forces Pest Management Board will work with appropriate organizations to have the assay incorporated into appropriate "Sets, Kits and Outfits" that are used by deployed Preventive Medicine Units.

Commercial applications: Vector-control organizations throughout the developing world require cheap, easy-to-use diagnostic assays for the detection and identification of insect-borne pathogens. The development of a field-usable, multiplexed sand fly-pathogen dipstick assay would provide an urgently needed device that would be commercially viable. During this phase the selected contractor shall make this product available to potential users throughout the world.

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KEYWORDS: Leishmania, Sand fly fever virus, detection, assay, next-generation, field-deployable, diagnostic

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A07-151 TITLE: Personal Insect Repellent Device

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Design and develop a portable device impregnated with a repellent(s) and/or insecticide(s) that can be attached to a soldier's field uniform and provide long-lasting, passive, whole-body (spatial) protection against insect vectors of disease.

DESCRIPTION: A. BACKGROUND:
Repellents and insecticides provide excellent protection against vector-borne diseases, including malaria, dengue fever, and leishmaniasis. In the military, personal protective measures (PPM) are the most effective means of protecting soldiers from arthropod-borne diseases (e.g., malaria, dengue, leishmaniasis, West Nile virus, scrub typhus, TBE, CCHF, etc.). Currently PPM consist of a combination of three measures: i) application of DEET repellent to the skin, ii) proper wear of a permethrin-treated uniform, and iii) sleeping under a permethrin-treated insect net. When properly used, this system of overlapping measures can provide close to 100% protection against vector-borne diseases. Unfortunately, PPM are rarely used properly - recent data from Iraq suggests that fewer than 30% of soldiers properly used PPM. This failure has resulted in many soldiers getting bitten by sand flies and an unexpectedly high incidence of leishmaniasis (currently >2,000 confirmed cases) in US military personnel deployed to Iraq. A number of factors contributed to the failure of PPM, to include: i) due to the intense heat, off-duty personnel normally wore shorts and T-shirts, slept in nothing but shorts, and did not use insect bed nets, even when available; ii) most soldiers failed to treat their insect nets and uniforms with permethrin, even when the appropriate products were available; iii) many soldiers did not know how to properly use the insect bed nets; iv) soldiers frequently slept with their body in contact with the insect bed nets, which allowed sand flies to bite the soldiers through the net; v) soldiers routinely did not use the DoD's Extended Duration Topical Insect and Arthropod Repellent [DEET] or several reasons: they believed it was unsafe, did not like its odor, felt it was uncomfortable when applied to the skin, and believed it was ineffective; and vi) the logistics system failed to provide PPM items at the time/place that they were needed. The failure of PPM in Iraq is primarily due to the fact that in order to be effective soldiers must actively implement PPM on a daily basis (treat uniforms and bednet, apply repellent on skin, set-up bed net, etc.). A simplified PPM system that would require minimal active participation from our deployed soldiers is urgently needed. The ideal system would require a single, light-weight component (minimal logistics burden) that could be easily implemented whenever needed and provide passive protection. The goal of this SBIR project is to develop a "Personal Insect Repellent Device" impregnated with a repellent(s) and/or insecticide(s) that can be attached to a soldier (or his/her uniform) to provide long-lasting, passive, whole-body, spatial protection against insect vectors of disease. The concept of a spatial repellent/insecticide already exists (see References). The challenge will be to (1) formulate a spatial repellent/ insecticide and (2) design a wearable device that releases the compound at effective release rates.

B. REQUIREMENT:
The "Personal Insect Repellent Device" should be light-weight (less than 8 oz.), sturdy, portable and water-proof. The device should contain a substrate that is impregnated with a repellent(s) and/or residual insecticide(s) that are in vapor phase at ambient temperatures. Current candidates include a number of highly volatile pyrethroid insecticides (see References). The device should provide long-lasting, passive, whole-body, spatial protection against bites from sand fly vectors of leishmaniasis, mosquito vectors of malaria, and other arthropod disease vectors (including ticks), for at least one month of continuous use, regardless of whether the user is stationary or mobile. The device should provide adequate control against biting insects outside, including large open areas. The device should be easily attachable and removable from a soldier, or an individual soldier's uniform. The device should provide protection for at least 30 consecutive nights of use (12-14 hours/night) against a range of biting flies. It should be easily

operated with a simple "on/off" or "open/close" function to maximize overall usage time when not in use. The longevity of the device should function in a range of different climates and optimized to withstand excessive heat (>120 deg-F). The device should not require any heating or burning to release the vapor, but should instead employ passive or active evaporation of active ingredients without the application of heat. The components of the device should not require special handling by the user and should not present any risk from exposure to the repellent(s) or insecticide(s) contained therein.

C. DESIRED CAPABILITY/CONCEPT OF THE FINAL PRODUCT:
To develop a light-weight, portable, water-proof “Personal Insect Repellent Device”, impregnated with a repellent(s) and/or insecticide(s) vapor, that can be attached to a solider, or an individual soldier's uniform, to provide long-lasting, passive, whole-body, spatial protection against bites from insect disease vectors (e.g. sand flies and mosquitoes) and other biting arthropods (e.g. ticks) for at least 1 month of continuous use.

PHASE I: Contractor develops a detailed plan (to include development milestones) and proof-of-concept study (to include technical feasibility and product evaluation) for a "Personal Insect Repellent Device". Phase I deliverables will integrate a chemical with an innovative design to develop a prototype product that has the potential to meet the broad needs discussed in this topic. Contractor determines the feasibility of the concept by conducting initial evaluations of the chemical(s) for their efficacy to repel vectors.

PHASE II: Selected contractor designs and manufactures at least 1 prototype product that meets all requirements. Contractor will conduct initial laboratory evaluations of the prototype devices to determine efficacy against biting insect vectors, followed by field evaluations. If more than 1 prototype product is tested, the contractor will down-select the best product(s) for subsequent field evaluations. Contractor will conduct comprehensive field evaluations against several vector species (mosquitoes, sand flies, etc.), to include a user acceptability trial that compares the developed product with topical repellents currently used by the military (e.g. DEET). Field evaluations are conducted in an existing military field environment or similar environment, and over extended operating conditions to determine the durability and operation of the candidate device(s). Results of laboratory and field evaluations will be used to further refine and improve the prototype device. Once a candidate device has been developed that meets the criteria outlined in this proposal, the selected contractor will conduct testing of the device’s physical, chemical and toxicological properties in accordance with EPA requirements for subsequent EPA approval.

PHASE III: This SBIR project has strong commercialization potential (customers include US and allied military forces, as well as the vast majority of people who spend time outdoors in the US – e.g., hunters, campers, and people who are exposed to vector-borne diseases in developing countries). Under Phase III the selected contractor will obtain EPA registration for the product and successfully commercialize the device, to include working with the Armed Forces Pest Management Board to obtain a National Stock Number for the device.

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KEYWORDS: Spatial repellent, insecticide, wearable device, passive protection, biting flies, sand flies, mosquitoes.

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A07-152 TITLE: Field-deployable source of Carbon Dioxide for use in Vector Surveillance

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: A key mission of deployed Preventive Medicine units is to conduct surveillance for arthropods (mosquitoes, ticks, sand flies, etc.) that transmit diseases capable of interrupting combat operations. The standard tool for conducting surveillance for arthropods is the Centers for Disease Control (CDC) miniature light trap baited with carbon dioxide (CO2). Currently, CO2 is only available as dry ice or as a compressed gas. Significant issues (cost, shipping hazards, weight, etc.) preclude the use of these forms of CO2 during military operations. A field-deployable source of CO2 is urgently needed.

DESCRIPTION: The goal of this SBIR is to develop a field-deployable source of CO2 and a means of delivering the CO2 to a CDC miniature light trap. Specific objectives for this product are as follows:

1) Should provide a constant (+/- 10%) CO2 output of no less than 200ml/minute (Objective is 400ml/minute) for 12 hours using <2 kg of starting material.

2) The starting material should be capable of being stored at ambient conditions and must not be considered a hazardous material for shipping purposes.

3) A method of delivering the CO2 to the CDC light trap is required. Methods that will deliver CO2 to the traps on multiple nights without using CO2 during the day are desired.

4) Portability of the device is critical. The delivery device should be less than 1 cubic foot in size and weigh less than 3 kg (excluding chemical required to produce the CO2).

5) The developed device should be rugged as it is intended for extended use under harsh environmental conditions (hot, dusty desert environments, tropical jungles, etc.). All critical components should be shielded from the elements.

6) The device should be easy to operate. It should be able to be set-up in less than 5 minutes and there should be a mechansism to determine if the device is operating properly (i.e., delivering appropriate rates of CO2).

PHASE I: Selected contractor determines the feasibility of the concept by developing a prototype device that has the potential to meet the broad needs discussed in this topic. Contractor conducts initial laboratory evaluation of the prototype device and provides a written report to the Contracting Officer Representative (COR). Contractor should coordinate in advance with the COR for any support required from the Walter Reed Army Institute of Research (WRAIR).

PHASE II: Selected contractor continues development of the prototype device and enhances prototype so that device is field-deployable, simple to use, rugged, and that will provide a constant output of no less than 200ml CO2/minute for 12 hours. Contractor completes laboratory testing and conducts field testing and validation studies against mosquitoes (Aedes sps. and Anopheles sps.), sand flies (Phlebotomus sps.) and ticks (Ixodes sps.) in at least 3 locations and provides resulting data to the COR for review. At the conclusion of Phase II contractor shall have developed a product that meets all requirements and is ready for commercialization.

PHASE III: During Phase III selected contractor will finalize design of a production model and successfully commercialize the desired device.

Military Use of this Product: The developed product will be used by deployed Preventive Medicine units to support vector surveillance activities both in the continental United States and during military deployments. During Phase III the selected contractor will coordinate with the COR to arrange for a review of the product by the Armed Forces Pest Management Board and a request for assignment of a National Stock Number (NSN) to this device. 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 deployable Preventive Medicine Units.

Civilian Use of this Product: Vector Surveillance operations are carried out by a variety of civilian organization throughout the world. In the United States, Mosquito Control Districts spend hundreds of millions of dollars annually conducting surveillance for and controlling mosquitoes. The device developed under this SBIR topic will have an extensive market with these organziations. In the developing countries of the world, vector-borne diseases such as malaria, dengue fever, and leishmaniasis infect hundreds of millions of people. Various government and non-government organizations carry out vector surveillance operations in these countries. The CO2 production device developed uder this SBIR topic potentially has a significant market in these countries.

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KEYWORDS: carbon dioxide, trap, surveillance, mosquito, sand fly

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A07-153 TITLE: A Point-of-Care Assay for the Detection of Spotted-fever group and Typhus group Rickettsia.

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Historically, rickettsial pathogens have been a leading cause of morbidity and mortality during military operations. There currently are no FDA-cleared, field-usable assays that can be used to diagnose rickettsial disease in sick soldiers. The goal of this SBIR topic is to develop this capability. We envision a rapid detection assay capable of determining whether a sick soldier is infected with either Spotted Fever group or Typhus group rickettsia.

DESCRIPTION: Rickettsial pathogens have been a leading cause of morbidity and mortality during military operations. Rickettsial pathogens are separated into two groups -- the Spotted fever group Rickettsia (Rocky Mountain spotted fever, Rickettsial Pox, Boutonneuse fever, Siberian and Australian tick typhus, and Oriental spotted fever) and the Typhus group Rickettsia (Epidemic and murine typhus). The causative agent of scrub typhus was formerly known as Rickettsia tsutsugamushi; however, it has been reclassified into the genus Orientia. There currently are no FDA-cleared assays that can be used to diagnose all rickettsial infections in sick soldiers. The goal of this SBIR topic is to develop this capability.

Due to the high mortality rate that can result from untreated rickettsial infections, early treatment with an appropriate antibiotic is critical. Rickettsia are highly resistant to most antibiotics -- for example, most fatal cases of Rocky Mountain spotted fever had received substantial courses of antimicrobial treatment, including beta lactams, aminoglycosides, and erythromycin. Sulfonamide antimicrobials actually appear to exacerbate the severity of rickettsial infections. Doxycycline is the drug of choice for the treatment of infections caused by Rickettsia except in cases of pregnancy and tetracycline hypersensitivity. Several fluoroquinolones, azithromycin, and clarithromycin, have been used successfully to treat boutonneuse fever but are not recommended for more pathogenic rickettsioses.

In order to ensure that appropriate treatment is initiated promptly, the early diagnosis of rickettsial infections is critical. Symptoms of many rickettsial infections are easily confused with a variety of other pathogens (e.g., dengue, malaria, leptospirosis, etc.) that require different treatment regimens. The development of a hand-held assay specific for Spotted fever group and typhus group Rickettsia that would allow for the prompt diagnosis of these pathogens, resulting in early treatment with the appropriate antibiotic.

The assay must be rapid (<30 min), one- or two-step format, and stable (storage at 35 degrees C for 2 years). The assay should be at least 85% as sensitive and specific as current current (non-deployable, non-FDA cleared) assays. The assay must be soldier-friendly (i.e., easy to operate), inexpensive, portable, use heat-stable reagents, have no special storage requirements, and require no power to operate.

PHASE I: Selected contractor determines the feasibility of the concept by developing a prototype diagnostic assay that has the potential to meet the broad needs discussed in this topic. The assay must detect and differentiate Spotted fever group and typhus group rickettsia. Contractor conducts initial laboratory evaluation of the prototype device and provides a written report to the Contracting Officer Representative (COR). Contractor should coordinate in advance with the COR for any support required from the Walter Reed Army Institute of Research (WRAIR) or the Naval Medical Research Center (NMRC).

PHASE II: The goal in Phase II is the development of a prototype assay that provides 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. Contractor should coordinate in advance with the COR for any support required from the WRAIR or NMRC.

PHASE III: The selected contractor carries out studies required to obtain FDA clearance for the assay and commercializes the assay. The WRAIR and/or NMRC 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 an military medical organization (such as a Battalion Aid Station, a Combat Support Hospital, or a fixed medical facility) to determine if Rickettsial pathogens are present in febrile patients. Upon successfully obtaining FDA clearnace 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 deployable medical forces.

Civilian Use of this Product: Rickettsial pathogens are a significant problem for a variety of civilian medical organzations (local health clinics, hospitals, etc.), primarily in the developing countries. This assay will have a significant commercial market in various overseas locations.

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KEYWORDS: Diagnosis, Assay, Typhus, Rickettsia, Point-of-Care, Manufacturing, Spotted-Fever

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A07-154 TITLE: Therapeutic/Prophylactic Use of Human Hyperimmune Polyclonal Antibodies for Neutralizing Staphylococcal and Streptococcal Exotoxins

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: Identify and develop human hyperimmune polyclonal antibodies against staphylococcal enterotoxins, toxic shock syndrome toxin-1, and/or streptococcal pyrogenic exotoxins. Such immunoreagents would be effective prophylactics/therapeutics in biowarfare, bioterrorism, and natural disease scenarios.

DESCRIPTION: Staphylococcus aureus and Streptococcus pyogenes naturally cause infections, many life-threatening in humans. To aid in their pathogenesis and survival in rather harsh conditions found in the human body, these bacteria produce various virulence factors that include potent superantigenic exotoxins. These secreted proteins called staphylococcal enterotoxins (SE), staphylococcal toxic shock syndrome toxin (TSST-1), and streptococcal pyrogenic exotoxins (SPE) induce a cascade of proinflammatory cytokines, chemokines, etc. from the host's immune system that accumulate to toxic levels, possibly eliciting severe shock and subsequent death.

Rising interest within the biodefense and public health communities regarding antibiotic resistance amongst the staphylococci, streptococci, and other pathogens logically suggest that other countermeasures must be developed sooner, than later. Additionally, the antibiotic paradigm of success is now "evolutionarily archaic" and we must invest in newer means of controlling rogue bacteria and their toxic products. Overall, this type of thinking when coupled with subsequent action will lead to enhanced health amongst the overall population and greatly aid our protective, fighting forces.

As an example targeting S. aureus and S. pyogenes, various prophylactic/vaccine studies in animals show that toxin-specific antibodies play an important role in abrogating the ill-effects of these toxins and overall pathology/disease progression. The prevalence, and therapeutic use, of antibodies in humans has been correlated with disease severity and occurrence. Specific antibodies towards the streptococcal and staphylococcal exotoxins are effective therapeutics/prophylactics experimentally in humans and animal models. Proposals are now being solicited to provide human hyperimmune polyclonal antibodies, derived after vaccination, directed towards these bacterial exotoxins that are of prophylactic and therapeutic utility.

PHASE I: Determine technical feasibility of developing human hyperimmune polyclonal antibodies to control or prevent ill-effects associated with staphylococcal enterotoxins (i.e. staphylococcal enterotoxin B, SEB), staphylococcal toxic shock syndrome toxin (TSST-1), and/or streptococcal pyrogenic exotoxins (i.e. SPEA) via established in vitro and/or in vivo models. This will be ascertained by using polyclonal antisera from an animal model (mouse or preferably non-human primate) immunized against one or more of the toxin agents. Specific antibodies can then be tested using established cell-based assays (inhibition of lymphocyte proliferation) or mouse assays (protection from lethality) by pre-mixing toxin with antisera. Results from such assays will logically lead to product development as briefly described in Phase II.

Write a set of standardized or validated assays, with clear standard operating procedures, necessary for evaluating Phase II products.

Draft a human use protocol for vaccination with recombinantly-attenuated vaccine(s) towards staphylococcal and/or streptococcal superantigenic toxins. This is necessary to ensure Phase II success.

Use of human cells, human tissues, and/or animals requires approval by the appropriate U.S. Army Medical Research and Materiel Command Regulatory Office. Phase I should include approval of appropriate regulatory documents necessary to execute Phase II.

PHASE II: Finalize human use protocol, perform vaccination with GMP-generated vaccine, and collect hyperimmune sera against staphylococcal and/or streptococcal superantigens. Validate efficacy of hyperimmune sera by using intoxication models in vitro (inhibition of cell-based proliferation assay) and in vivo (mice and nonhuman primates).

PHASE III: Successful Phase II products will be of use for both biodefense AND public health pending human clinical trials. The most likely path for transition of this SBIR from research to operational capability involves clinical testing. Funding for such trials would be obtained from the Department of Defense and/or the National Institutes of Health. Successful trials will logically lead to FDA approval for human use, perhaps much like the orphan drug BIG-IV (Human Botulism Immune Globulin Intravenous) recently approved for treating infant botulism (Arnon et al. 2006).

For human testing, there must first be a GMP process designed for sera fractionation and development of a suitable product. There is currently no FDA-approved product for targeting the critical, exotoxin virulence factors of either S. aureus or S. pyogenes. Ever-increasing antibiotic resistance amongst these Gram-positive bacteria suggest that such a product, like human hyperimmune polyclonal antibodies directed towards a vaccine (not a natural infection), will be of increasing value in the future for fighting these microbial pathogens and potential biowarfare/bioterrorism adversaries.

Those in the Government that will ultimately use this product include soldiers/medics in the field (specific use against a biowarfare/bioterrorism event), along with clinicians in both the military and civilian sectors of our society.

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KEYWORDS: Staphylococcus, Streptococcus, Exotoxins, Therapy, Prophylaxis, Shock

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A07-155 TITLE: Enhanced Camouflage System Materials for Protection Against Arthropod-Borne Disease

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop enhanced camouflaging materials with residual insecticidal and/or repellent properties that can be incorporated into the standard military field camouflage system (nets and poles) to provide area-wide protection against biting arthropods (mosquitoes, sand flies, deer flies, etc.) while supporting the concealment function.

DESCRIPTION: Vector-borne diseases such as leishmaniasis and malaria continue to threaten the health of deployed military personnel. Although vaccine development is a research priority, there are no currently available vaccines for protection against many of these diseases. The impact of vector-borne illness to deployed forces is enormous in terms of costs for treatment, loss of duty time, and to troop morale.

There are two primary modes of action against vector-borne disease threats: vector control programs and personal protection methods. Vector control is performed by theater preventive medicine units and DoD and contractor pest management professionals. Personal Protection Methods rely on troop participation in treating their clothing, wearing the clothing properly, using bed nets, and applying repellents. If employed properly, Personal Protection Methods provide maximum protection against arthropod vectors; however, inadequate education of troops and/or careless attitudes towards the use of Personal Protection Methods reduces the effectiveness of this strategy. Additionally, pest management operations are often focused on larger facilities, bases, and installations. Operational necessity may cause certain units to be positioned in areas that are not accessible to routine vector surveillance activities. Furthermore, highly mobile equipment and personnel, particularly those involved in the early stages of operations, frequently employ their equipment and activities in areas prior to theater establishment of vector control operations. The development of alternative methods of passive vector suppression applications that accompany the unit will provide additional protection against arthropod-borne disease threats.

The goal of this SBIR is to develop materials that are enhanced with insecticides or repellents and incorporate those products into the standard military camouflage system of netting and poles. The development of new materials with insecticidal properties for area control will enhance the function of the camouflage system. When deployed, the improved camouflage system continues to provide effective concealment of troops and equipment. The development of this product will provide deployed units with additional vector suppression capabilities that reduce the threat of acquiring vector borne disease.

REQUIREMENT: The enhanced camouflaging materials should provide effective area-wide suppression of flying arthropod vectors when compared to the standard camouflage system without enhancements. The materials should have residual insecticidal or repellent properties such that replacement is as infrequent as possible. The enhanced materials should not require special handling by the user and present no risk from pesticide exposure.

DESIRED CAPABILITY/CONCEPT OF THE FINAL PRODUCT: We envision a material that is easily incorporated into the standard military camouflage system that provides effective insecticidal activity for vector control in the concealment area. The material does not interfere with the concealment properties of the camouflage and does not require any special handling for its application or removal and destruction. The material can easily be removed or replaced to provide continuing protection against biting arthropods. The goal is to provide a barrier to arthropod disease vector populations in field environments.

PHASE I: Selected contractor determines technical feasibility of the concept by developing prototype materials that have the potential to meet the requirements for incorporation into the military camouflage system and providing spatial protection against arthropod vectors. Selected contractor designs and tests candidate materials and provides results of candidate novel product(s).

PHASE II: Selected contractor evaluates relevant properties of the novel materials based on Phase I to meet requirements for further field evaluations. The contractor will demonstrate integration of product into camouflage system and efficacy against vectors. The selected contractor will conduct testing of physical, chemical and toxicological properties in accordance with Environmental Protection Agency requirements.

PHASE III: In Phase III, the enhanced camouflaging for vector control demonstrates significant force health protection applications for use in operations conducted out-of-doors. The new materials fabricated and integrated into the existing military camouflage system will not effect the concealment function of the system. Under Phase III the selected contractor will obtain Environmental Protection Agency registration of the product and successfully commercialize the product, to include working with the Armed Forces Pest Management Board to obtain a National Stock Number. This SBIR also has strong commercialization potential. The materials developed from this SBIR can also be incorporated into commercial applications for outdoor recreation materials (e.g. equipment for hunting, camping and outdoor sporting events) where vector-borne disease has the potential to affect the civilian population.

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KEYWORDS: vector control, pesticides, disease transmission, repellents, fabrication, camouflage

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A07-156 TITLE: Strain Measurement System for Parachute Canopies

TECHNOLOGY AREAS: Materials/Processes, Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop an instrumentation system which measures the entire continuous strain field in a parachute canopy while it is inflating and once it is fully inflated.

DESCRIPTION: Traditionally, parachutes are developed through full-scale flight testing which is a time consuming and expensive process. Advanced computer models are being developed by the US Army Natick Soldier Center to simulate airdrop systems in order to provide a resource for early evaluation and initial development of airdrop systems. These computer models need to be validated with test data to ensure accurate prediction results from the simulation. The validation of the parachute canopy structural dynamics in the simulation would be greatly aided by detailed knowledge of the temporally evolving strain field in the canopy as the parachute inflates and once the canopy is fully inflated and falling under steady descent.

The intent of this solicitation is for the development of an instrument or sensor system which measures the strain in a fabric over the entire continuous surface of the parachute canopy not at a few distinct points. This implies a two-dimensional field measurement not single point measurements. By measuring the strain over the entire surface, a complete strain field can be obtained for a thorough comparison with the numerical simulation ensuring a more complete validation of the simulation. Additionally, if the strain measurement system were utilized in a parachute development program, then regions of high strain in the canopy could be identified allowing the parachute designer to take measures to reduce the strain in those regions thereby reducing the chance of fabric failure.

Estimates of the peak strain in a parachute range from 0.2% for a fully inflated parachute canopy falling under steady descent to 3% during the canopy inflation process with fabric failure at approximately 25%. It is therefore desired to be able to measure strain over the estimated range of 0.002% to 40% to capture the entire range of strain the canopy could encounter. The strain measurement system should have a frequency response of at least 2000 Hz in order to accurately capture strain events occurring on the order 1 ms which occur during the canopy inflation. The system should be able to measure the strain on parachutes ranging in size from mid-scale parachutes (3 - 20 ft in diameter) to full-scale parachutes (20 - 100 ft in diameter). Solutions requiring the instrumentation be mounted on the parachute payload are acceptable although it should be noted that the mid-scale parachutes typically have small payloads (as low as 3 lbs in weight). It is envisioned the mid-scale parachutes will be tested indoors inside a large hangar allowing for the strain measurement instrumentation to be mounted on the ground or a scaffolding system near the parachute. The full-scale parachutes will be tested outdoors and deployed from an aircraft. The strain measurement system should have a spatial resolution of approximately 5% of the canopy diameter. Any solution should avoid significantly altering the material properties of the fabric although attachment of small objects or devices onto the surface of the canopy fabric would be considered. The measurement system might be susceptible to electrostatic energy induced in the canopy fabric during inflation and descent. Therefore steps should be taken to mitigate any electrostatic discharge or EMI induced failures in the system. If the proposed solution to the topic includes sensors or arrays of sensors being attached to the canopy fabric, it is recommended the sensors operate wirelessly or contain on-board data storage eliminating the need for long lead wires to the data processor/recorder. Optical interrogation measurement methods which involve modifying the canopy surface through application of an optical pattern or fabric coatings would be considered as possible solutions provided the material properties of the fabric are not significantly altered. Should an optical interrogation method system be proposed, careful consideration should be given on how the optical systems will be positioned for full-scale parachute testing. Possible mounting positions for the optical systems include attachment to the payload or on a “chase” aircraft or parachute system.

PHASE I: During Phase I, a feasibility demonstration of the strain measurement system should be provided in a laboratory on various samples of parachute fabric. The demonstration should show the strain range and frequency response capability of the system. Concepts should be provided for the development of a prototype system useable on mid-scale and full-scale parachute systems.

PHASE II: During Phase II, a prototype system should be developed for demonstration of the system on mid-scale parachutes initially then developed for deployment on full-scale parachute systems. The ultimate goal is to measure the strain on a full-scale parachute system deployed from an aircraft.

PHASE III: A successfully developed system would be used as a tool to acquire data for the validation of numerical computer models of parachute systems. A properly validated computer model will be used to expedite and decrease the costs associated development and improvement of parachute systems. The development of a strain measurement system is a critical tool needed to aid in the validation of these numerical parachute models. A strain measurement system capable of measuring the strain in a large flexible fabric could be applied to numerous structures and objects such as tents or clothing. The device would also make it possible to test and measure strain in other textile objects such as webbing used to secure loads on trucks or in aircraft, airbag systems, kites, or sails. The successful transition from SBIR research to an operationally capable system would require the refinement of the prototype systems developed during Phase II to a user-friendly, turn-key commercial instrumentation system.

REFERENCES: 1) H. G. Heinrich and R. A. Noreen, "Stress measurements on inflated model parachutes", Defense Technical Information Center (DTIC) Technical Report No. AD 907 4471, Dec 1972, Defense Logistic Agency, Alexandria Virginia 22314.
2) P. M. Wagner, "Experimental measurement of parachute canopy stress during inflation", Wright -Patterson Air Force Base Technical Report No. AFFDL-TR-78-53, May 1978, Ohio 45433
3) M. El-Sherif and C. Lee, "A novel fiber optic system for measuring the dynamic structural behavior of parachutes", Journal of Intelligent Material Systems and Structures, Vol. 11, No. 5, pp. 325-414, May 2000.

KEYWORDS: strain, measurement, fabric, parachute, instrumentation, airdrop

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A07-157 TITLE: Smart Small Arm Protective Inserts

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: To develop an embedded, distributed sensor network capable of detecting damage to ceramic-based inserts used in personal ballistic protective armor.

DESCRIPTION: The primary personal ballistic protection against small arms rounds uses ceramics with a fiber-reinforced composite backing. The nature of the materials used is such that the ceramics are subjected to cracking and composite backing can be separated from the ceramics upon impact. Such damage is often unseen and not readily observable through method of visual inspection. The current non-destructive inspection procedures are time consuming and require sophisticated instrumentation and experienced personnel. A simple, cost-effective method is needed to assess the ballistic integrity of the armor inserts during use in the field. Recent advances in smart materials and structures research demonstrate the potential for embedding advanced sensors into materials for self-inspection and damage detection [1-3]. The desired outcome of this project is a ceramic-based personal protective armor insert embedded with a passive, non-emission sensor network capable of detecting ceramic cracks and, if possible, delaminations between the ceramics and composite backing when interrogated by a separated portable device. Embedding of the sensor network should neither degrade the ballistic integrity of the current ceramic-based armor inserts nor increase the weight significantly.

PHASE I: Demonstrate the feasibility of an embedded sensor network that can detect ceramic cracks and, if possible, interlayer delaminations. Develop a mechanism capable of detecting fine cracks in the ceramics, and a sensor network that can cost-effectively monitor the entire inserts. Evaluate the sensitivity and reliability of the sensor. Study the technical and economical feasibility of embedding the sensor network into the ceramic-based personal armor inserts. Deliver a report documenting the research and development efforts along with a detailed description of the proposed sensor system and its performance. The most effective designs and materials will be determined and proposed for Phase II efforts (Technology Readiness Level 4, TRL-4).

PHASE II: Develop prototype smart personal protective armor inserts by embedding the sensor network developed in Phase I into current ceramic-composite inserts. Develop sensor distribution and embedding methods. Fabricate a prototype sensor system, then fabricate sufficient smart insert samples to demonstrate experimentally that the sensor embedding does not degrade either the sensitivity or reliability of the sensor network or the ballistic integrity of the armor inserts. The embedded sensor network shall in no way increase the likelihood of delaminations. Deliver a report documenting: (1) the design of the smart, ceramic-based protective inserts including the sensor network and its embedding method; (2) the fabrication processes; and (3) the experimental procedures and results that demonstrate the effectiveness of the embedded sensor network and the ballistic protection performance of the inserts. 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-5).

PHASE III: Upon successful completion of the research and development in Phase I and Phase II, the smart, ceramic-based personal protective armor inserts will be manufactured and deployed in the field for self inspection for damage. In addition, this smart inserts can be applied to civilian law enforcement equipment with similar operational purposes. This could greatly enhance the capabilities of the nation's law enforcement protection as well (TRL 6).

REFERENCES: 1) Culshaw B., Smart Structures and Materials. London: Artech House; 1996.
2) Inaudi, D., et al (Editors), "Smart Structures and Materials 2006: Smart Sensor Monitoring Systems and Applications", Proceedings of SPIE, Vol. 6167, March, 2006, San Diego.
3) Tomizuka, M. (Editor), "Smart Structures and Materials 2006: Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems", Proceedings of SPIE, Vol. 6174, March, 2006, San Diego.

KEYWORDS: Embedded Sensors, Ballistic Protective Inserts, Personnel Armors, Self Inspection, Damage Detection, Ceramic Cracks

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A07-158 TITLE: Constructive Simulation Representation of Ground Soldier

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Improving constructive simulation representation of User-Defined Operational Picture (UDOP) for Ground Soldiers and small ground combat units.

DESCRIPTION: The UDOP for Ground Soldiers and small ground combat units is a Joint Capabilities Integration and Development System (JCIDS) Key Performance Parameter (KPP). Currently, constructive simulations lack the ability to adequately represent these, because they lack a human-in-the-loop (HITL) to perform real-time interpreting of battlefield information. As a result, constructive simulations need to provide a representative UDOP to their inherent Ground Soldier and dismounted SCU entities.

Representing information technologies in simulation is a multi-faceted issue that includes: encoding of information into elements for transmission, physical transfer of data elements, decoding of the received data and subsequent use of the information to support decision making. An improved UDOP simulation representation will provide a greater capability to assess information and information technology effects on overall mission effectiveness.

A UDOP cannot be included in a constructive combat simulation in isolation. For the information contained in the UDOP to be valuable, it must relate to operational decisions which an individual or unit leader needs to make. Informational elements can certainly pertain to critical operational context elements, such as; mission, time, terrain, disposition of friendly/enemy forces and non-combatants, environment, uncertainty, threat and many other factors. Many UDOP representations assume that data concerning the disposition of friendly and enemy forces will be the predominant information elements contained in a UDOP. While these elements are critical, there is a wide range of information elements that can be either useful or detrimental to supporting decision making (i.e. course of action). On one level, modeling a UDOP within a constructive simulation will be accomplished differently than providing a UDOP to an individual or a unit leader.

There are at least two potential starting points for research in this area;

1) Defining information elements that are likely to be available in a UDOP and then looking at the decisions that these data / information would support.

2) Identifying decisions that need to be made and then looking at the information elements needed to support the decision.

It appears as though an appropriate starting point is to focus on the use of the information to support decision making. To make the best decision in each case, the supporting information must be tied to the decision at hand. This would require identification and focus on very specific decisions that an individual or small unit leader would have to make, e.g. where do I place my troops to set-up a perimeter, should I engage the enemy, which path do I take to get to my objective, etc.

Autonomous agents in simulations need a UDOP that represents their Area of Interest (AOI) within their Area of Operations (AO) to include a capability to mark/monitor selected items of interest (e.g. cleared rooms and buildings, collection points, target reference points, obstacles, hazardous areas, sectors of fire) for actionable information (AI). This could be accomplished through agent profiles or filters that an agent maintains on their UDOP (e.g. all the information my Team Leader is pushing to me, all enemy entities within 1 kilometer of my position) within a scenario. The needed UDOP representation can be accomplished by building constructs within the proposed methodology. The proposed innovative small ground combat unit UDOP methodology should be demonstrated using a constructive simulation and its existing behavior engine, such as the Infantry Warrior Simulation (IWARS).

PHASE I: Based on a thorough understanding of UDOP studies and data pertaining to the Ground Soldier and small ground combat unit UDOP representation in existing simulations, explicitly list the assumptions that support a formulated, innovative approach and methodology to represent agent and small ground combat unit UDOPs in a constructive simulation. Assumptions shall not reduce the usefulness of the model. Natick will provide guidance on selected decisions, identification of information elements, scenarios, and different Ground Soldier type UDOP representations. Design and identify first cut profiles or filters supporting agent Area of Interest (AOI) within their Area of Operations (AO) to include a simulation representation capability to mark/monitor selected items of interest. Phase I results will include a detailed report of the findings, data and gaps, assumptions, innovative methodology supporting the objective, planned commercialization for the proposed methodology and a draft roadmap/plan identifying the tasks required to complete methodology development. Proof–of–Principle should address risk, demonstrate some form of coupling to a constructive simulation such as IWARS, and provide evidence of a successful Phase I and a clear transition to an executable Phase II effort.

PHASE II: (Prototype development and demonstration.) Phase II objectives will include prototype development and demonstration of the constructive simulation Ground Soldier UDOP methodology representation. Research and methodology development will be continued and completed to include additional information elements, decisions, profiles/ filters and use cases for remaining Ground Soldiers types. The developed Phase II methodology should also include UDOP information elements/decisions supported by interactions with vehicles/robots/sensors in the Future Combat System and Future Force Warrior Network Centric Information Environment (NCIE). A prototype module, which incorporates the innovative UDOP methodology implementation developed, will be demonstrated. It will include all the appropriate interfaces, APIs, knowledge structures, etc., to support integration and demonstration in a DoD Soldier and small combat unit-centric constructive simulation, such as IWARS. Documentation shall include explicit statements of any assumptions on which the model is based, inputs and outputs of the model, test results showing the verification and validation of the model, data elements and interactions required from the simulation in which the model is to be implemented, a clear overview and detailed description of the model, necessary data for interaction with an entity-based simulation, and a clear and through commercialization plan. Phase II results should evidence a successful transition path to a Phase III application.

PHASE III: The developed methodologies and associated implementation will significantly improve the ability to represent a UDOP and support intelligent decision-making in constructive simulations. The representation of Soldiers and small combat units in DoD models such as IWARS, COMBAT XXI, and OneSAF will be enhanced. A UDOP M&S representation is needed to better assess and provide materiel solutions related to requirements, hardware and the acquisition process through such activities as identification of information elements needed by the UDOP by position, assisting in Concept Exploration and post-FFW programs, and recommending and supporting different strategies for utilization of a UDOP. PEO-STRI is responsible for developing the OneSAF Objective System (OOS). SAF refers to semi automated forces. There has been coordination with PEO-Soldier to link the Infantry Warrior Simulation (IWARS) with OOS and coordination with PEO-STRI will facilitate transition of the Phase II to PEO-STRI. In addition, there will be commercial application in the world of computer games and other commercial simulation products that incorporate decision-making and Human Behavior representation (HBR). Other Non-DoD government agencies that employ operational simulations (e.g. police, CIA, FBI, homeland security, security planners/exercise mangers) could also use this capability. It is also anticipated that developers of equipment for ground Soldiers would be benefactors of the potential product forms resulting from this effort.

REFERENCES: 1) Draft Ground Soldier System (GSS) Capabilities Development Document (CDD), version 1.1, dated Jan 06.
2) Transforming the Way the DoD Manages Data: The DoD Net-centric Data Strategy and User-Defined Operational Pictures, Power Point Brief, Daniel Risacher, DoD CIO(IM), OASD/NII, Nov 05.
3) Command & Control Information Exchange Data Model (C2IEDM) Tutorial; Powerpoint Presentation; Curtis Blais, Charles Turnitsa, and Andreas Tolk, Apr 05.
4) Combat Decision Aide Software (CDAS) for Network Centric Warfare/Effects Based Fires, Powerpoint Presentation, Norman Coleman, ARDEC/AETC, Jun 04.
5) M&S in the GIG Environment: an Expanded View of Distributed Simulation, S.K. Numrich, M. Hieb, and A. Tolk. 2004 C2IEDM Workshop.

KEYWORDS: Ground Soldier Operations, User-Defined Operating Picture (UDOP), Small Combat Unit Operations, Dismounted Operations, Situational Awareness, Situational Understanding, constructive simulation small unit UDOP.

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A07-159 TITLE: Modeling Encumbrance Effects of Ground Soldier Systems on Soldier Performance

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Represent encumbrances and their resulting effects on Ground Soldier performance within operational effectiveness simulations so that we can more fully assess the operational costs of encumbrances that are associated with the materiel solutions.

DESCRIPTION: Encumbrances on the Soldier generally impact task performance (e.g. weapon firing rate and accuracy), either directly or indirectly, due to a change in physiological state (e.g. heat stress and hydration) or through direct interference (e.g. limited field of view) and result in degraded performance states. From an operational and a research, development, and acquisition perspective, Warrior Systems proponents have an on-going need to examine trade-offs between the burden and benefit of various equipment items that comprise the Soldier's equipment. Encumbrance factors most often cited as problem areas include: interference with ability to sense, center of balance, interference with movement or individual movement techniques (IMTs), thermal properties and load (weight and bulk). A need exists to include the effects of encumbrances on Ground Soldier performance in simulations so that both the benefits and costs of materiel solutions can be included at multiple stages in the acquisition process.

Numerous studies have been conducted concerning various types of encumbrances, resulting in a vast amount of existing research data held by different sources. DoD models and simulations could benefit from this research, allowing analyses of the effects of encumbrance, introduced by new equipment, on the ability of Soldiers to perform Ground Soldier tasks (e.g. move, shoot, communicate, sense). However, in many cases, the data and algorithms from the various sources have not been synthesized, and models and algorithms have not yet been developed that could reflect the results in models and simulations of Ground Soldier performance of tasks.

Proposed methodology(s) will present a clear measure of encumbrance as it applies to the Soldier and capture the effects of encumbrance on the Soldier and the Soldier's performance of critical Ground Soldier activities. In order to facilitate use of methodologies resulting from this effort in DoD Ground Soldier simulations, necessary interactions with other elements of such simulations should be stated with the developed methodology, such as inputs needed from the simulation, posture and movement capabilities required in the simulation, and variation in the load over time caused by Ground Soldier activities.

PHASE I: Utilize existing encumbrance literature, studies and data relevant to Ground Soldier Systems. The topic lead will provide direction in the identification and selection of encumbrance factors, task interactions and initial Ground Soldier type representations. Identify a set of encumbrance factors associated with Ground Soldier systems that are shown to impact upon task performance. Summarize research findings and design an innovative approach to develop methodologies to represent various Ground Soldier encumbrance effects in a constructive simulation. Proposed methodology development should focus on some form of the coupling of encumbrance effects on Ground Soldier tasks with a simulation that is focused on the individual and small combat unit, such as the Infantry Warrior Simulation (IWARS). Input data needed for the proposed methodology will be identified and included with the description. Further, all methodology assumptions shall be stated explicitly and should not be so limiting as to reduce the usefulness of the methodology. The Phase I product will provide an audit trail back to the sources by providing a detailed report identifying the research findings, available data and gaps, assumptions, limitations, proposed innovative methodology design alternatives for synthesizing and representing encumbrance effects in a constructive simulation, rationale and planned commercialization for the preferred alternative and a draft roadmap/plan identifying the tasks required to complete methodology development. Proof–of–Principle will address how the proposed methodology is coupled and provides simulation representations of identified encumbrance effects on various Ground Soldiers, to include a clear transition to an executable Phase II effort.

PHASE II: Phase II objectives will include continuing Phase I activities in addition to completing efforts to design a method for implementing the proposed innovative methodology into a DoD constructive simulation, such as IWARS. The primary objective is to include the significant effects of a variety of encumbrances associated with military equipment on the ability of the Soldiers to perform their combat critical tasks within the simulation so that we can better assess the how new equipment contributes to operational effectiveness. The synthesized encumbrance effects methodology design, development and demonstration also will be extended to include the following two objectives not addressed in Phase I: additional encumbrance factors and application for remaining (all) Ground Soldier Systems (i.e. a greater set of tasks). The accompanying supporting documentation shall provide an audit trail to include an explicit statement of any assumptions on which the methodology is based, inputs and outputs of the methodology, test results showing the verification and validation of the methodology, data elements and interactions required from the simulation in which the methodology is to be implemented, a clear and concise description of the methodology itself, and necessary data for simulation implementation, use, and verification and validation (V&V).

PHASE III: Phase III Dual Use Application: The results are expected to transition to the Infantry Warrior Simulation (IWARS), and potentially other operational effectiveness simulations. The military use results of the simulations containing effects of encumbrances to support critical management decisions throughout the acquisition life-cycle; from concepts exploration and requirements generation through milestone decisions and product improvements. In addition, transitions can also be made directly to the hardware development programs at Natick Soldier Center and PEO Soldier and to developers of military equipment so they can factor the impacts of encumbrances on the user into their development process. Outdoor and sporting goods vendors rely heavily on continuous testing of new equipment and its effect on the consumer (the consumer's energy expenditure and the adverse impacts upon the consumer's physiological state and potential degradation of critical task performance). These commercial vendors could use the compiled, categorized, and summarized research to enhance development and design the latest outdoor and sporting equipment. The methodologies and algorithms could also be used by the commercial gaming industry to add performance decrements from encumbrance effects on game avatars as well as game operators.

REFERENCES: 1) STP 21-24-SMCT, Soldier's Manual of Common Tasks Skill Level 2, 3, and 4, Headquarters Department of the Army, August 2003
2) Field Manual 21-18 "Foot Marches", 1990.
3) Auditory Detection and Sound Localization for Computer-Generated Individual Combatants, Naval Postgraduate School, June 2005.
4) Physical Performance Benefits of Offloading the Soldiers Load, U.S. Army Institute of Environmental Medicine (USARIEM) Soldier Load Study, 2003.

KEYWORDS: Ground Soldier encumbrance, Load, simulate, simulation, Ground Soldier Operations, Infantry Operations, task performance, task degradation.

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A07-160 TITLE: Temperature Controlled Enhanced Human Remains Transfer Case

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop a Temperature Controlled Human Remains Transport System which can preserve remains at the optimal temperature during a minimum ten-hour transport usually on a military aircraft.

DESCRIPTION: Currently, when a death occurs in an area of operations such as Iraq or Afghanistan, remains are placed in a human remains pouch (HRP), which is then placed inside an aluminum transfer case for preparation for transit. Once the HRP is situated in side the transfer case, 40-60 pounds of ice is packed around the remains, the top is placed on and the case is sealed for transport. This method does not provide the ability to control the temperature and offers little assurance that internal temperature is maintained at the optimal 34-37o F which is necessary to preserve remains during transportation. The current case is a Vietnam-era solution and does not have any insulation or an active cooling mechanism to control the temperature and offers little assurance that internal temperature is maintained at the optimal 34-37o F.

The Temperature Controlled Human Remains Transport System must maintain remains at the optimal temperature of (Threshold) 38- 40 degrees Fahrenheit, (Objective) 34-37 degrees Fahrenheit during a ten hour flight on a military aircraft. The remains may or may not be cooled to the optimal temperature prior to loading into the transport system. The total system must be able to be lifted by six personnel to a height of three feet. The total weight of the system, with remains (of 300 pounds), shall not exceed 480 pounds. The system must ensure proper temperature is maintained and provide a visible means to check internal temperature. The system must include a secure locking mechanism and a means to tie down to the transport platform. The complete system is to be reusable, stackable and capable of being nested or collapsible (when empty) to reduce shipping cube. The system shall be capable of being sanitized with water and common cleaning solutions, such as bleach. The system shall be designed to prevent the collection of fluids or water inside the system's crevices, cracks, holes, or indentions. The system must prevent leakage of all fluids. The target cost for each system in production is $3000 or less. The Temperature Controlled Human Remains Transport System must be able to be loaded onto a 463L aircraft pallet and if external power is required, the system must be compatible with power supplies on military aircraft (C5, C17, C130, UH-60, CH 47), military cargo vehicles, and military vehicle and ground power systems. The transport system must have a back up or alternate means of maintaining the optimal temperature of 34-37 degrees F in the event of power loss or mechanical failure.

The following are examples of technologies to investigate to develop a highly effective remains transfer system with the potential of realizing the stringent goals in the description above. Two known technologies include integrating high impact resistive energy absorbing plastics and/or composite technologies with phase change materials, aero gel and/or super insulated vacuum panel technology. Both technologies provide a highly durable shell with a super insulated material allowing thin walled construction decreasing weight, and significantly improving thermal performance. The super insulation also decreases the amount of energy required by the cooling unit and maximizes temperature hold when power is lost or intermittent when transporting on military aircraft. A possible third technology uses high efficiency, active cooling units utilizing, high efficiency DC vapor compression, thermo electrics or free piston sterling cooling systems powered from the vehicles 24 Volt DC power source or batteries. Research should not be limited to the examples mentioned but should consider other innovative concepts.

PHASE I: Research, develop and propose a transport system design with the potential of realizing the stringent goals in the description above including weight, capacity, thermal performance, durability and cost. Investigate and identify potential applicable technologies such as superinsulating materials, composites, phase change materials, thermoelectric, etc., and conduct research and experimentation to determine the most promising approach(es). Develop technical specifications for materials/components and identify as commercially available or to be developed. Conduct necessary investigation on the design and performance of critical components to demonstrate the feasibility and practicality of the proposed transport system design to include mitigation of risks associated with factors limiting system performance. Deliver a report documenting the research and development effort along with a detailed description of the proposed transfer system to include specifications of key components. Dynamic thermal/mechanical modeling including creep deformation, drop, and elastic recovery testing shall be conducted. Heat Transfer analysis, thermal modeling, and insulation performance testing shall be conducted to characterize thermal performance. Various active cooling technologies will be evaluated for optimum temperature control, reliability, and performance. Modeling, material performance testing will identify the most promising approach. A final report will be developed documenting the research and development effort and identifying the proper materials and processes required to develop a new remains transfer system to meet key performance parameters.

PHASE II: Develop and Fabricate a new remains transfer system identified in Phase I. Mechanical, thermal, and cooling performance testing will be conducted to validate the modeling analysis used in Phase I and to demonstrate optimal performance to meet the goals in the description above. Deliver a report documenting the concept, design component specifications, performance characterization and recommendations for production representative transport system. The Phase II results must demonstrate that the prototype has met the requirements as stated.

PHASE III DUAL-USE APPLICATIONS: The enhanced transport system will be used by Army Theater Mortuary Evacuation Points, Air Force Search and Recovery Teams, Army and Marine Corps Mortuary Affairs Collection Points, Joint POW and Accounting Command (JPAC), Dover Port Mortuary (US Air Force), Army and Navy Mortuaries. The transport system will also be used for ground transportation of remains to and from airports, necessitating the need to be able to operate using vehicle or ground power sources. Additionally, the Transfer case supports possible future integration into the Human Remains Decontamination System Increment II. This system has commercial/civilian potential use for natural disasters, Home Land Security, and mass casualty's scenarios.

REFERENCES:
Army Regulation 638-2 - Care and Disposition of Remains and Disposition of Personal Effects
AR 638-2 - Care and Disposition of Remains and Disposition of Personal Effects
AR 638-25 - Armed Services Graves Registration Office
Joint Publication 4-06 - Mortuary Affairs in Joint Operations
JTTP 4-06 - Joint Tactics, Techniques, and Procedures for Mortuary Affairs in Joint Operations
NAVMEDCOMINST 5360.1 - Decedent Affairs Manual
DOD Directive 1300.22 - Mortuary Affairs Policy
http://www.quartermaster.army.mil/mac/#REFERENCES

KEYWORDS: human remains, transfer case, insulation, temperature control, aero gel

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A07-161 TITLE: Novel Interactive Insignia for Combat Uniforms

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Provide novel concepts and prototype materials for several types of soldier insignia and means of attachment that: do not have to be removed from the new Army Combat Uniform (ACU), can display the Soldier's name, rank, and other specialty qualifications, and can be disabled so, at times, the information is hidden or disappears.

DESCRIPTION: In the past, high cost embroidery patches were used on the Battle Dress Uniform (BDU) and had to be sewn on to the fabric. This did not allow for easy removal of these patches either for reuse or operational security/sanitization. The same high cost embroidered patches are attached and removed by employing hook & loop fastening systems in the new Army Combat Uniform (ACU) eliminating both problems. Several concerns have come to light using this new attachment system for the insignia. The hook& loop patch may need to be quite large to provide for securing several patches on one uniform taking away from the camouflage print of the uniform, the attachment area can get dirty and contaminated with debris that will hinder secure attachment of the patches, causing the loss of patches in the field, and the need to purchase new expensive patches, The durability of the hook & loop areas can also degrade faster than the uniform itself making it necessary to purchase new attachment patches for the insignia.

Unfortunately, the need to display the combat Soldier's name, rank and specialty qualifications are also essential, but at times, should not interfere with the camouflage pattern. A new system or type of patch is needed to display this information. A high technical fabric-based or attachable display for simple characters and symbols that can convert back to a camouflage pattern may be one approach, but novel low technical solutions to alleviate current problems with the high cost embroidered insignia and means of attachment/detachment are also welcome.

PHASE I: The Phase I effort would seek to demonstrate novel concepts and prototype materials for several types of Soldier insignia and means of attachment that: do not have to be removed from the new Army Combat Uniform (ACU), can display the Soldier's name, rank, and other specialty qualifications, and can be disabled so, at times, the information is hidden or removed. Deliverables for phase I would be to provide information on several concepts and provide sample materials to help demonstrate promising concepts and a technical report detailing the development and manufacturing parameters for the materials. The most effective designs and materials will be determined and proposed for Phase II efforts (Technology Readiness Level 5, TRL-5: developed sample materials for use in prototypes).

PHASE II: Phase II effort would involve scale up and optimization of the most promising concepts identified in Phase I as well as the incorporation of those materials onto the ACU. The phase II prototypes would need to demonstrate both suitably low cost display of information with the ability to disable the information. All research, development and prototype designs shall be documented with detailed descriptions and specifications of the materials, designs, processes, and performance (TRL-6: laboratory testable prototypes).

PHASE III: Military uniforms across the services and fields of specialization will benefit from the use of improved materials for identification of personnel and their skills. PEO Soldier/PM-CIE will plan the transition of the technology by conducting wear and field operational evaluations. Commercial uses in the area of uniform industries would also significantly gain from this insignia technology. Security and appropriate recognition of employees will be enhanced by ID materials embedded into the garments. Commercial wear prototypes shall be capable of being tested in a simulated operational environment (TRL 7: field testable prototypes).

REFERENCES: 1) Army Regulation 670-1 Wear and Appearance of Army Uniforms and Insignia, 5 Sep 03. (http://www.colostate.edu/Dept/ArmyROTC/AR670-1.pdf)
2) Marine Corps Order (MCO) P 1020.4G, Marine Uniform Regulations, 31 Mar 03.
3) Hongu, T. and Phillips, G. O., New Fibers. (2nd Ed.), Woodhead Publishing Limited, Cambridge, England, 1997.
4) Air Force Instruction (AFI) 36-2903, Dress and Personal Appearance of Air Force Personnel, 1 Feb 99.

KEYWORDS: Army Combat Uniform (ACU), Insignia, Patches, Hook & Loop, Display, Interactive Textiles, Electro-Textiles, Embroidery

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A07-162 TITLE: Sub80 Container for Semi-perishable Rations

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop technology for a passive, low cost, retrofit for standard 8’ x 8’ x 20’ ISO Containers capable of maintaining internal storage temperatures no more than 5ºF above the average daily temperature (below 80°F is desired).

DESCRIPTION: Annually, the Department of Defense procures, transports, and stores more than 40 million units of the Meal Ready-to-Eat (MRE). The shelf-life of these, and other semi-perishable items (Unitized Group Ration - Heat and Serve (UGR-H&S), First Strike Ration, etc.), is highly dependent upon the storage temperature. When stored at temperatures of 80°F and below, the shelf life of the MRE is no less than 3 years. However, when stored in standard 20’ ISO containers in environments such as the current Area of Responsibility (AOR) where ambient temperatures can reach 120ºF1, and container temperatures can reach 160ºF, shelf-life is reduced to just one month. As a result, the Army has incurred large inventory losses due to food spoilage, with costs approaching $50M per calendar year. Rations could be stored in refrigerated containers; however the cost of leasing those containers, as well as fuel and maintenance costs would be prohibitive. It is preferred that technology be developed that can be retrofitted into standard ISO containers that adsorbs minimal solar radiation and is capable of tempering daily high temperatures with daily low temperatures. The goal is to keep the container temperature near the daily average temperature, with a threshold maximum temperature of 5ºF higher than the daily average temperature. For design parameters, solar radiation can be as high as 1120 W/m2 , the average high temperature in Bagdad in July2 is 110ºF, the average low is 78ºF, and the average daily temperature is 94ºF. Accordingly, a low cost, passive method to lower container temperatures and reduce or eliminate ration losses is required. No external power is available for any form of mechanical cooling. Eutectic phase change materials, insulation, or other non-powered methods of preventing heat transfer are preferred. However, cooling derived from solar radiation (photovoltaic or heat driven) may be considered. One approach includes the combined use of insulation and phase change materials to adsorb and store the heat while the temperature is high during the day (120°F), then conversely release this heat at night. All materials on interior walls shall be no more than 2" of thickness to allow storage of sixteen 40 x 48 x 36 inch pallets of rations. Exterior coatings such as Thermal Control Coatings (TCC) or Solar Load Abatement (SLA) technologies can be proposed to reduce the solar radiation. Any proposed TCC/LSA technology must have good adhesion, while maintaining resistance to corrosion, wear/abrasion, fire and fading. It is also desired that the coating be capable of providing camouflage such as desert sand. Given a cost of $3500 for a dry storage 20' container, and $10000 for a commercial refrigerated 20' container, the one time cost to retrofit a container shall not exceed $3500.

PHASE I: Work in Phase I will consist of research to develop concepts, explore technology, and model solutions for laminations and combinations of insulation, phase change materials, TCC/LSA coatings, and other technologies required to meet performance goals stated above. The research must include potential configurations and interfaces with standard 20' ISO storage containers. The strengths and weaknesses of the proposed technology(ies) shall be detailed in terms of performance, weight, cost, size, durability and safety. From this data, a trade off analysis shall be performed to delineate what characteristics are preferred to integrate with the container. A small scale proof-of-principle shall be designed and tested for the best alternative(s). The tests shall be performed in a temperature controlled room that provides 5 days of temperature cycling at two conditions from 80ºF to 120ºF, and from 60ºF to 100ºF. It is desired that solar radiation also be simulated. A report documenting the research and development effort along with a detailed description of the proposed technology to include specifications of key components shall be delivered upon completion of the Phase I effort. An initial cost analysis should be included within the Phase I report.

PHASE II: Based on the successful completion of Phase I, a full-scale technology demonstrator shall be designed, fabricated and tested. The technology shall be integrated within a standard 20' ISO container. The tests shall be performed in a temperature controlled room that provides 5 days of temperature cycling at two conditions from 80ºF to 120ºF, and from 60ºF to 100ºF. The test shall also include solar radiation. The durability, manufacturability, and cost of the proposed technology must also be assessed. In addition to the Sub80 container, broad application will be evaluated for new and existing DoD refrigerated container systems, including the various Refrigerated Container Systems (RCS) and Multi-Temperature Refrigerated Container System (MTRCS), and scalability shall be evaluated where appropriate.

PHASE III: The commercial market for both standard and refrigerated container systems includes maritime, air, roadway, and railway refrigerated container and trailer transport, a multi-billion-dollar worldwide industry. The savings associated with extended shelf-life of semi-perishable subsistence when applied to non refrigerated containers as well as the fuel savings and ability to use lower powered vapor compression systems in refrigerated containers will ensure technology transfer for commercial applications as well as the military Advanced Composites for Lightweight Refrigerated Containerized System (ACLRCS), Army MTRCS, the 8x8x10 ISO Refrigerated Container System and Quad Refrigerated Container System for the USMC, and the Air Force Advanced Design Refrigerated (ADR) 300 and 1200 containers. Other DOD classes of supply negatively affected by high heat will also benefit from this effort (i.e. JSLIST, bottled water).

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2) http://www.washingtonpost.com/wp-srv/weather/longterm/
historical/data/baghdad_iraq.htm
3) MIL-PRF-44015A – Military Performance Specification – Refrigerator-Container, Field, 8 Feet by 8 Feet by 10 Feet.
4) MIL-PRF-32017 – Military Performance Specification – Refrigeration System, Advanced Design.
5) MIL-HDBK-774 – Military Handbook – Palletized Unit Loads.
6) ISO 1496-2 – Series 1 Freight Containers – Specification and Testing – Part 2: Thermal Containers.
7) MIL-STD-810E – Environmental Engineering Considerations and Laboratory Test.
8) AR-70-38 – Research and Development, Test and Evaluation of Materiel for Extreme Climatic Conditions.
9) ASTM E1925-1 – Specification for Engineering and Design Criteria for Rigid Wall Relocatable Structures.

KEYWORDS: ISO Container, Refrigerated Container, Ration Storage, Food Preservation, Meal Ready-to-Eat, Dry freight

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A07-163 TITLE: Off-Grid Pallet Chilling for Bottled Water

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a stand-alone chilling system for individual pallets of bottled water in high ambient temperatures.

DESCRIPTION: Soldiers aboard HMMWVs in Iraq use 8–12 liters each of bottled water per day — depending on season and mission. Sun and high heat can raise the product to 135°F (60°C), yet studies find soldiers are reluctant to drink water that is even just warm [1] — they "typically take a sip, pour some over their head, and dump the rest on the ground." At the very least, this is wasteful, but such consumption habits can lead to dehydration weaknesses and heat stress. Cold beverages will, therefore, improve readiness, so a requirement exists to supply each HMMWV crew of four with 48 liters (13 gallons) of 60°F (15°C) water per day [2].

Warfighters can deploy with frozen bottles, but this is energy intensive and the water soon warms. Instead, cool water should be made available in the field for immediate consumption at any time of day. Unfortunately, there are a limited number of refrigeration trucks and containers for transport or onsite storage, and there is no technology plan for distribution from base camps to remote units. To address this problem, envisioned is refrigeration equipment sized to handle individual standard-size pallets holding 1296 liters (342 gallons) of water in 0.5, 1, or 1.5 liter bottles. The equipment would cool then hold water to the required 60°F in ambients of 105-135°F (40–60°C). The equipment would be positioned near kitchens and billeting

A variety of refrigeration technologies will be considered based on efficiency, robustness and reliability, weight, equipment size, ease of use, power requirements, and limited noise and heat signature — listed in descending order of importance. To provide maximum flexibility, the pallet chiller shall operate on the move and independent of grid- or asset-based power. Potential technologies may include diesel-engine on-pallet generators or direct drive; solar or JP-8 combustion heat driven processes; photovoltaics; or simple evaporative techniques. Possible tactics for increasing holdover might include advanced insulation, eutectics, chemical or latent-heat energy storage, diesel burners, or batteries. Safety, of course, is very important. Other considerations are setup and startup time. Concepts proposed will be judged on innovation. To be considered innovative, designs relying on conventional technology should include a convincing argument. Proposals shall be explicit about how performance requirements will be met.

PHASE I: Research and develop a design that has potential for realizing the goals described above. Develop technical specifications for components and identify them as commercially-available or to-be-developed. Conduct modeling on the design to estimate performance of all components and demonstrate feasibility. Conduct investigation to determine economics, practicality, and mitigation of risks associated with factors limiting system performance. Deliver a report documenting the research and development effort, and detailed description of the proposed design, including specifications of key components and subsystems.

PHASE II: Develop, fabricate and demonstrate a fully-functional, pallet-sized chiller meeting the function and performance parameters described, and suitable for field demonstrations. Deliver a report documenting the theory, component specifications, and performance characterization. Include recommendations for improvement.

PHASE III: Robust, efficient, independent and easily maintainable refrigeration systems can serve well in disaster relief where terrain is rough, logistical infrastructure support is limited, and generators are scarce or not available — contemporary examples include U.S. hurricanes, Pakistani earthquakes, and Indonesian tsunamis. The commercial sector would benefit from a pallet-sized chiller for transportation of small disparate loads for remote sales opportunities such as catering large outdoor events. For the military's first application, envisioned is pallet-sized chilling equipment for bottled water. Following a successful technical demonstration, the technology would be transitioned to Product Manager - Force Sustainment Systems (PM-FSS) for approval of final performance requirements and initial low-rate manufacturing contracts.

REFERENCES: 1) Engell, D., and Hirsch, E., 1991, Environmental and Sensory Modulation of Fluid Intake in Humans, In Booth, D., & Ramsay, D. (eds.), Thirst: Physiological & Psychological Aspects, London: Springer-Verlag, PP 382-390.
2) Sandlick, BL, Engell DB, Maller O, 1984, Perception of Drinking Water Temperature and Effects for Humans after Exercise, Physiology and Behavior 32:851-855.
3) Murphy, B., and Westfalen, D., Cold Storage Temperature Stabilization, Natick Soldier Center Technical Report TR-01/017, October 2001.
4) American College of Sports Medicine, Position Stand on Exercise and Fluid Replacement, http://www.acsm-msse.org/pt/pt-core/template-journal/msse/media/0196.htm.

KEYWORDS: refrigeration, water cooling, heat-driven, adsorption, thermoacoustic, beverage

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A07-164 TITLE: Lightweight, low-cost armor panels for installation in soft-walled shelters

TECHNOLOGY AREAS: Materials/Processes, Human Systems

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop a lightweight, low-cost, composite armor panel that can be easily integrated into military soft-walled shelters without modification to the existing frame, skin, or anchoring.

DESCRIPTION: Indirect fire, such as mortar fragmentation, has become a daily occurrence in some hostile areas, so enhanced defense against it is a top priority. In many cases, customary methods of ballistic protection such as sandbag walls and/or concrete barriers may require more logistical support than is available. Thus, a system of rigid armor panels has been designed to provide ballistic protection where mobility and rapid deployment requirements preclude the use of more “heavy-duty” armor systems. The system is lightweight, rapidly deployable, and reusable. It requires no modification to a shelter frame, no additional anchoring, and no special tools to install. The full system integrates into a deployed shelter beneath the existing shelter skin, thereby eliminating unwanted signature issues. Most importantly, the system provides sufficient ballistic protection from indirect fire, namely mortar fragmentation.

Nevertheless, in an effort to continually improve the armor system as a whole, it is essential that the panels themselves be made lighter and less expensive, while maintaining ballistic performance and flexural strength.

Commercial off-the-shelf armor materials are often too heavy, too costly, or lack the flexural strength to meet the aforementioned requirements. Due to the nature of the threat, innovative composites and design techniques are necessary in this development. Fragmenting munitions produce both high speed fragments as well as blast overpressure at close range. Therefore, these panels must be able to both prevent fragmentation penetration and withstand blast load; hence the ballistic performance and flexural strength requirements noted above.

The panels should be designed to attach directly to the shelter frame, while maintaining adequate flexural strength. The panels must meet the following requirements:

? Panel ballistic performance using Right Circular Cylinder (RCC) projectiles:
o 2-grain RCC – 4200 fps = V50 = 6000 fps
o 4-grain RCC – 3500 fps = V50 = 4500 fps
o 16-grain RCC – 3000 fps = V50 = 4200 fps
o 64-grain RCC – 2500 fps = V50 = 3500 fps

? Panel flexural strength (using three point bend test on 22 inch span):
o 400 lbs = Peak load = 500 lbs
o 0.25 in = Deflection at peak load = 0.75 in

? Panel weight:
o Areal density = 3.0 psf
o A 3.5' x 8' panel must not exceed a total weight of 85 lb
o Two-person lift is desirable on all panels

? Panel cost:
o Material cost = $25 per square foot

? Other requirements:
o Panels must be UV protected, they must not degrade under UV exposure
o Panels must be flame resistant, per ASTM E 1925:
? Afterflame/afterglow – less than 30 seconds
? Char length – less than 1.25 inches
o Panels must be moisture resistant, no moisture absorption should occur
o Panels must be ruggedized to withstand extreme environmental conditions
o Panels must not off-gas in normal or extreme temperatures
Ballistic performance of the panel must not degrade in extreme temperatures

PHASE I: The intention of Phase I of the program is to design conceptual armor panels that meet or exceed the requirements described above. This effort includes selecting the materials to be used in the panels, designing the layering scheme, and constructing testable panel specimens. Innovative coatings may also be used to add flexural strength, improved ballistic capabilities, and/or panel protection. Panels must then undergo both RCC testing and flexural load testing to simulate the two facets of the indirect fire threat. Technical Readiness Level 3 should be met at the end of Phase I.

PHASE II: The focus of Phase II will be fabrication of full-size prototype panels to be integrated into a shelter and submitted to live fire cartridge detonation and environmental testing. These testing routines will assess the true effectiveness of the panels outside of a laboratory environment. In addition, using data collected from the Phase I and Phase II testing, innovative modeling and data analysis are encouraged. This will assist in improving and advancing the panel design to achieve the best possible product.

PHASE III: The focus of Phase I and II of this program was with respect to military applications for the panels, specifically in soft-walled shelters. While military collective protection will undoubtedly benefit from this technology, Phase III should focus on developing fabrication techniques for mass production and designing the panels to be integrated into a variety of tent systems, both military and otherwise. In a military environment, lightweight armor would be useful in highly mobile scenarios where transportability and deployment time requirements make the use of "heavy-duty" armor systems unfeasible. Similarly, in the commercial domain, lightweight, modular ballistic protection is applicable wherever the logistical burden of more robust armor systems is unacceptable, and not necessarily in a shelter configuration. For example, lightweight armor could be used in armored vehicles where weight is a concern or security checkpoints where space may be limited.

The existing armor panels are produced in extremely small quantities using a press and only integrate into a single type of soft-walled shelter. More innovative and high-tech production methods are either currently available or could be devised. The goals of Phase III are to identify the most cost effective and efficient production method for the panels and expand the functionality of the armor system to other shelters. A detailed quality control scheme should also be developed in this phase. Phase III will conclude with panel fabrication for three separate shelters and/or vehicles using the techniques identified and outfitting them for use as a technology demonstration. Plans for field evaluation and commercialization of the panels should be addressed as Phase III concludes as well. Technical Readiness Level 5 should be met by the end of Phase III.

REFERENCES: 1) Adanur, Sabit Ph.D. Wellington Sears Handbook of Industrial Textiles. Technomic Publishing Company, Inc., Lancaster, PA, 1995.
2) Meyer, Raymond W. Handbook of Pultrusion Technology. Chapman & Hall, New York, NY, 1985.
3) Polystrand®. http://polystrand.ezweave.com/polystrand.asp
4) Security Coating Systems. http://www.securitycoatings.com/
5) V50 Ballistic Test for Armor. ARMY MIL-STD-662F. Army Research Laboratory, Weapons and Material Research Directorate. Dec 18, 1997.
6) Walker, James D. Ph.D. “Turning Bullets into Baseballs.” Technology Today®. Spring 1998. Southwest Research Institute.

KEYWORDS: armor, ballistic, fragmentation, panel, protection, shelter, tent

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A07-165 TITLE: Flameless Personal Water Heater Using Battlefield Fuel (JP-8)

TECHNOLOGY AREAS: Materials/Processes, Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop a personal water heating system that uses JP-8 fuel to safely and efficiently heat water and melt snow without an open flame.

DESCRIPTION: The Warfighter needs an effective means to heat small quantities of water for beverages, dehydrated rations, and personal hygiene, as well as to melt snow during cold weather operations. Past and present approaches to this problem have been the trioxane fuel bar and commercial backpacking stoves. But fuel bars have had historical supply problems and are no longer available, and existing commercial stoves are too heavy, inefficient, and expensive for infantry use. Even the latest development, a new JP-8 stove based on Capillary Force Vaporizer (CFV) technology (see reference #2), that sets new standards for size, weight, and ease of use, leaves room for improvement. Open-flame stoves have numerous shortcomings, including soot and smoke during priming, dangerous emissions when used without adequate ventilation, poor performance in the wind, multi-step operation that requires subjective decisions on the part of the user, and water heating efficiency limited to about 70%, even if coupled with specially designed high-efficiency cookware.

Accordingly, new approaches and new technologies are sought for a "Hot Cup" concept that challenges the backpacking stove paradigm by providing a flameless alternative for heating water. It is envisioned that the Hot Cup would be configured as a self-contained heating cup, a heating module that can be paired with arbitrary canteen cups, or an immersion heating device. One promising technological approach is small-scale catalytic combustion, which has been demonstrated in enclosed chambers or channels.

The Hot Cup shall heat 0.5 liter of water by 55 °C in less than 10 minutes, including warm-up/priming time, with a goal of boiling water in less than 10 minutes. The minimum efficiency is 70% (goal of 90%), as determined by heating 500 grams of water from 4 °C to boiling and dividing the energy added to the water (~200 kJ) by the heating value of JP-8 fuel consumed. The Hot Cup shall weigh less than the CFV stove system (425 grams for the stove and pot), with a goal of 225 grams or less. The Hot Cup shall be rain- and wind-proof, and because the primary customer will be cold weather troops, it must perform well in cold weather environments down to -29 °C. Water-contact surfaces shall allow proper cleaning and sanitation and shall be protected against fuel contamination. The Hot Cup shall be safe to handle when hot by means of insulation, wire handles, or similar, and all exposed parts should cool quickly to minimize the potential for severe burns. It is imperative that the Hot Cup operate on JP-8 battlefield fuel.

In addition to the requirements expressed above, other potentially desirable characteristics include: sufficiently clean exhaust for operation inside a tent; built-in fuel reservoir holding enough fuel for three days of typical use; foolproof push-button operation; safeguards to prevent overheating; output control allowing fast boiling or slow simmering; mess-free refueling; and, if power is required, self-powered, self-recharging, or man-powered (e.g., hand crank) solutions.

PHASE I: Establish the feasibility of a personal water heater concept that meets the operational requirements stated in the topic description by conducting research to demonstrate that the approach is scientifically valid and practicable. Mitigate risk by identifying and addressing the most challenging technical hurdles in order to establish viability of the technology or process. Perform proof-of-principle validation in a laboratory environment, and characterize effectiveness through experimentation using JP-8 fuel (operation with other fuels does not constitute concept validation). Address safety and human factors concerns, and provide credible projections of performance, size, weight, energy requirements, and cost of a system suitable for fielding.

PHASE II: Refine the technology and fabricate advanced prototypes that meet all operational, effectiveness, and reliability requirements. Address manufacturability issues related to full-scale production for military and commercial utilization. Observe strict attention to safety and human factors. Provide prototype units that and are sufficiently mature for technical and operational testing, limited field-testing, demonstration, and display. Provide user manuals and training to support government testing of the equipment.

PHASE III: PHASE III DUAL-USE APPLICATIONS: The initial military application for this technology will be a personal water heating system for cold weather troops. The transition from research to operational capability will most likely result from a partnership or licensing agreement with a manufacturer of outdoor recreational gear and subsequent military procurement as a commercial or non-developmental item. The outdoor recreational market for backpacking stoves and similar products is much larger than the military market, and any advances in system weight, efficiency, and ease of use can easily be marketed to outdoor enthusiasts, particularly campers, hikers, and mountain climbers. Beyond heating water, small-scale flameless combustion technology also promises to lay the foundation for a new class of battlefield fuel powered Warfighter individual equipment, including battery chargers, beverage chillers, and personnel warmers.

REFERENCES: 1) Detail Specification MIL-DTL-83133E – Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8), NATO F-35, and JP-8+100
2) Modular Individual Water Heater fact sheet, http://nsc.natick.army.mil/media/fact/food/miwh.pdf
3) Squad Stove fact sheet, http://nsc.natick.army.mil/media/fact/food/squad_stove.pdf

KEYWORDS: water heater, catalytic combustion, individual equipment, logistics fuel, camp stove

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A07-166 TITLE: Night Vision Enhancement Technology for Paratrooper Eye Protection Goggles

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Develop night vision enhancement technology for eye protection used in personnel airdrop operations that is effective, lightweight and low-cost.

DESCRIPTION: Current night time military airdrop operations which, is the standard environment for Military Free Fall (MFF) operations, rely on the use of Night Vision Goggles (NVGs) to provide increased visual capabilities to the soldier. NVGs are mounted on top of the parachutist's helmet and must be moved into place while simultaneously trying to control canopy, track the other parachutists, and maintain flight path. This distracts the parachutists from other vital mission critical functions such as proper canopy control and steering.
As a result, there is a need for night vision enhancement technology which can interface directly with or replace the current eye-protection goggles already in use in personnel airdrop operations. The current parachutist eye protection goggles can be referenced at http://www.kroop.com/. This technology would NOT modify or replace the Night Vision Goggles (NVGs) in any way. The eye-protection goggles alone would be affected either by replacement or modification. In all cases, the current degree of eye protection shall be maintained.
The desired night vision enhancement technology would provide a 10-25% increase in non-aided night vision given minimal background illumination (stars, moon, urban lighting, etc.) for the parachutist. This would preferably be accomplished without the aid of any electronic components or a minimal amount if needed to achieve this performance goal. The technology should not interfere with the parachutist's ability to meet mission requirements. It must also be lightweight and low cost for maximum application in the field.

PHASE I: Investigate, research and develop material technology capable of enhancing night vision capabilities. Define minimum degree of illumination enhancement necessary for replacement of NVG's in an MFF operational environment. Demonstrate night vision enhancements in a controlled environment.

PHASE II: Develop and demonstrate night vision enhancement prototype in a test and an operational setting. Work with soldiers directly to develop a prototype. Gather user feedback and modify enhancements as needed. Assure that current level of eye protection is maintained. Incorporate final enhancements into protective goggles. Cooperate with Army and vendor on a retrofit and re-fielding plan.

PHASE III: The enhanced night vision technology will expand the airdrop capability of Special Operations Forces (SOF). This technology will specifically support The United States Army Special Operations Command (USASOC)Initial Capabilities Document (ICD) for the Joint Aerial Insertion Capability (JAIC). This topic has been authored and endorsed by the PM-CIE, Personnel Airdrop office and the transition of this technology will be directed by that office.
Visual enhancement technology is marketable for any outdoor sport and recreational activity in which a low degree of lighting may adversely impact needed visual ability. Examples include camping, hiking, hunting or nocturnal wildlife observation. A simple visual enhancement technology will find a market for these uses.

REFERENCES: 1) Poynter, D. and Turoff, M., "Parachuting: The Skydiver's Handbook," Para Publishing, 2004.
2) "2006 Skydiver's Information Manual", http://www.uspa.org/publications/SIM/2006SIM/section1.htm , United States Parachute Association, Alexandria, VA, 2006.

KEYWORDS: night vision, eye protection, military free fall, parachute, vision enhancement

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A07-167 TITLE: Waste Management System for Chemical/Biological Protective Garments

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

OBJECTIVE: Design and prototype a waste management system that can be incorporated into a chemical/biological protective garment without degrading the overall protection of the system during use.

DESCRIPTION: Current Chemical/Biological (CB) protective ensembles do not provide the means to eliminate human waste. As CB protective material technologies advance so does the time in which a Soldier can effectively operate within a CB incident/environment. As these operation times increase, so does the need for advanced concepts which provide the ability to remove human waste from the system. Current systems require the Soldier to doff his CB protection or wear a Depends type of undergarment for purposes of waste elimination. The topic objective meets the need for a high performance waste management system which can be incorporated into garments and provides a sanitary means of elimination without degrading the performance of the system. The design of the waste management system will include selection of functional CB protective materials, identification of novel closure concepts, integration within the CB protective ensemble, and address sanitary issues/concerns, among others. The system must be provided in a form-factor which is low bulk/weight and does not hinder the Soldier’s ability to complete mission tasks. The life cycle of the system, from both a CB protection and durability standpoint, must be equal to that of the overall protective garment. The waste management system will enhance the capabilities of current CB protective garments and provide added features which will ultimately allow the suit to be more comfortable and user friendly. There are potential applications for this type of material within both the military and civilian communities. The waste management system will be incorporated into CB protective garments providing significant improvements to currently utilized garments. This technology would apply to every war-fighter currently utilizing CB protective garments. Also, the system could also be included into systems within the civilian sector to include, Hazardous Materials (HAZMAT) ensembles, National Aeronautics and Space Administration (NASA) Space Suits, National Fire Protection Agency (NFPA) Certified CB protective ensembles, and CB ensembles for law enforcement. Currently, spacesuits have many of the same issues as CB protective ensembles with regard to waste management. Females wear an extra-absorbent "diaper" for urination while both males and females wear the diaper for fecal containment. Advances in this type of a waste management system could have applications within this arena.

PHASE I: Design a novel concept for waste management which includes concepts for integration with the ensemble, closure mechanisms which maintain protection, and disposal of liquid and solid waste. Survey a variety of materials/technologies which will be utilized in the development of the waste management system. Select suitable materials/technologies that can be utilized in the development of the system and easily integrated into the CB protective system. Demonstrate and provide pre-prototype materials or components (fabric samples/swatches) through screening tests. This testing will include chemical warfare agent simulant and physical properties testing. Provide methods of integration and proof-of-concept that the materials/technologies can be integrated into a fully functional garment item. The technical feasibility to integrate the waste management system into garments will be established by showing methods, designs, and analysis on how the materials can be integrated. The most effective designs and materials will be determined and proposed for Phase II efforts. (TRL-4)

PHASE II: The waste management system shall be integrated into functional garments and be tested to determine the effects of CB performance. This testing shall include baseline testing of the CB protective garment (without the waste management system) for comparative purposes and to quantify any performance degradation that may occur. The testing included within this phase will include material swatch testing, aerosol fluorescent screening tests (FAST), complete biological aerosol testing, and chemical vapor testing. This phase will focus on perfecting the material/technology in a fully functional prototype form factor. All research, development and prototype designs shall be documented with detailed descriptions and specifications of the materials, designs, processes, and performance. (TRL-5)

PHASE III: The commercial market for chemical protective ensembles includes a multitude of end-item operators from Homeland Security (HLS) personnel, which includes police, firefighters, and other first responders to the aeronautical industry. The development of a waste management system which increases the capabilities of current CB protective systems and utilizes advances in novel materials and closure mechanisms has applicability and technology transfer potential for commercial applications as well as the military Future Force Warrior (FFW) Program and the Joint Service Lightweight Integrated Suit Technology (JSLIST) Program. Other military efforts with extended mission durations including air crew operations could benefit from this effort. This phase will Align with consumer product markets and industrial protective services for commercial variants of the waste management system and integration with currently available CB protective garments. Commercial wear prototypes shall be capable of being tested in a simulated operational environment (TRL 6).

REFERENCES: 1) NASA, The Space Suit http://www1.jsc.nasa.gov/er/seh/suitnasa.html
2) The Space Suit Show http://www.parkland.edu/coned/pla/guidesuit.html

KEYWORDS: Waste Management, Chemical/Biological, Chemical/Biological Protective Clothing, Waste, Waste Elimination, Elimination

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A07-168 TITLE: Development of Nuclear Protective Materials for Incorporation into Military Protective Clothing and Equipment

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To develop and prototype a lightweight and flexible material with protection from low-level ionizing radiation for use either in current military protective clothing and equipment or as a standalone personal protective system.

DESCRIPTION: Current Protective Systems are not designed to protect the Soldier from the radiation hazards often associated with dirty bombs. The Alpha/Beta radiation protection afforded by the current chemical/biological (CB) system, the only system that has radiological protection, is limited to dust particles only. The current protective systems do not include ionizing radiation protection capabilities, such as protection from gamma rays, x-rays and high energy beta radiation. The threat of radiological hazards on the battlefield is more noticeable now than ever with the possible implementation of dirty bombs by terrorist groups. In order to provide protection essential to the Warfighter’s survivability, radiological protection must extend beyond particle protection and into ionizing radiation protection. Development of a lightweight (below 10 lbs. total weight for a completed garment) and flexible ionizing radiation protective material or system, without decreasing any current protection capabilities and without increasing heat stress is necessary for the Warfighter’s operational effectiveness. In addition, this technology will allow greater operational capability as well as sustainability for the Soldier in a radiological contaminated environment. Ionizing radiological protection will address this protection gap within current systems and ensure that the Soldiers have the highest levels of protection possible.

This material or system will be required to increase the radiation protection above what is currently fielded. The material would be required to reduce ionizing radiation (examples are radiation from materials such as Cesium-137 and Cobalt-60) exposure to the individual soldier by 75%. The use of innovative technology is desired for this effort. This includes but is not limited to novel polymer nanotechnology, barrier technology, multifunctional materials, nonwoven technology, and plasma technology. An example of currently available technology can be found at http://www.radshield.com. In addition, a Battelle testing report (reference 3 below) shows that there is wearable technology on the marketplace that can significantly reduce ionizing radiation exposure. This material or system must be capable of integrating into current protective clothing and equipment as an integrated or standalone system for specific operational objectives relating to radiological contamination. In addition, this material must have the capability to be printed or dyed with the appropriate counter surveillance Visual (VIS) and Near Infrared (NIR) signatures.

PHASE I: The phase I effort would be to demonstrate materials for use as ionizing radiological protection. This phase will concentrate on developing a technology to provide a flexible, lightweight and cost efficient radiological protective material. This material shall be able to withstand nuclear radiation threats which include but is not limited to alpha/beta particles, gamma rays, x-rays and high energy beta radiation. This material shall be capable of integration with current protective equipment, and current combat uniform protective systems for the dismounted Warrior as an integrated or a standalone system. Deliverables from phase I would be to demonstrate the capabilities listed above with relevant testing data. In addition, information must be provided on general ionizing radiation protective theory as well as the specific approach used. A technical report will be required, which will include a detailed description of the development and manufacturing parameters for the material. The most effective designs and materials will be determined and proposed for Phase II efforts (Technology Readiness Level 4, TRL-4).

PHASE II: Phase II will include the development of a prototype garment from the sample material developed in phase I. The sample material will be thoroughly tested for physical performance and radiological resistance. The testing results will be compared to the appropriate military specifications and compiled in a technical report. A prototype will be constructed for individual wear testing as well as system level protection evaluation. The prototype must be wearable and not hinder the overall effectiveness of the operator. 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-5).

PHASE III: The technology developed in this effort would be used as a standard issue component for combat units that are likely to come into contact the myriad of IED and “dirty bombs” that are currently being used against our forces. This technology could also be used to integrate into current NBC protective suits, giving these suits an added layer of protection from radiation threats. This technology can also have additional applications that extend beyond military protective ensembles to include transport of radioactive materials, radioactive events in garrison, and civilian first responders. In addition, this material or system can be easily transferred to industry where radiological hazards are realized on a daily basis such as the medical community. Commercial wear prototypes shall be capable of being tested in a simulated operational environment. Upon successful completion of this effort, the technology could be transitioned to the Joint Program Office to be included in the NBC protection ensemble (TRL 6).

REFERENCES: 1) Acute Radiation Syndrome.http://www.bt.cdc.gov/radiation/arsphysicianfactsheet.asp
2) The Dirty Bomb Threat Heightens. http://www.cdi.org/terrorism/dirty-bomb.cfm
3) Battelle Test Report on Demron™ Radiation Suppression Blanket. http://www.radshield.com/pdf/Battelle%20final%20report.pdf

KEYWORDS: Ionizing Radiation, Radiation Technology, Radiation Protection, CB Protection, Chemical Biological Defense

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A07-169 TITLE: A High Speed Towed Magnetic Array for In-Road Detection of Improvised Explosive Devices Employing Optimized Magnetic Map Differencing

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: Develop and test a prototype magnetic array which can effectively detect Improvised Explosive Devices with near zero false alarms through optimization of “before and after” magnetic mapping analysis of the road, challenges being design of the array (type of devices, number, orientation, etc) in conjunction with novel solutions which optimize the magnetic differencing method (control of device orientation, position, etc).

DESCRIPTION: The primary threat facing military personnel and operations in Iraq and Afghanistan (and by extension, possibly most future conflicts) is the improvised explosive device or IED. These devices have been constructed from a variety of on-hand materials, and therefore vary widely in size, shape, mass and composition. They can be quickly manufactured and installed beneath roadways such that a roadway that is clear one day may be seeded and armed the next. In-road installation allows relatively small devices to attack the vulnerable underside of even heavily armored vehicles. While geophysical or remote sensing methods for detecting and discriminating unexploded ordnance (UXO) are well developed, these methods are not generally suited to clearing a roadway of IED’s. In UXO and IED detection, discrimination of actual rounds/devices from general urban and/or war zone “clutter” is essential. Otherwise, time and resources will be wasted “disarming”, mufflers, wheel rims, and other miscellaneous debris. Emerging UXO discrimination methods will not be entirely suitable for IEDs as a result of their ad-hoc and variable size and construction, and therefore variable “signatures”. However, the common characteristic of IEDs is their temporal non-constancy. That is, a buried target that is not present one day, but appears on the next, may be more likely to represent an IED than would a target that has occupied the same subsurface location for many days or weeks. Therefore, time-lapse or time-differencing remote sensing could provide IED discrimination. In this scheme, the data from a given sweep would be compared to a map of all previous sweeps of the same roadway to highlight changes of the type that would be associated with IED implantation. Even with the time-lapse concept, a suitable sensing system must be developed. Existing UXO technology is not well suited because they map at relatively low speeds (i.e. walking pace or slow driving). In a hostile environment, a detection system should be capable of mapping at very high speed to avoid both the very IEDs it is detecting, as well as other potential attacks. To achieve accurate detection at even 60 mile per hour will require sensor sampling rates of hundreds, if not thousands of Hertz – characteristics not available, nor necessary, in the current UXO industry. The deep-sensing metal detectors that are the standard for UXO detection are active electromagnetic transmitter/receivers and are therefore physically (not just technologically) limited to sampling rates less than 50 Hertz. Ground Penetrating Radar (GPR) systems can achieve the necessary sampling frequencies, and the US military has reportedly attempted IED detection using “Horned Owl” airborne radar sensors, but have had limited success as a result of insufficient penetration depth. Experiments with hand-held, ground-contact microwave devices have shown that GPRs with sufficient resolution to discriminate UXO or IEDs will be physically (not just technologically) limited to insufficient detection depths. The proposed project will develop a very high speed, real-time IED detection and discrimination system based on magnetic sensors, which have ample sampling frequency, employed in a time-lapse mode to reject urban war zone debris. An array of in-line sensors will be developed to provide single-pass clearance of any given roadway. Furthermore, the possibility of vehicle signature compensation routines will be investigated so that the entire system could ultimately be mounted in various, inconspicuous, indigenous vehicles to further lessen the likelihood of attack during clearance sweeps.

Technical challenge/specifications for the sensor array/magnetic mapping system can be summarized as follows 1) configurable for both attachment to or tow by carrier vehicle, perform scan/magnetic map creation over the full width of the vehicle (on board vehicle) or width of 2 lane road (approximately 15 feet, when towed) 2) deployable on military and commercial vehicles covering a range of 30 to 60 mph on or off road speed including HWMMVs, trucks, and commercial 4X4 utility vehicles 3) lightweight and significantly smaller than current mine/UXO sensor arrays with goal to be capable of stealthy deployment on carrier vehicle and low/stealthy profile in towed configuration, thus allowing proliferation of the system to many vehicles such that specific targeting of the system by the enemy is significantly reduced 4) achieve 90% or better false alarm rejection over scanning path using high resolution, highly correlated magnetic map differencing method on the first comparative scan attempt 5) operate off vehicle prime power without extensive modification 6) depth of detection of potential IED threat to 3 feet. Approach should consider user selection of sensitivity and/or power of the sensing system to allow enhanced discrimination, reduced false alarms, and potential detection/classification of a range of potential IED threats.

PHASE I: Identify/modify/develop the sensor type and array configuration that meets the high sampling rate required for this application, as well as suitable GIS-compatible positioning, and extremely high speed real-time data differencing. Real-time data display/anomaly identification will be provided by RF data transfer to a remote system operator in a secure location or vehicle. Test system performance on prepared roadway sites.

PHASE II: Assemble prototype sensor platforms, rover data loggers, RF data transmission sub-system and compatible remotely-operated high speed tow vehicle. Test system performance on various prepared roadway test sites. Develop and test real time data differencing algorithms and IED GIS database and expert mapping system.

The prototype system will functionally represent the intended full up system design to include speed of scan, width of scan, length of scan (download of magnetic scan data over a minimum of 100m), subsequent roadway scan and calculation of magnetic map differencing to reveal location of mock IEDs emplaced in the roadway. Calculation of the magnetic map differencing and map creation need not be performed in real time but should achieve rapid transfer to a remote data logger/laptop computer to facilitate analysis of IED location within 5 minutes of final scan

PHASE III: Design and assemble production systems for deployment in the Iraqi theater. Incorporate GIS data bases and information distribution system architectures to support IED detection systems within the Army's Command/Control and Tactical Internet structure. Investigate the incorporation of systems on high speed autonomous guided vehicles that can be deployed routinely on Iraqi highways and integrate with normal traffic flow. Develop real time vehicle compensation or signature removal software to allow incorporation of the system on a wide range of vehicles. Improve expert discrimination systems to further enhance the discrimination of IED type detected.

Potential Dual Use Applications - High speed in-road IED detection systems which incorporate magnetic map differencing have a large potential military and commercial market. Such systems will be broadly marketable to thwart terrorist activities, provide effective unexploded ordnance removal, and to enhance homeland security efforts in any area of the world involved in the global war on terror. Systems can be configured for scanning of large areas both on and off road, with scalability of deployment enhanced through the use of magnetic map GIS data base management. Currently many countries are buying UXO detection equipment in a non-military commercial capacity through police or other organizations for essential public safety reasons. This concept will address a large portion of that market with potentially expansion to address the proliferation of potential IED threats.

REFERENCES: 1) Fulghum, D. A. (2005), Rise in Suicide Attacks in Iraq Propels Search for Better IED Detection, Aviation Week & Space Technology, 05/08/2005.
2) Bechtel, T., Ivashov, S., Razevig, V., Sheyko, A., and Vasilyev, I. (2006) Non-Destructive Evaluation of Dielectric Structural Materials by Holographic Subsurface Radar. Progress in Electromagnetics Research Symposium (PIERS), Cambridge, MA, USA.
3) Breiner, S. (1973), Applications Manual for Portable Magnetometers, Geometrics, Sunnyvale, CA, USA.
4) Billings, S. D., Pasion, L. R., and Oldenburg, D. W. (2002), UXO Discrimination and Identification using Magnetometry, Proceedings of the Symposium on the Application of Geophysics to Environmental and Engineering Problems (SAGEEP), Las Vegas, NV, USA.

KEYWORDS: IED, detection, magnetic, data differencing, GIS, signature removal

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A07-170 TITLE: Innovative Propulsion Methods for Small Arms Projectiles

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Ammunition

OBJECTIVE: The main objective of this effort would be develop a small arms platform which would use novel means of projectile propulsion. A secondary objective is to vary the projectile velocity for scalable effect (Non-Lethal and Lethal applications).

DESCRIPTION: The proposed work effort would address novel means of storing and using energy to propel small arms projectiles. With the use of a different means of propulsion, there would be several benefits to the warfighter. The research & development of such concept technologies for small arms applications would have several advantages. In current 5.56mm projectiles, the weight of the projectile is a third of the weight of the entire cartridge assembly. This suggests that the combat load can be three times what it is now based on mass alone. Based on volume, up to 5 times the combat load can be carried. There is also storage and survivability advantages to having propellant-less means of projectile propulsion. The projectile would be inert so there wouldn't be safety hazards as there are with ammunition with cases and propellant. Also, there would be no propellant degrade over time in storage.

Also one of the main advantages for the weapon system would be its scalability. The muzzle velocity could be changed based on range to the target. This would be advantageous to increase the non-lethal small arms engagement ranges to current lethal weapon system ranges. With the ability to vary the energy that is delivered to the projectile, one would have a much greater engagement than current non-lethal munitions which have limited engagement ranges in which an individual can be engaged effectively. A shortcoming of current Non-Lethal weapons and munitions are their limited effective non-lethal engagement range. Those with greater range have greater risk of injury to target individuals at close ranges. The capability to scale the kinetic energy up or down gives the warfighter on the ground greater flexibility in the employment of the non-lethal methods. Several different non-lethal and lethal projectiles exist or can be developed that could be used with the concept technology. The rate-of-fire for the weapon could also be variable, limited to the capabilities of the technology. Eventually, such capabilities could be integrated into the Army's Future Combat Systems programs and platforms.

PHASE I: Design and prototype a proof-of-principle energy storage and means of propulsion. Demonstrate proof-of-principle of energy storage for small arms platform and projection of small caliber ammunition at non-lethal and lethal velocity.

PHASE II: Develop and demonstrate the storage of energy for an individual dismount combat load (7 magazines=210 M855 ball rounds at 950 m/sec=380,000 Joules) with same or less weight and volume as current small arms capabilities. Demonstrate projectile velocity and engagement range variability

PHASE III: The developed technology will have several uses. The developed technology can be used for military as well as law-enforcement requirements. The resultant technology can also have applications for energy storage that is lightweight and low volume.

REFERENCES: 1) US ARMY TACOM - RI "Small Arms Information"
http://tri.army.mil/LC/CS/csi/satoc.htm

KEYWORDS: small arms, urban warfare, non-lethal

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A07-171 TITLE: Advanced Torque Measurement Systems for Main and Tail Rotors

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and demonstrate an advanced torque sensor that accurately measures the torque for main and tail rotors using a real-time, on board measuring system.

DESCRIPTION: The Army's goal to transition to a Condition Based Maintenance (CBM) approach requires an improved accurate torque measurement system at the main and tail rotors which will improve calculations of remaining service life on existing parts. At present, the torque seen at the main and tail rotors is calculated by measuring torque output at the engine, then assuming certain loses, and concluding with a conservative estimation for both rotor heads. Worst case scenarios at the rotors are used to evaluate component life because the exact torque split varies depending on flight regime. Accurate torque measurement systems placed at the rotor heads, supplemented with an existing health and usage monitoring system (HUMS) will improve calculations of the remaining life of rotor components. This facilitates an opportunity for real-time torque level monitoring in order to better assess the remaining fatigue life of the dynamic components in the drive system of all current and future Army rotorcraft.
Desired characteristics of the sensor system include delivering a robust design that will provide reliable torque measurements of both main and tail rotors. It should be non-contacting and of minimum weight. High accuracy is expected (error less than 2%) as well as high thermal tolerance (-50°F to 300°F). There should be no error introduced due to thermal changes or vibration. There should be no error due to axial or lateral shaft movement. Furthermore, the Army is looking for innovative methodology and techniques; Wireless sensors may be considered. The sensor's signals will be integrated into the HUMS so that real-time data is available for determining remaining fatigue or service life.

PHASE I: Develop and conduct a feasibility demonstration of the proposed measurement system technology on a laboratory scale. The overall system must be able to produce accurate torque measurements using a bench test set up and include algorithms that will use those measurements to determine remaining fatigue life of parts in future phases of the program. This demonstration should validate the concept's achievement of topic objectives.

PHASE II: Further design and develop the proposed torque measurement system, preferably coordinating with an airframe manufacturer, to fully validate the operating characteristics and performance through experimentation. The design during the Phase II effort should be implemented using a relevant hardware platform and display the ability to accurately predict the remaining fatigue life of parts. These capabilities should be validated using additional bench or rig tests. Environmental standards are required to meet MIL-STD-810F qualification procedures.

PHASE III: The application of a main and tail rotor torque measurement system will have application to all commercial and military rotorcraft. The lives of rotorcraft parts are currently based on flight time with worse case loads assumed. By installing the system on aircraft, such as the CH-47, UH-60 or AH-64, measurements of the torque applied to the main and tail rotors will be recorded using on-board HUMS equipment. The torque measurement coupled with existing HUMS flight data will enable parts to be removed based on actual fatigue/load cycles rather than assumed flight loads. The torque measurement system will allow parts to remain in service for their full fatigue life, resulting in reduce operational costs and improved aircraft availability.

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2) Wireless Magnetoelastic Resonance Sensors: A Critical Review, C. Grimes, C. Mungle, K. Zeng, M. Jain, W. Dreschel, M. Paulose, and K. Ong, July 2002. http://www.mdpi.net/sensors
3) A Brief Comparative Analysis of Magnetoelastic Torque Sensors: Permeability Based vs. Polarized Band, Ivan Garshelis and Sami Bitar, MagCanica, Inc.

KEYWORDS: Torque Sensor, Rotorcraft, Drive Shafts, Main Rotor, Tail Rotor

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A07-172 TITLE: Small Light-Weight Precision Localization and Geo-registration System

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: PEO Aviation

OBJECTIVE: Develop a vision-based onboard system applicable to a wide variety of aviation platforms from small UAVs to manned aircraft that provides high precision localization and geo-referencing for accurate self-position and target location estimation and GPS-disrupted navigation.

DESCRIPTION: With the common availability of GPS jamming there is a real need to give aviation systems the ability to do precision navigation and relocating in GPS denied environments over extended periods. One of the key technology areas for operating without GPS is vision based geo referencing and localization. This provides the ability to identify terrain features as landmarks and use their geo-locations as reference to mitigate loss in platform state information accuracy due to drift in inertial measurement data. This technology also permits increased precision in localization over and above that provided by GPS position. Additionally, vision based systems have the advantage of being potentially very light weight and could permit utilization of existing sensors or conversely could allow the geo referencing sensors to serve dual duty and complement existing sensors.

This system will focus on developing a geo-registration system with sufficient precision for a small aviation platform to know its self-location precisely and conduct its reconnaissance and targeting missions with precision. The Contractor should develop an integrated suite of imaging sensors and sensor data processing to generate accurately geo registered terrain feature, cultural feature and target localization data. The system may be designed to utilize existing sensor systems (targeting or navigation) on a non-interference basis to enhance precision or be based on a dedicated set of sensors and processors that supports or at least complements the RSTA mission functionality of the targeted platform This additional functionality may include mapping, aided/automated target recognition, feature recognition and change detection. The system needs to be applicable to small UAVs operating at battalion and below levels.

PHASE I: Conduct trade studies to address scalability of the system to different platforms and identify how best to utilize and complement conventional sensor systems. Develop a proof of concept demonstration of key technologies associated with a small light weight, low power precision localization and geo registration system for small UAVs (Class 2 or smaller).

PHASE II: Design and develop a complete system and install it on a small UAV or surrogate and conduct testing to characterize system performance. Refine and validate the key technologies through simulation and laboratory testing as needed. Define requirements and goals for follow-on system development efforts based on the results of this research.

PHASE III: This technology addresses the critical capability of operating UAVs in GPS-denied environments, and has application to the current fleet, to FCS, and commercial UAVs. This system also has the potential to sustain precision targeting capabilities for manned aircraft like Apache and ARH operating in a GPS-denied environments. For Commercial UAVs, this system would add an inherent Geolocation capability as a backup to current GPS systems enhancing the overall safety and reliability of UAVs operating in a commercial environment. This technology has very broad applicability to the development and certification of commercial UAVs. This technology will also have direct applications in the areas of intelligent transportation and geological surveying. Beyond these it could enable a vast assortment of new and unanticipated applications in both the commercial and military domains.

REFERENCES: 1) Navigation via Signals of Opportunity (NAVSOPP), DARPA SPO, Program Manager: Dr. Greg Duckworth, http://www.darpa.mil/spo/programs/navsopp.htm
2) Visual Servoing for Tracking Features in Urban Areas Using an Autonomous Helicopter, http://cres.usc.edu/pubdb_html/files_upload/474
.pdf
3) Aerial Robots: Airframes, Sensing and Navigation, Paul Y. Oh, Drexel University – Mechanical Engineering - http://www.wtec.org/robotics/
us_workshop/June22/Aerial-robots-paul-oh.pdf

KEYWORDS: UAV, Autonomous, Navigation, GPS-free, Visual Odometry, Algorithms, GPS, Algorithms, geo-referencing, localization, visual sensors

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A07-173 TITLE: Tactical Intra-Vehicle Information Bus (TIVIB) for command and control applications

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: To develop a common architecture for integrating multiple electronic systems and computing platforms within a vehicle by adapting commercial automotive control, automotive entertainment, telecommunications, computer, and consumer audio/video topologies into a single (or smaller set of) standards for military use.

DESCRIPTION: Currently, a tactical vehicle can have systems that operate as individual subsystems that are not interconnected within the vehicle to form an integrated system. The current practice of “bolting on” separate subsystems greatly increases the cost, reduces operational flexibility, and reduces operational readiness and increases training requirements. This sub-optimal “bolt-on” approach requires significant systems engineering effort to add or change systems in the vehicle. This piecemeal approach also burdens the vehicle operator and maintainer with the need to support a greater number of individual subsystems.

The objective of this SBIR is to demonstrate an intra-vehicular architecture that integrates common command processing resources, operator display and operator control interface, communications subsystems and navigation subsystems. The sharing of resources among the various subsystems is a key element of this effort.

The TIVIB architecture must provide the following capabilities:
(1) Support data rates of 10 Mb/s as a minimum
(2) Accommodate up to 32 individual subsystems connected to the bus
(3) Fault tolerance to a single bus failure
(4) Internet Protocol compliant support
(5) Support of voice, video, and data service with good quality of service
(6) Adaptable to legacy government GPS navigation (DAGER), computing platforms (FBCB2 and MTS) and tactical radios (SINCGARS and EPLRS).
(7) Electro-magnetic Interference (EMI) mitigation in a vehicle environment

PHASE I: Phase I will be technical analysis and feasibility study to determine an appropriate demonstration scenario and environment to demonstrate the innovative solution prototype during Phase II. The offerer will identify the specific technical barriers that will need to be overcome in building the prototype, characterizations of each barrier’s relative risk and complexity, as well as proposed approaches to address them. The feasibility study will also provide a technical and operational walkthrough of the proposed prototype’s design approach, composition, operational behavior, and design assumptions. The feasibility study should also define the presumed operational scenario for demonstrating the effectiveness and value of the prototype.

PHASE II: The scope of the Phase II prototype will be to execute and demonstrate a solution that shares subsystems and their data within the vehicle in an integrated manner. The offer will connect a representative intra-vehicular system consisting of a processing subsystem, navigation subsystem, communications subsystem, common display and operator interface/controls. The offer shall define the bus approach and interfaces to the subsystems.

The final work product should be supported by any other documentation necessary for the government to make a well-informed Phase III decision.

PHASE III: During this phase, the Phase II hardware and software deliverables shall be implemented, integrated, tested, and certified for Army operation. The Phase III business implementation plan approved by the government shall be developed and delivered via hardware components and any documented software (both executable and disclosure of source code) along with all necessary documentation and testing, compatibility, and performance results.

The end-state demonstrated prototypes being researched within this topic will have dual-use value in commercial and government application. Potential commercial market applications for this innovation would include applications leveraging compute intensive subsystems to a common vehicle infrastructure. Example markets include: tactical first responder vehicles; armored transport; business and entertainment applications for livery vehicles; and, delivery fleet vehicles.

The vendor is responsible for marketing its demonstrated prototypes for further development and maturation for potential Post-Phase II transition and integration opportunities including actual military Programs of Record and any dual-use applications to other government and industry business areas.

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KEYWORDS: bus architectures, vehicles

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A07-174 TITLE: Materials for Combustion Enhancement in a 100 kW Power Unit

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Command, Control and Communications Tactical

OBJECTIVE: To investigate the potential use of advanced state of the art ceramic and polymer air separation membrane materials for use in next generation Combustion Control mechanisms. The design and construction of these future Combustion Control Mechanisms shall be based on the use of polymer or ceramic air separation techniques and to integrate solutions with OEM engines and engine combustion control systems intended for use on 100 kW Power systems.

DESCRIPTION: Internal IR&D has shown promise for the use of air separation as a means to create an Oxygen Enriched Combustion environment for Burners and Heat Engines. Potential benefits in enabling oxygen enriched combustion environments include

- Cold start operation
- Emissions Control
- Combustion Control
- Increased Power Density
- Increased system Efficiency

Air separation using polymeric or ceramic membrane materials is of interest for improving combustion and emissions performance and control. Air separation refers to the ability to control the ratio of oxygen to nitrogen to suit a particular purpose. An oxygen-rich or nitrogen-rich airflow impacts the thermodynamics and chemical kinetics of combustion and the product gases, thereby impacting performance and emissions in burner systems and engines.

The use of membranes permits air separation for mobile applications. Whereas oxygen enriched air can be supplied or shipped to a fixed site application, portable use would not be practical if premixed pressurized air cylinders were used. The weight of such cylinders would detract from any improvements made by changing the makeup of the air used for combustion. Membrane use, therefore, is investigated to determine its effectiveness and practicality for military tactical applications.

The focus of this effort will be to identify, modify/develop and use advanced state of the art ceramic and polymer air separation membrane materials for use in next generation Combustion Control mechanisms found on 100 kW power systems.

In order to achieve a highly power dense system that can effectively and efficiently (>45 %) convert JP-8 fuel to electricity, the development and use of multifunctional materials technologies are sought. The baseline system to be used for comparison is the 100 kW TQG system. (http://www.pm-mep.army.mil/technicaldata/100kw.htm).

PHASE I: Phase I will be technical analysis and feasibility study to determine an appropriate demonstration scenario and environment to demonstrate the innovative solution prototype during Phase II. The offerer will identify the specific technical barriers that will need to be overcome in building the prototype, characterizations of the barrier’s relative risk and complexity, as well as proposed approaches to address them. The feasibility study will also provide a technical and operational walkthrough of the proposed prototype’s design approach, composition, operational behavior, and design assumptions. The feasibility study should also define the presumed operational scenario for demonstrating the effectiveness and value of the prototype. Technology drivers considered shall be size, weight, and cost.

The designs should include the following elements:

1. Narrative and graphical depiction of the design
2. Projected physical attributes (size, weight…)
3. HMMWV Towability Analysis (trailer, payload limitations, towability limits…)

A decision model of selected materials and component designs shall be constructed with weighted values for performance & logistics parameters. Weighting factors shall be assigned to each parameter by the contractor and justification for these weights shall be provided. It shall also be possible to easily change weighting factors to study the effects on the overall utility of the design.

Using a decision model, or another suitable approach, the contractor shall propose an optimal combination of materials and critical power components for development in Phase II and integration into an operational 100 kW TQG.

PHASE II: Component Fabrication/ Integration of Mule / Testing: The component and subsystem designs from Phase I will be fabricated using the selected materials, integrated into a mule (prime mover, alternator, power electronic controls/conditioner) configuration, and tested under conditions that will determine component/subsystem readiness to be employed in a 100 kW power system.

This final work product should be supported by any other documentation necessary for the government to make a well-informed Phase III decision.

PHASE III: During this phase, the Phase II deliverables shall be implemented, integrated, tested, and certified for Army operation. The end-state demonstrated prototypes being researched within this topic will have dual-use value in commercial and government application. Potential commercial market applications for this innovation include the US Army and commercial railroad companies. Oxygen-enriched and Nitrogen-enriched combustion using polymer membranes has been studied for very large locomotive applications by Argonne National Lab using membrane materials from Compact Membrane Systems, Inc. and others (see references). In-house research at Fort Belvoir has shown promise for small, burner-based applications of oxygen-enriched combustion using polymer membrane materials. Polymer membrane materials are readily available commercially. Also, there have been several patents granted in the field of membrane-based combustion enhancements (see references). For these reasons, this ARMY SBIR seeks this type of technology push.

The vendor is responsible for marketing its demonstrated prototypes for further development and maturation for potential Post-Phase II transition and integration opportunities including actual military Programs of Record and any dual-use applications to other government and industry business areas.

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KEYWORDS: Optimized combat effectiveness, variable speed, load following 100 kW (nominal); HMMWV towable; enhanced strategic responsiveness

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A07-175 TITLE: Control Strategies for Advanced Military Diesel Engines

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: To examine, develop, and demonstrate diesel engine control technologies that will increase fuel economy, increase power density with respect to volume and or weight, and reduce specific heat rejection of high output military diesel engines which are required to operate on heavy-hydrocarbon fuels including DF-2, JP-8, JP-5, Jet-A, and Jet-A1.

DESCRIPTION: Future high output diesel engines for tactical vehicles will be modified from commercial variants to meet military performance requirements. Such vehicles are expected to operate in 125 F ambient conditions with significant solar radiation loading and in a high concentration of airborne particle environment. Optimal diesel engine performance targets include minimization of heat rejection (< 20 BTU/BHP-min; total heat rejection to crankshaft power ratio), inclusion of significant torque rise for transient operation, maximum power density (> 100 bhp/l; crankshaft power to cylinder displacement ratio) and thermal efficiency (>40% at best point), and sufficient air filtration toward minimization of main barrier maintenance interval. Today these targets are difficult to attain with purely commercially available diesel engines. Last, such engines must be able to operate to start at ambient temperatures less than - 25 F.

This topic will strictly focus on optimizing a diesel combustion system that targets the aforementioned performance targets through use of variable valve timing events (camless in nature), high pressure and multi-pulse fuel injection events, and the optimization of the spray targeting and piston bowl geometry through use of advanced simulated-based optimization techniques.

Success is dictated based on technological advances made to improve future military diesel engines.

PHASE I: Identify and determine potential valvetrain and fuel system technology along with advanced optimization techniques that will target military engine requirements shown in the description section.

PHASE II: Demonstrate, validate, and optimize the combustion system toward meeting military engine requirements shown in section 1. This combustion system should include variable valve and fuel system technology.

PHASE III: Develop a combustion system strategy that will both meet military engine requirements given in the description section and also meet current on-road emission standards. This technology could be integrated into future military truck engines and also in commercial truck engine applications with the differential in application based on engine control strategy perturbations. Additionally, future military medium to heavy-duty trucks could benefit from this combustion system development by minimizing multi-fuel power loss and possible fuel economy penalties associated with using JP-8 versus DF-2. It is envisioned that the developed combustion system strategy will be transitioned to a Military engine supplier for production consideration.

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KEYWORDS: diesel engines, heterogeneous combustion, combustion optimization, camless engine, genetic algorithm

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A07-176 TITLE: Advanced System Level Durability Analysis, Prediction and Optimization

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop innovative computer modeling tools and techniques to perform durability analysis, fatigue life prediction and optimization for military ground vehicle systems and subsystems.

DESCRIPTION: This SBIR will define, determine, and develop an innovative methodology, modeling techniques, approach and tools for predicting durability, life, and optimization of ground vehicle systems and subsystems based on expanding available modeling techniques. Subsystem of a ground vehicle must include multiple components (two or more) that interact with each other or are connected to each other so that loading one component of the subsystem will affect another component and/or entire system. Connections with linear and nonlinear properties such as bushings, ball joints, springs, shock absorbers are included in the subsystem. The typical example of a “subsystem” is: a Steering knuckle which is attached with a ball joint to a control arm that in turn is attached to the vehicle frame with rubber bushings. “System” should consist of multiple components (20 or more). A typical system would be a vehicle chassis which should include four suspension modules, steering, and frame. Modifications applied to design or material properties of one component may affect not only life of that particular component, but also reaction and life of other components in the system or subsystem as well as the life of the system as a whole. The developed methodology is supposed to accurately predict durability and life of the system or subsystem based on individual component’s life and, most importantly, interaction between components within the system. The methodology should also attempt to optimize design of the components in the system based on durability prediction of the system as a whole, while minimizing component weight. Recommendations of design modifications of components in the system which leads to improved durability/reliability and life of the system as a whole while minimizing weight of the system are the measures of optimization effort. The analysis of a “system” may require a multiprocessor environment such as High Performance Computers (HPC). Effective scalability and parallelization methods should be utilized to make this analysis efficient.

PHASE I: Subsystem durability analysis (4-6 components).
Perform durability analysis and life prediction of subsystem consisting of four components connected with idealized joints (bushing, spherical joint, etc) and two load cases. Study/recommend a feasible approach to optimize subsystem performance. The main goal of this study is to understand multiple component subsystem behavior, fatigue participation of each component of the subsystem and optimization approach and feasibility. Load cases for the durability analysis model should be generated through internal physics calculation, but thought should be given to how to receive external data files from physical test and sensor output.

PHASE II: System durability analysis (20 or more components) and optimization of the system. Perform durability analysis, life prediction and optimization of a system (assembly) of components using HPC multiprocessing capabilities. Develop and complete the methodology, tools, and techniques for predicting durability and life of the system of components. Load cases for the durability analysis model should be generated through internal physics calculation, but model should also have capacity to receive external data files from physical test and sensor output. Validate methodology with testing and show acceptable correlation between analytical and test results under identical load conditions. Develop optimization objectives, criteria, and methodology. Perform optimization on system of components and demonstrate how optimized system improves the performance or saves material/costs vs. original system. Demonstrate how the HPC multiprocessing capabilities could be effectively utilized to solve the problems of this size and scale. Investigate and verify design, manufacturing, and assembly feasibility of optimized system.

PHASE III: The techniques and methodologies developed will be used by Army (i.e. TARDEC, TACOM) engineers and managers, as well as Army suppliers to analyze durability, predict life, and optimize systems of vehicle components for complex load cases. The technology will improve the fidelity, accuracy and processing for system level (this is key) fatigue/durability/reliability Modeling and Simulation (M&S). This technology can be used by the US Army, USMC, Allies, vehicle OEM's and suppliers who produce ground vehicles to conduct M&S and analysis on systems impacted by modifications such as armor, payload or mission profile changes. This will support related analyses (and possible related recommendations of design changes as appropriate) and reduce vehicle failure impacts / O&S costs for equipment from various PM offices, including TV, HBCT, SBCT, and FTS, as well as reset and recapitalization vehicles.

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KEYWORDS: durability, fatigue, modeling and simulation, reliability, high performance computing

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A07-177 TITLE: Development of Reactive Reflector Technology for Vehicle and Crew Protection from Blast of Landmine and Improvised Explosive Device (IED)

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: The objective of the proposed research is to develop a new computational design methodology with an innovative reactive structural concept for a deflector that can be installed in current and future tactical vehicle systems for crew member protection under landmine blast and Improvised Explosive Device (IED) assaults. The deflector reconfigure from normal working condition to blast protective mode on detection of explosive blast using embedded sensors.

DESCRIPTION: Protection of vehicles and its occupants against landmine blasts and blasts from IEDs is a major concern in current and future military tactical vehicle systems. In this research program innovative structural concepts of a deflector that can be installed in current and future tactical vehicle systems for the improved safety of crew members will be developed with proof-of-concept prototypes built and tested . The innovative ideas include developing a new structural-material configuration with embedded sensing capability, which can react to the blast of explosives and reconfigure itself from normal working condition to blast-protective mode. This may include both shape change and material re-organization in response to the detected blast energy of the explosive. It may be realized using a reactive mechanism such as those used in explosive and nonexplosive reactive armors or an innovative mechanism. In the shape design deflector will be optimized to deflect and resist blast shock wave in the most effective way with minimum weight and space volume added to the vehicle without adversely effecting vehicle mobility, safety, transportability, and durability performance under normal working conditions. In the material re-organization design the aim is to: (1) distribute blast energy to a much larger area so that it will be absorbed by a larger amount of material due to the novel re-configurable material design; (2) adjusting reactively the overall structural stiffness and damping properties of the deflector so that fatal damage of the main vehicle structure may be prevented; and (3) re-distributing material density and orientating material in the local area in response to fragment impact to achieve better penetration protection. The deflector reconfiguration may have several predetermined configurations for different protection levels which can be initiated depending on the detected blast energy of explosives.

In addition to the above design tasks, an embedded sensing and ignition capability needs to be developed for detecting blast level and igniting the reactive structure accordingly.

PHASE I: Develop basic concepts of the reactive deflector which can morph shape from normal to blast protective configuration on detection of blast. Perform shape optimization for protection against blast over pressure and fragment penetration. Develop fundamental mechanism of re-configurable material distribution which can further defeat fragment penetration and improve occupant safety. Develop a concept for embedded sensors and igniter that can detect blast energy and initiate the reactive structure to position it in blast protective mode. Perform computer simulation of the concept developed to determine its effectiveness in mitigating blast damage. This may include determination of blast load, vehicle structural response and response of occupants with and with out deflector.

PHASE II: Phase II Desired End Product: Develop a computer simulation code for the reflector design concept. Design, build and test a prototype of the reflector to validate its effectiveness for occupants survivability in a tactical vehicle underbelly landmine blast and IED fragments impact. Conduct parametric and trade off studies for optimal deflector and associated structure design based on desired protection level or blast event. Assess potential extension of the technologies developed in this program to defeat large size mines and side attack mines.

PHASE III: If this program is successful then its technology can be applied to current vehicle programs such as Stryker, Bradley, HMMWV and to future vehicle programs such as FCS, JLTV, FMTV and others. There is a high potential for insertion of commercially available sensor technology for detection of landmine and IED blasts into vehicle programs as a result of this technology development.

Additional civilian applications may be in the automotive industry. Including use in design of bumpers for collision damage mitigation in passenger cars, commercial utility vehicles and armored security vehicles. Other potential application can be in the design of recreational boats to minimize damage from collision with other boats in water.

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KEYWORDS: Landmine, IED, explosion, sensor, detection, reactive, armor, blast, fragments

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A07-178 TITLE: Multi-mechanism, Mine Blast Protection

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

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

OBJECTIVE: Investigate novel, non-traditional blast mitigation materials, techniques & phenomenologies and synergistically integrate them with traditional armor approaches to demonstrate the most optimal, mass efficient, underbelly armor solution against blast/fragment threats.

DESCRIPTION: Traditional blast protection approaches have relied on brute force armor mass and strength to prevent rupture, which generally points towards heavy metallic solutions. This is often too much for tactical vehicles to bear on top of the already weight-laden side armor. Geometric armor shaping reduces incident energy through deflection, however, is difficult to retrofit onto current flat-bottom vehicles. Energy absorbing crush layers reduces peak shock loads, but requires room for thick false floors and is tuned for specific maximum loads after which mitigation drops off quickly. However, there are non-traditional mitigation approaches such as momentum transfer onto frangible components, shockwave disruption/dispersion, shear rate sensitive materials, and endothermic chemical reactions, just to name a few, that have not been fully explored, but may offer significant mass efficiencies.
All proposed underbelly armor solutions will need to address fragmentation (frag) protection as well. A practical armor system will need to either be inherently fragmentation resistant or demonstrate compatibility with traditional ballistic/frag protection layers/approaches. Although innovation is only being sought for blast energy mitigation, the proposer is welcome to offer lower risk, non-traditional ballistic/frag protection approaches as well.

PHASE I: Phase I proposals should include complete armor recipes for blast and fragmentation protection with detailed descriptions of how each proposed non-traditional and traditional material, technique and/or phenomenology may contribute to blast and/or fragment protection. Proposals shall include sufficient theoretical, empirical and/or modeling & simulation data to assess technical merit of your approach. If possible, include estimate of proposed armor areal density to achieve NATO STANAG 4569 (Protection Levels for Occupants of Logistic and Light Armoured Vehicles) Level 2 Mine Protection (i.e. 6 kg TNT at 16" standoff) and STANAG Level 5 Artillery Protection (i.e. 20 mm FSP at 1200 m/s). Describe your concept validation & development approach, major tasks, schedule, test plan, risk areas, risk mitigation plan, estimated development cost and estimated unit production cost.

During the phase I effort, the contractor shall execute their proposed approach with the goal of demonstrating the feasibility of their concept. The contractor shall validate the theoretical, empirical and/or modeling & simulation data presented in their proposal. Whereas, the proposal data is of sufficient quality to judge technical merit, phase I validation data shall be of sufficient quality to confirm feasibility. In addition to any contractor testing, the contractor shall fabricate and deliver a 4'x4' lab-grade prototype test coupon for independent gov't validation. The contractor shall deliver progress reports every other month for incremental payment with a comprehensive final technical report detailing the entire development effort to include: detailed quantitative analysis of the contributions of each non-traditional and traditional material, technique and/or phenomenology, estimated unit production cost with each defeat mechanism itemized, and a revised optimal & practical underbelly armor recipe based on a balance of performance, weight and cost that will meet STANAG Level 2 Mine Protection and STANAG Level 5 Artillery Protection.

PHASE II: Phase II effort shall focus on developing the Phase I revised armor recipe into a full-scale prototype armor kit for integration and live-fire testing/demonstration on a tactical vehicle (exact model to be determined) against STANAG Level 2 Mine and STANAG Level 5 Artillery threats. Prior to final live-fire demonstration on a tactical vehicle, the contractor shall conduct sufficient sub-component Modeling & Simulation (M&S) and/or empirical testing to optimize and validate performance or panels, seams, geometry, fasteners, and fabrication processes. In addition, the contractor shall identify manufacturing processes and concerns for cost-effective, full-rate production. The contractor shall deliver progress reports every other month for incremental payment with a comprehensive preliminary technical report at end of year 1 and a comprehensive final technical report at end of year 2/contract. Technical reports shall detail armor recipe, validated performance, weight and cost of complete armor kit, manufacturability processes & concerns, and solid Computer Aided Drawing (CAD) model (sufficient for Finite Element Analysis (FEA)).

PHASE III: In addition to obvious military applications, especially for Program Executive Office Combat Support / Combat Service Support managed tactical vehicle systems, a more mass-efficient blast protection system would be appropriate for integration onto commercial VIP vehicles and for infrastructure protection of buildings and checkpoint guard stations. If successful, this technology will be matured further under the TWVS ATO and technology transferred at a mature Technology Readiness Level (TRL) to Program Manager (PM) Long Term Armor Strategy (LTAS) and PM Joint Light Tactical Vehicle (JLTV).

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5) http://www.sfu.ca/casr/id-blast-resistant-vehicles.htm
6) http://www.angelfire.com/art/enchanter/guntruck.html <== water-filled tires
7) http://en.wikipedia.org/wiki/Technology_Readiness_Level

KEYWORDS: blast, explosive, mitigation, protection, survivability, underbelly, underbody, armor, endothermic chemical reactions, shock

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A07-179 TITLE: Intelligence, Surveillance & Reconnaissance (ISR) Net-Centric Workflow

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: The objective of this effort is to research innovative technology and methods to facilitate the integration of independent, heterogeneous workflows. Future net-centric environments will require the ability to seamlessly exchange information between sensor platforms to satisfy mission objectives. The results of this research should be applicable to Intelligence, Surveillance & Reconnaissance (ISR) environments such as

Distributed Common Ground Systems (DCGS), Future Combat Systems (FCS) or Network Centric Collaborative Targeting (NCCT) and flexible to support other problem spaces such as Command, Control, Communication and Computer (C4) and logistics.

DESCRIPTION: Future multi-intelligence operations clearly depend on effective net-centric environments for time critical targeting. Seamless ISR workflows supporting emerging concepts of deployment are needed to leverage integrated intelligence products.

The complex nature of existing ISR workflows are characterized by minimal systems interoperability and manual processes. Different sensor platforms handle Warfighter intelligence requests in different ways. For example, the validation and prioritization of requests are focused on individual, rather than combined, mission objectives. This results in a fragmented view of the battlespace.

The challenge is to coordinate and manage the intelligence products from diverse sensors as a coherent activity to increase the quality and speed of engagement. Information exchange should not be hindered when legacy systems are included. A significant technical risk is in the orchestration of heterogeneous workflows in near real-time and with ever-increasing data sets. A key technical focus of this effort is the investigation of emerging semantic technologies to represent and integrate business process workflows. These technologies show promise in overcoming the inertia in the necessary evolution of dynamics of business processes. The lack of effective business workflow can be found in many DOD and industry vertical markets and therefore unclassified notional datasets should be used during this research.

PHASE I: Develop the requirements, usage scenarios and candidate architecture for an effective workflow in net-centric environments.

PHASE II: Capture the specific operational scenarios within a government specified domain. Develop a prototype to demonstrate the capability of the system for use by the Army.

An "alpha" software version of the phase II technology will be developed.
The architecture for the technology and how it fits into the target environment architecture will be defined. The phase II software will be integrated in a lab or simulated environment with the characteristics of the target environment. Initial performance benchmarks will be determined to validate the technology. A plan for Verification, Validation, and Accreditation (VV&A) will be defined and initial VV&A activities will be initiated.

PHASE III: The end state of this research is effective information workflow in net-centric environments being utilized by heterogeneous organizations to achieve unprecedented collaboration and information throughput. Potential dual use would be the application of this technology in commercial organizations to improve the production of critical business intelligence about competitors, customers, suppliers, and new markets. Large financial institutions would rapidly embrace an automated workflow technology capable of consuming federated banking information to understand and analyze consumer trends.
As a tangible commercialization example, pharmaceutical companies could leverage this technology to automate different business workflows (e.g. research, manufacturing and marketing) to expedite the discovery and the time to market for new drugs.

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KEYWORDS: Net-centric workflow, system interoperability, service oriented architectures, business process definition, execution and monitoring.

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A07-180 TITLE: Radar on a Chip

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Intelligence, Electronic Warfare and Sensors

OBJECTIVE: The objective is to develop a low cost, low weight, low power, multifunction radar on a chip. The radar should be capable of supporting search, track, identification, and communication. The output of the chip should be digital. The chip should be capable of operating on missiles, military vehicles, and ground sensors.

DESCRIPTION: With the advent of higher density chip fabrication capabilities operating well into the microwave band, developing highly complex mixed signal circuitry is becoming more common. These advances enable the development of high-frequency radar and communication functions on a single chip. Their development would require the integration of several high-frequency digital and analog circuits such as voltage controlled oscillators (VCO), transmit/receive (TR) modules, oscillators, mixers, low noise amplifiers (LNA), digital-to-analog converters (DAC), and analog-to-digital converters (ADC). The carrier frequency should be at least 10 GHz, the bandwidth should be at least 1 GHz, and the spectral purity should be greater than 50 dB. The radar data should have a dynamic range of at least 35 dB. The chip should be capable of generating an output power of at least 100 mW and the total power consumption should be less than 15 W. For higher power applications, the chip should support an additional external stage of amplification. The chip should also be capable of generating the following waveforms: chirp, step frequency, and phase modulation. The output data rate requirements for the chip should be compatible with a low-cost standard I/O interface.

PHASE I: Develop a block diagram of the chip with a road map for implementing each component. Deliver a report describing the block diagram and its estimated cost, weight, power requirements, design time, and performance.

PHASE II: Design, build, package, test, and deliver a chip. The chip should be integrated on a board with a standard input/output (I/O) interface. The chip will be controlled and the data archived using a graphical user interface (GUI). The design will include an antenna. The design, performance, power requirements, weight, and cost will be documented with a report.

PHASE III: There are many commercial opportunities for a radar on a chip. The major military applications are unattended ground sensors (UGS), missile seekers, phased array antennas, unmanned aerial vehicles (UAV), and manned and unmanned vehicles. PMs from IEW&S and Missiles & Space have expressed interest in this topic. The largest market for transitioning this technology to a fielded system is UGS. UGS such as OmniSense lack radar search capabilities due to cost, weight, power, and size constraints. Radar could add additional capabilities to UGS such as improved search and discriminating moving targets from clutter and noise.

The major civilian application for this technology is next generation radars for automobiles that are capable of obtaining improved range and Doppler resolution, and are less sensitive to interference. This technology can also be integrated into large phased arrays for applications such as monitoring the weather or imaging people at airport security.

REFERENCES: 1) "Compact single-chip W-band FMCW radar modules for commercial high-resolution sensor applications", A. Tessmann, etal, IEEE Transactions on Microwave Theory and Techniques, Volume 50, Issue 12, 2002.
2) "A 9-Bit 9.6-GHz 1.9W Direct Digital Synthesizer MMIC Implemented In 0.18um SiGe BiCMOS Technology", F. Dai, W. Fieselman, etal, IEEE International Solid-State Circuits Conference, to be published Feb. 2007.
3) "A 77-GHz automotive radar MMIC chip set fabricated by a 0.15/spl mu/m MHEMT technology" D.M. Kang, etal, IEEE MTT-S 2005.
4) “Direct Digital Synthesis Applications for Radar Development” E. Adler, E. Viveiros,T. Ton, J. Kurtz, M. Bartlett, 1995 IEEE International Radar Conference.

KEYWORDS: RF System on a chip, Direct digital synthesis, high density packaging, radar, MMIC.

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A07-181 TITLE: Miniaturized North Finding Module

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.

DESCRIPTION: The Program Executive Office, Missiles and Space has multiple applications for a miniaturized lightweight, low-power north seeking module (NSM) which can operate accurately in varying magnetic fields such as those created by nearby weapon systems, generators, vehicles and other ferrous objects. These modules would be integrated into a variety of sensors such as missile launchers (Javelin, ITAS, etc), hand held far target locators, and hand held global positioning system (GPS). Current state of the art sensors that fall within acceptable size, weight, power and affordability constraints do not provide the level of accuracy needed for reliability and repeatable to determine magnetic North and require frequent, complicated procedures to maintain even marginal accuracy. The ability to determine the azimuth to a target with a high degree of accuracy is critical as the services move toward the employment of myriad networked battlefield sensors to generate calls for fire from a host of remotely positioned precision weapon systems. The proposed SBIR program provides the Army with an opportunity to improve existing capabilities by increasing the accuracy and reducing the weight and cost of north seeking systems for critical military weapon systems.

PHASE I: Develop alternative methods of determining north using new technologies and/or new and innovative applications of existing technologies. Factory magnetometer calibration of the module is allowed as a threshold requirement, however the objective module shall not allow such a calibration. Modules will provide 10 meter horizontal accuracy or better at a range of 3000 meters. For operation within the presence of a periodic magnetic field with a peak of 100 mGauss the frequency of the periodic signal should range between 10 Hz and 400Hz as a threshold. The objective magnitude is 1000 mGauss between 10 Hz and 400Hz. For operation within the presence of random magnetic fields with a peak of 100 mGauss the frequency content of the random signal should have a flat power spectral density between 10 Hz and 400Hz. The objective magnitude should be 1000 mGauss with the same spectral shape. Modules will weigh less than 250 grams and occupy less than 40cc volume. Electrically powered solutions will provide a minimum of 72 hours operation from a power source less than or equal to the power density of two AA batteries. Acceptable solutions should have a production cost of $350 or less for quantities of 1000. Module must output data via an industry standard electrical interface. Contractor will verify environmental and accuracy performance through simulations. Contractor will provide a report of the recommended technical solution, outlining the technical approach, assessing the technical risks associated with successfully implementing the solution in hardware and provide estimates for weight, volume, power requirements and cost for the Module.

PHASE II: Based on the outcome of Phase I activities develop and fabricate a prototype north seeking module system and demonstrate its ability to meet accuracy requirements in the presence of varying magnetic fields. Provide a final report summarizing observed performance of the prototype system. If the prototype fails to meet all technical requirements, provide an estimate of time schedule, technical risk and funding required to mature the design to meet them.

PHASE III: The goal of this effort is to reduce the size, weight and cost of NSMs while at the same time increasing the accuracy available. This will be of great benefit to the military in improving the target location error for target acquisition systems, particularly man-portable systems where weight and power consumption are critical, applications for this technology spread across the military and commercial fields. The military could use this in a number of weapons systems which utilize GPS for positioning, examples of this are the improved target acquisition system (ITAS) that is incorporating a far target locator (FTL) system which requires a high degree of accuracy and the Javelin system will at some point in the future implement a FTL system onto the command launch unit (CLU). There are numerous commercial applications for a lightweight and affordable north seeking module. Some commercial applications that may benefit from this SBIR include automotive, aviation, nautical, manufacturing and law enforcement.

KEYWORDS: factory magnetometer calibration, periodic magnetic fields, random magnetic fields, mGauss

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A07-182 TITLE: <u>Modeling and Simulation Method to Analyze the Aerodynamic Performance of Paratroopers in Military Free fall Operations</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PEO Soldier

OBJECTIVE: Improve current (commercially available) computational fluid dynamics (CFD) based software to model a free fall parachutist. Specifically, the model must be capable of supporting analysis of the aerodynamic forces on the parachutist allowing the program office to (1) develop new concepts for free fall system design, (2) validate body position optimization, and (3) compare and contrast competing designs crucial to delivering safe and reliable parachuting equipment to the field of operations.

DESCRIPTION: Program Manager-Clothing and Individual Equipment is responsible for delivering safe and reliable parachuting equipment to the field of operations. Modeling this environment through computer aided simulation provides information which guides engineers to develop improved and more effective parachute systems that are more responsive to the needs of the user. Of specific interest is the free fall environment prior to deployment of the main canopy. Due to the complexity inherent in the free fall environment, there is a lack of understanding as to how various independent factors such as parachutist weight, body positioning and equipment orientation, etc. affect the aerodynamic flow and resulting forces surrounding the parachutist. Current attempts are being made using commercial computational fluid dynamics (CFD) based software. The goal of this topic will be to improve upon this initial work and develop a proper free fall modeling and simulation package which will respond to multiple variables. The tools and package developed from this topic would be used to perform a comprehensive parametric study of variables such as (but not limited to) parachutist weight, body form, equipment configuration and arrangement, and altitude to reliably predict aerodynamic performance data in each instance. It is anticipated that the solution to this topic would use a commercial CFD package with methodologies being developed for the use of models of the human body to simulate the freefall environment and allow for modification of the models to include the simulation of new equipment or the repositioning of equipment. Additionally, the models in the simulation should react to the flow conditions which could result in the model translating and/or rotating due to changes in the flow based from an initial condition and orientation. This implies the parachutist model will not remain a fixed orientation during the entire simulation but will react to changing flow conditions. Once a greater understanding of how these multiple variables affect aerodynamic performance in freefall, this new modeling ability will provide guidance for new parachute system design efforts and body positioning techniques. Engineers will be able to get better ideas out to the end users faster since a lot of guess work and trial and error testing will have become a thing of the past.

PHASE I: This phase will demonstrate the feasibility to develop and implement a strategy for a method to predict and simulate the aerodynamics and flow around a military freefall parachutist using commercially available software tools. During Phase I, the software tools should be used to accurately and reliably predict the flow conditions around a model of a parachutist in a single configuration (i.e. a given weight, equipment configuration, etc.) with a fixed orientation in the flow. Develop a method to change the input parameters which would be implemented during Phase II.

PHASE II: The methods developed during Phase I should be implemented and expanded to allow the user of the tool to easily change the input parameters and the parachutist configuration. The input parameters which are needed as input parameters include (but are not limited to) parachutist weight, equipment placed on the body, location of equipment on the body, orientation and position of body parts (such as legs, arms, torso shape, etc.), and atmospheric conditions (such as altitude, temperature, etc.). Implement methods to allow the parachutist models to react to the flow conditions being calculated. Validate the results from the modeling and simulations with results obtained from operational environment under identical conditions. Refine model and simulation based on feedback of results and determine an acceptable degree of accuracy for the final product.

PHASE III: The Phase III vision of this SBIR for military applications will be the direct use of improved computational fluid dynamics (CFD) modeling to support the Special Operations Advanced Ram Air Parachute System (SOARAPS) program, the United States Army Special Operations Command (USASOC) Initial Capabilities Document (ICD) for the Joint Aerial Insertion Capability (JAIC), validated by the United States Special Operations Command (USSOCOM) on 22 February 2006, and the life cycle management of all Military Freefall parachute systems. More specifically, a thorough CFD analysis of a body in freefall can be used in the development of the SOARAPS and other in freefall programs to reduce the scope of live testing, thus saving money. A reliable modeling and simulation methodology for freefall operations can also be transitioned directly to use for commercial skydiving applications. Reliable models of body positioning in freefall will find use in skydiving schools for training purposes. Manufacturers of skydiving parachute systems and accompanying items will be able to use this same technology for their research, development and design efforts to greatly reduce product lifecycle from concept to market. Little or no modifications will be needed in order to switch between modeling military and civilian parachutists on the computer since both environments are essentially identical.

REFERENCES: 1) Poynter, D. and Turoff, M., “Parachuting: The Skydiver’s Handbook,” Para Publishing, 2004.
2) “2006 Skydiver’s Information Manual”, http://www.uspa.org/publications/
SIM/2006SIM/section1.htm , United States Parachute Association, Alexandria, VA, 2006.

KEYWORDS: modeling, CFD, free fall, parachutist, parachute, aerodynamics, wakes, computational fluid dynamics

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A07-183 TITLE: Accessory Rail Communication and Power Transfer

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Soldier

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 an accessory attachment system for small arms weapons that enables attached accessory devices to draw power from a central power source and communicate with the user or other devices without exposed wires.

DESCRIPTION: In order to complete their mission, war-fighters are required to carry heavy loads into the battlefield. Therefore, it is imperative to reduce the weight of equipment and systems that make up a soldier or marine’s load. One area that needs to be targeted for weight reduction is the accessories, batteries, and mounting systems used to attach accessory devices to weapons. These devices include flashlights, laser pointers, reflex optics, and other devices fielded and not yet fielded. Current devices each mount to weapons using a rail grabber to attach the device to a MIL-STD-1913 rail. Each powered device carries its own battery and necessitates that it have a battery compartment to protect and draw power from those batteries. Each device has varying power requirements that result in multiple battery types being used. For purposes of this proposa, it can be assumed that each device will have a power requirement from 1.5 – 7.5 volts, and a maximum of 1 ampere per device.

Soldiers are currently carrying multiple batteries to meet mission requirements, adding weight to his load. The attachment of battery powered accessories is altering the balance of the weapon, potentially negatively impacting soldier’s effectiveness with the weapon.

It is desired that an accessory attachment system be designed and developed that will enable the soldier or Marine to reduce his/her total carry weight. This attachment system will provide a means to allow a single power source to provide power to the accessories and the war-fighter or fire-control device to communicate (primarily for device controls) with those devices while allowing the weapon system to remain modular for individual configuration of the weapon as required for specific missions. Communication is defined as the ability to turn devices on and off, and to switch the settings of devices, e.g. as on the AN/PEQ-2a, there are settings for HI/LOW Aim Light, as well as HI/LOW dual (Aim Light and illuminator). Any communication protocols required are to be proposed/developed by the contractor with an emphasis on non-proprietary solutions.

These attachment devices are required to be able to maintain alignment with the barrel of the weapon through repeated shock loading as found during weapon firing, soldier movement and rough handling. The attachment device should be similar in function to current Mil-Std-1913 rails that allow various devices to be attached to small arms weapons with flexibility to mount at varying locations on the weapon. In addition, the accessory attachment system must include a central power source to be mounted elsewhere on the weapon to provide power to mounted accessories. This power and communication system must be unaffected by environmental conditions including removal and replacement of devices in wet, muddy, and sandy environments. Also, the attachment device must provide the user with the ability to communicate with and control mounted accessories. Lastly, the device must allow backward compatible with current systems, while allowing the Soldiers to complete a 72 hour mission.

Prior market surveys conducted by Canada and the US Army have yielded no responses from industry for current capabilities that meet the requirements as stated herein. In addition, the USMC has stated they have an interest in developing a similar capability. Using the SBIR program is the correct approach as the technologies to allow power transfer and communication in the environments that soldiers and marines are subject to, as well as the shock levels from firing weapons, are currently not available. In addition, this proposal requires battery chemistry research to enable high power densities in smaller packages subject to the environments typical of weapon systems, such as temperature extremes, shock and rough handling.

PHASE I: Design/develop an innovative concept for the attachment, powering, and communication with accessories as outlined above with a central power source capable of providing power for a 72hr power mission. The attachment device must enable backward compatibility with accessories currently fielded. The device must come complete with a central battery source, control device to turn simulated devices on and off, as well as to control those devices (i.e. brightness of red dot in a reflex sight, change between high and low power on a laser pointer, etc.) Conduct limited testing that will prove the concept of power transfer and electronic signal transmission. For development purposes the power requirements are between 1.5 to 7.5 volts and 1.0 amps (max).

PHASE II: Fabricate prototypes that can be mounted on M4 and M16 weapons; demonstrate the operation of mounting and removing currently fielded devices; demonstrate, through the use of physical models, power and signal transfer from the device to the simulated accessories; and validate projected performance through test conditions1 including High-Temperature, Low-Temperature, Sand and Dust, Zero Retention, Zero Repeatability, Durability2 and Rough Handling. These tests are to be conducted at contractor expense.

PHASE III: This phase will concentrate on application and commercialization potential. The military end-state is to use this attachment device on all small arms weapons currently fitted with rails to reduce the need for multiple batteries and control surfaces for accessory devices. The successful device will create military application opportunities to develop accessory devices without the batteries and controls currently built into devices, resulting in smaller packages. Also, the development of higher density power sources is another technology that can be spun off to complete the system. A potential commercial application is in the automotive field. As accessories such as GPS, hands off mobile telephones, internet access, etc. are becoming more widely available to the public, this, or a similar standard attachment would allow a single mounting system with standard interfaces to be used to power the devices as well as provide external control from existing control surfaces while in difficult environments.

REFERENCES:
1. TOP (Test Operating Procedure) 3-2-045, Automatic Weapons, Machineguns, and hand and Shoulder Weapons, 21 December 1983.[TOP 3-2-045 is available through the National Technical Information Service (NTIS). However, due to the year of the document, interested parties must call 1-888-584-8332 to order. Accession number is ADA136335.]
2. TOP 1-2-502, Durability, 19 December 1984. [TOP 1-2-502 is available to the public through DTIC (http://stinet.dtic.mil/). Use accession number ADA149003.]

KEYWORDS: Accessory rails, small arms, modular weapon systems, batteries

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A07-184 TITLE: <u>High Speed Wireless 3-D Video Transmission to Support Virtual Dismounted Training</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

OBJECTIVE: Develop a high speed wireless (to include video, power and any other interface) image generator capable of generating and transmitting a high resolution greater than SVGA 3D virtual environment to dismounted Soldiers, fire teams and squads wearing head/helmet mounted display (HMD) systems during virtual training in an urban/complex environment.

DESCRIPTION: Recent advances with innovative wearable displays and scene generation capabilities have enabled virtual environments to closely match the live scene. Current dismounted Soldier/Leader and small unit virtual training systems are tethered to an image generator with cables that restricts Soldier range of movement and posture changes. Advances in head mounted display technologies and man-wearable computers have partially solved the cabling problem but add weight that further restrict movement and posture changes. The purpose of this effort is to develop high speed (real-time) image generators (IG) with refresh rates (60 Hz. or greater) that can transmit the 3D virtual environment through a secured wireless network without restricting the range of movement and adding to

Soldier load. This technology would also enable Future Force Warriors to conduct dismounted training in local training areas and motor parks by using a combat vehicle as a platform for the processor/IG.

PHASE I: Using current off-the-shelf (OTS)wireless technology, design a wireless image generating system capable of transmitting data to a man worn visual display system that is completely untethered. The design must consider the following: size, weight, comfort, network and transmission security, power to sustain an exercise lasting 1 hour, and rugged enough to withstand daily Soldier use. The design shall also consider delays that would cause scene stepping, or interruptions to the real-time environment. The design shall also consider transport delays that could cause simulator sickness often associated when wearing HMD's.

PHASE II: Develop and demonstrate a prototype system (TRL 5) in a relevant training environment. Conduct testing to prove medium fidelity and secure data transmission over short range distances (10-20 meters) to multiple players.

PHASE III: Technology can be used to support the collective training of future force dismounted leaders/soldiers at home station and deployed. The most likely paths for transition of the technology from research to operational capability are use in a dismounted Soldier embedded training application by the Embedded Training integrator for FCS, or transition into a current DOD S&T program related to Embedded Training and Ground Soldier Systems such as the Scalable Embedded Training and Mission Rehearsal Advanced Technology Objective as an innovative method to provide virtual training under the size, power and weight limitations imposed on these systems. The commercial applications include training of rapid/first responder teams that usually conduct missions on the ground, in urban complex terrain, and away from their vehicles. The Department of Homeland Security could also use this technology to immerse individuals and teams in a variety of operating conditions or emergency situations.

REFERENCES: 1) Virtual Environments for Infantry Soldiers, Authors: Charlotte H. Campbell, Bruce Knerr & Donald Lampton, US Army Research Institute dated May 2004.
2) Embedded Training for Future Force Warriors: An Assessment of Wearable Virtual Simulators, Authors: B.W. Knerr,P.J. Garrity and Lampton, D.R.; Proceedings of the 24th Army Science Conference, Orlando, FL
3) Future Force Warrior (FFW)-US.Army Natick Soldier Center, http://www.natick.army.mil/soldier/wsit/
4) American Forces Press Service: Future Force Warrior Exhibits Super Powers- June 27
5) Kraemer, W. & Pray, R. (July, 2000). Remote Wireless High Resolution Display Systems. Presented at IMAGE 2000, Scottsdale, AZ.

KEYWORDS: Virtual training, simulation, wireless, head/helmet mounted visual display systems (HMD), man-worn computers, image generators, soldier load

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A07-185 TITLE: Battlefield Effects for Live Embedded Training

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 and demonstrate a low weight, low power and low cost prototype system for embedded live training battlefield effects on combat vehicles that would provide visual and aural indications of combat vehicle weapons being fired.

DESCRIPTION: In a live training mode under force on force conditions the simulation of battlefield effects that closely replicate actual combat conditions is a key element in providing a realistic experience for the training audience. These effects include both visual and aural indications of weapons being fired. Without these effects the live training audience has no situational awareness of the weapon firings as would occur under combat conditions with its associated noise, light and smoke. Training without these effects is unrealistic and often negative.

Embedded training is a key element in the transformational process for the United States Army and is a requirement for many combat systems including Abrams, Bradley, Stryker and Future Combat System (FCS) vehicles. The goal of embedded training is to have all modes of training simulation resident on the weapon system including the ability to support live training. Today live training is supported at the vehicle level by the Multiple Integrated Laser Engagement System (MILES). MILES which provides the simulated weapon firing effects with an explosive cartridge. MILES take considerable time to append to a vehicle during exercise preparation, then additional time to remove after the exercise. MILES does not meet the needs of live embedded training because of its appended nature, high cost, weight and logistical demands and safety issues created by the explosive cartridges used to create explosive effects. Thus it would be desirable to embed a smaller, lighter, less costly capability on weapons systems that would permanently reside on the vehicle.

This topic proposes to research innovative and unconventional alternatives to provide battlefield effects for embedded training in the live training environment. Possible examples includes acoustic and lighting technologies that could be incorporated into the vehicle while meeting the performance, reliability and maintainability specifications required of combat systems. This research would develop new techniques for battlefield effects that offer significant performance increases and cost reductions over current devices. As a goal, any embedded training approach should minimize hardware to support training by using the operational systems to provide this functionality. Given this focus, the development of a device that also supports operational needs such as safety, crowd control, etc., would be positive. The performance metrics desired to satisfy the embedded training solution of this research are well defined and include; 130 db sound at 20 meters, light flash visible at 1,800 meters, infrared signature visible at 3,000 meters, smoke visible at 3,000 meters, weight under 25 pounds, cost under $2,000, operational under vehicle power, and smaller than a shoe box. The device should have minimum logistical requirements and should not require explosive cartridges to operate.

PHASE I Conduct Innovative research to identify possible solutions and associated trade offs. Perform a design feasibility study/analysis for a system that will provide the Embedded Battlefield weapons firing signature effects.

PHASE II: Design and implement a prototype embedded Live Training Battlefield Firing Effects system on a current force vehicle and demonstrate it in a Live Training exercise.

PHASE III: The products of this research could have enormous commercialization possibilities for both military and civilian applications. All of the Army's combat vehicles (Abrams, Bradley, Stryker, and Future Combat System (FCS)) have requirements to provide embedded training and provide a transition path for this research. Components developed by this research could be installed to provide live embedded training and other dual use functionalities on all of the Army's vehicles as they begin their planned engineering upgrade as well as FCS systems as they are fielded. This research should lead to a major improvements over current appended live embedded training systems that now take significant time to prepare for use. To ensure that current force platform Program Managers (PM) are aware of the results of this effort the Program Executive Office for Simulation, Training and Instrumentation (PEO STRI) (with support from the Research Development and Engineering Command's current force embedded training research program) will present to the candidate platform PMs the findings and benefits for embedding this technology. The most likely source of funding for embedding this technology will come from the platform program offices that have endorsed this research. In addition to the military application, commercialization opportunities exist in the entertainment, law enforcement and safety industries for using the innovative special effects generated by these devices.

REFERENCES: 1. Department of the Army Pamphlet 350-9, Training Index and Description of Army Training Devices, 3 September 2002
2. Operational Requirements Document for the One-Tactical Engagement Simulation System
3. Prime item product function specification for the keyless Direct/Indirect Fire Cue, 29 June 1998

4. Prime Item Product Function Specification for the keyless Main Gun Signature simulator (MGSS), 19 April 1999
5. System Specification for Battlefield Effects Simulator (BES) Omega 60/B2, 29 September 2005

KEYWORDS: Embedded Training, Live Training, Weapon Fireing Simulation effects, Tactical Engagement Simulation System, Special Effects, Flash, Smoke, Bang, Audio/Visual Cues

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A07-186 TITLE: Non-Destructive Evaluation (NDE) and Testing of Ceramic Armor

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 a nondestructive field portable technique or an in-situ methodology to monitor the health of ceramic armor from non-ballistic impacts.

DESCRIPTION: The ceramic armor concept is widely employed in body armor, aircraft armor and ground vehicle armor. Armor ceramics provide effective and efficient erosion of and defeat of ballistic threats. Effectiveness of ceramic armor can be impacted by operational damage (e.g. rocks, trees, shop maintenance/storage, etc.) or by defects present from production. The purpose of this SBIR topic is to develop a field portable technique or an in-situ methodology to monitor the health of appliqué armor from non-ballistic impacts. The armor composition typically consists of a ceramic followed by multiple layers of glass-reinforced-composites, and or metals. The ceramic tile can also be encapsulated with rubber or metal.

PHASE I: Demonstrate feasibility of a NDE or in-situ health monitoring technique in a laboratory environment of 3 standard pre-damaged ceramic armor surrogate with: 1) 0.75 inch thick ceramic glued on to a 1" thick composite backing, 2) a standard pre-damaged ceramic armor surrogate 0.75 inch thick ceramic glued on to a 0.75" titanium backing and 3) standard pre-damaged ceramic armor surrogate with 0.75 inch thick ceramic glued on to a 1 inch thick aluminum backing.

PHASE II: Mature the selected NDE or in-situ health monitoring technique from Phase I into a field portable system and demonstrate said system for examining vehicle armor panels and body armor in the field.

PHASE III: Transition NDE and/or in-situ health monitoring system to production and utilization in quality assurance in motor pools/depots and production facilities. Endorsement from an Army program office has been received due to the importance and relevance of this work: Program Manager Future Combat Systems, Brigade Combat Team (PM FCS (BCT)) has endorsed this SBIR and is a co-author of the topic. When successful, products from this SBIR will greatly enhance analysis and maintenance of FCS armor, greatly mitigating risk and improving performance while reducing associated life-cycle costs.
The NDE system will first be transitioned to the FCS Structure and Armor ManTech Objective(MTO) program and demonstrated its utility in B-armor production line for quality assurance follow by utilization during FCS LFT and

LRIP. The system will also be transition to PMs of current system to inspect ceramic armor panels (e.g. EFV, Stryker, and appliqués on tactical vehicles).

REFERENCES: 1) Liu, John M., "Microwave Nondestructive Evaluation (NDE) of Marine Composites," Report number ADB285616, NAVAL SURFACE WARFARE CENTER CARDEROCK DIV BETHESDA MD,2001.
2) Weight, Kristen , "An Overview of NDE Methods for Thick Composites and a Proposal for Analysis of Computed Technology Data," Report number ARL-TR-516, Army Research Lab Watertown MA Materials Directorate, 1994.
3) Carriveau, Gary W.,"Benchmarking of the State-of-the-Art in Nondestructive Testing/Evaluation for Applicability in the Composite Armored Vehicle (CAV) Advanced Technology Demonstrator (ATD) Program. Phase 1 ," Report number TARDEC-TR-13604, Tank and Automotive Research, Development and Engineering Center, Warren, MICH, 1993.

KEYWORDS: NDE, armor, ceramics, field-portable

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A07-187 TITLE: Phase Transition Explosive Driven Pulsed Power Generators

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: The objective of this effort is to develop shock wave devices that can function either as a g-hardened power supply or switch.

DESCRIPTION: Explosive pulsed power is currently being developed for use as single shot power supplies in advanced munitions. These explosive pulsed power devices include Magnetocumulative (or Flux Compression) Generators (MCGs), Ferroelectric Generators (FEGs), and/or Ferromagnetic Generators (FMGs). With the possible exception of the FMG, these generators probably cannot be built to survive the high g-force environments of munitions. Shock wave sources are similar to flux compression or magnetocumulative generators, with the exception that magnetic field compress occurs within a material such as aluminum powder or other suitable dielectric that metallizes under shock compression. Due to the fact that MCGs function in air or a gas, such as sulfur hexafluoride, it has additional disadvantages including instabilities (e.g., Rayleigh-Taylor) and several loss mechanisms including 2p-clocking, nonlinear diffusion, and so on. It has been proposed that these instabilities and loss mechanisms can, at least partially, be eliminated by compressing the MCGs magnetic flux in solids such as ionic salts or oxide coated aluminum powder. This is accomplished through a process that transitions a dielectric into a metallic state under shock conditions. This converging metallic shock would take the place of the liner in conventional MCGs. The presence of this material will also serve to g-harden the generator. Therefore, the objective of this effort is to develop solid filled MCGs as power supplies for use in high g-force environments. Another objective is to determine if the presence of a solid in the armature will help eliminate some of the problems encountered, in particular enhanced loss mechanisms, as the diameter of the MCG is decreased to diameters as small as 25 mm (1 inch).

PHASE I: Identify potential technologies and analyze, design, and conduct proof-of-principle demonstrations 1) to verify that the proposed solid filled MCGs are predictable and are consistent with predictions and 2) to assess their ability to drive various loads and meet the form factor size requirements. 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. It is not expected in Phase I that the prototype devices tested meet the goal of a 25 mm diameter.

PHASE II: Design, build, and test enhanced solid filled MCGs for explosive pulsed power applications, verify their ability to drive various types of loads, and verify that they can meet the size requirements of a platform with a diameter as small as one inch. Other issues that should be addressed in Phase II are hardening the technology to survive high g-force launches and designing production processes for mass production.

PHASE III: The Army is currently developing multi-functional warheads and munitions for enhancing the lethality and increasing the range of conventional munitions. This includes special warheads and grenades for defeating unconventional devices currently being used in various countries. Based on previous work, it is believed that these pulsed power sources may overcome the limitation of other devices in that they should be able to handle high g-force launches plus provide improved performance by reducing losses. The goal of this effort is to develop multi-functional muntions that could be transitioned to one of the Prime contractors that produce munitions for the Army. Those Firms selected for this effort will work with the Missile Program Element Office and the various supporting Army Research, Development, and Engineering Centers and their contractors to facilitate this transition. The explosive pulsed technologies developed under this effort could be applicable to multiple military and commercial applications requiring pulsed power. Commercial applications include water purification units at remote sites, nondestructive testing systems, portable lightning simulators, portable expendable X-ray sources, plasma chemistry, industrial chemical processing, and oil and mineral exploration. Military applications include multi-functional warheads, as well as multi-functional munitions of various calibers.

REFERENCES: 1) L. Altgilbers, M. Brown, I. Grishnaev, B. Novac, S. Tkach, Y. Tkach, Magnetocumulative Generators, Springer-Verlag, New York (1999).
2) A. Neuber, Explosively Driven Pulsed Power: Helical Magnetic Flux Compression Generators, Springer-Verlag, Berlin (2005).
3) P.W. Cooper, Explosive Engineering, Wiley-VCH,, Inc., New York (1996).
4) C.M. Fowler and L.L. Altgilbers, “Magnetic Flux Compression Generators: a Tutorial and Survey”, Journal of Electromagnetic Phenomena, 3(3(11)), pp. 305 – 357 (2003).
5) L. Altgilbers, “Recent Advances in Explosive Pulsed Power”, Journal of Electromagnetic Phenomena, 3(4(12)), pp. 497 – 520 (2003).

KEYWORDS: Munitions, Pulsed Power, Magnetocumulative Generators, Magnetic Flux Generators, Power Conditioning, Ferroelectric Generators, Ferromagnetic Generators, Transformers, Switches, Vector Inversion Generators

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A07-188 TITLE: Power Conditioning for Explosive Pulsed Power for Missiles and Munitions

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: The objective of this effort is to develop the power conditioning needed for explosive driven pulsed power devices to properly drive various loads being considered as payloads for missiles and gun launched projectiles.

DESCRIPTION: There is interest in developing multi-functional warheads and munitions with enhanced lethality and extended range for defeating a variety of electronic targets. While considerable work has been done in developing explosive pulsed power systems, there are several areas that still need to be worked to develop these munitions. This includes power conditioning, antennas, and g-force hardening. This topic addresses two of these critical areas; that is, (1) impedance matching and pulse shaping and (2) g-force hardening. The radius of damage and the destructive power of conventional munitions are limited to that of the blast and fragments. Thus, the overall objectives of this effort are to extend the lethal range of munitions, increase the scope of the target set, and enhance destruction capability. A directed energy component, such as high power microwaves, ultra wide band signals, X-rays, or masers can attack sensitive electronics and may have longer lethal ranges than blast waves and fragments. Electrically driven reactive and thermobaric materials can enhance conventional munitions by adding a component that can provide new sensor blinding and power system disruption mechanisms to enhance lethal damage of targets. Some of these capabilities may require detonator arrays. The technical objective of this effort is to develop the requisite survivable power conditioning for compact explosive pulsed power devices that will enable it to drive a variety of inductive, capacitive, and/or resistive loads. Based on decades of R&D, the best candidates for these power supplies are Helical Magnetocumulative Generators (HMCGs), Ferroelectric Generators (FEGs), and Ferromagnetic Generators (FMGs). However, recent research has established that efficient operation of these generators require proper impedance matching between them and the loads they drive. Since the focus is on miniaturizing these pulsed power generators to diameters as small as 1 inch (25 mm), their power conditioning must meet the same stringent requirements. Therefore, the focus of this effort is to develop power conditioning technologies (e.g., transformers, opening and closing switches, peaking inductors, transmission lines, vector inversion generators) that will produce current and energy gains from explosive driven pulsed power generators with diameters as small as 1 inch. In summary, the objective of this effort is to develop power conditioning technologies for explosive driven pulsed power devices (flux compression, ferroelectric, and/or ferromagnetic generators) to achieve impedance matching and pulse shaping for effectively driving various loads being considered as payloads for missiles and gun launched projectiles. A further objective is to address miniaturization and g-force hardening of these power conditioning units.

PHASE I: Identify potential technologies and analyze, design, and conduct proof-of-principle demonstrations 1) to verify that the proposed power conditioning devices are predictable and are consistent with predictions and 2) to assess their ability to drive various loads and meet the form factor size requirements. 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. It is not expected in Phase I that the prototype devices tested meet the goal of a 25 mm diameter.

PHASE II: Design, build, and test enhanced prototype power conditioning technologies for explosive pulsed power generators, verify their ability to drive various types of loads, and verify that they can meet the size requirements of a platform with a diameter as small as one inch. Other issues that should be addressed in Phase II are hardening the technology to survive high g-force launches and designing production processes for mass production.

PHASE III: The goal of this effort is to develop multi-functional munitions that could be transitioned to one of the Prime contractors that produce munitions for the Army. Those Firms selected for this effort will work with the Missile Program Element Office and the various supporting Army Research, Development, and Engineering Centers and their contractors to facilitate this transition. The explosive pulsed technologies developed under this effort could be applicable to multiple military and commercial applications requiring pulsed power. Commercial applications include water purification units at remote sites, nondestructive testing systems, portable lightning simulators, portable expendable X-ray sources, plasma chemistry, industrial chemical processing, and oil and mineral exploration. Military applications include multi-functional warheads, as well as multi-functional munitions of various calibers.

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2) A. Neuber, Explosively Driven Pulsed Power: Helical Magnetic Flux Compression Generators, Springer-Verlag, Berlin (2005).
3) P.W. Cooper, Explosive Engineering, Wiley-VCH,, Inc., New York (1996).
4) C.M. Fowler and L.L. Altgilbers, “Magnetic Flux Compression Generators: a Tutorial and Survey”, Journal of Electromagnetic Phenomena, 3(3(11)), pp. 305 – 357 (2003).

5) L. Altgilbers, “Recent Advances in Explosive Pulsed Power”, Journal of Electromagnetic Phenomena, 3(4(12)), pp. 497 – 520 (2003)

KEYWORDS: Munitions, Pulsed Power, Magnetocumulative Generators, Magnetic Flux Generators, Power Conditioning, Ferroelectric Generators, Ferromagnetic Generators, Transformers, Switches, Peaking Inductors and Capacitors

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A07-189 TITLE: Characterization of Cloud and Storm Ice/Hail/Graupel Concentrations and Its Impact on High Speed Missile System Performance

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 topic is to characterize the cloud and storm environment above the water freezing line. This topic will lead to a full understanding of how this environment impacts high speed missile systems leading to new design approaches and methods. Areas of research include: innovative ground testing methods, analytical damage modeling, global environment characterization, and analytics addressing vehicle flowfield coupling and particle shattering.

DESCRIPTION: Recently there has been a revived effort to investigate the impact of weather on high-speed vehicle performance and durability. These efforts focus on both ascent and descent missile trajectories through cloud formations and storms, sand, dust, and rain erosion on helicopter blades, aircraft components, and IR windows and dome performance during both flight and captive carry. In response to this need, a comprehensive roadmap as been developed by the Army in conjunction with other government organizations to address all relevant areas of research that are needed in order to advance the current state of the art in understanding of weather impact. One such area is in the realm of high-speed impacts of non-liquid hydrometeors. Little research has been devoted to this important area of weather encounter in the last 30 years, and our current methodologies require updates and enhancements.

This solicitation covers several areas of interest. There is a need for correlated ground testing that can properly simulate flight-like impacts with a variety of non-liquid hydrometeors. Included in this would be the procedures for creation and acceleration of these particles to supersonic velocities. Development is also desired for both storm and cloud concentrations of each type of non-liquid hydrometeor, including the probability of occurrence on a global scale. Finally, analytical modeling must accompany any testing approach. Modeling enhancements might include the influence of the vehicle aerodynamic flow on the particles leading to trajectory modifications or particle shattering. Impact modeling of these events is also needed for ceramic, ablative, and composite materials

PHASE I: The focus of the Phase I effort is to develop and demonstrate methods, procedures, and test facility upgrades to support any of the listed aspects of non-liquid hydrometeor impacts at supersonic speeds. The Phase I program will need to clearly demonstrate the feasibility and applicability of the proposed method to real-world environments. The Phase I program should also highlight the probable performance, cost, set-up, calibration time, and usage requirements of the expected Phase II system.

PHASE II: The Phase II program will develop and demonstrate the device/approach proposed in the Phase I effort. Deliverables under this Phase would be the analytical or test standard and methodologies developed.

PHASE III: The Phase III use for this topic exists in enabling Government, major aviation/missile system integrators, and subsystem component developers to produce superior aviation and missile flight systems with sufficient design margin to make advanced systems “all-weather” capable. These advancements would include improved radome and communication antenna designs, cost effective testing methods to assure system compliance to weather requirements, and validated analytical methods to predict flight material response in adverse weather environments. Such research would support the Kinetic Energy Interceptor, THAAD, PAC-3, GLMRS, Army Avaitionand other similar systems.

REFERENCES: 1) Reinecke, W., Waldman, G., McKay, W., and Ziering, M., “Shock Layer Shattering of Water Drops and Ice Crystals in Reentry Flight.” Air Force Materials Laboratory, AFML-TR-75-71, Wright-Patterson AFB, Ohio, June 1975.
2) Nakaya, U., “The Formation of Ice Crystals”, Compendium fo Meteorology (T.F. Malone, ed.), American Meteorological Society, Boston, MA, 1951.
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4) Callens, E,, Jr., Ball, H., and Miller, J., “Results of a Snow Erosion Test Program in the Hyperballistic Range” (U), AEDC-TR-74-43, Arnold AFS, Tenn., May 1974.
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KEYWORDS: Clouds, Hail, Graupel, Snow, Ice, Hydrometeors, High Speed Impact Modeling, Cloud Formation, Test Methodologies

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A07-190 TITLE: Reduced Eye Hazard Wavelength High Energy Laser Technology

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: To research and develop innovative reduced eye hazard wavelength, high energy laser architectures and technologies that are scalable to power levels of greater than 10kW while reducing the possibility of collateral eye damage due to laser scatter. Architectures and technologies could include fiber based lasers, ceramic slab based laser, thin disk lasers, etc.

DESCRIPTION: While it has been determined that high energy lasers can provide a tremendous benefit to the army for area protection against rockets, artillery, and mortars (RAM) and other potential threats, there is concern about current Nd:YAG based high energy laser systems potentially causing collateral eye damage due to scatter off of target surfaces. This SBIR topic focuses on develop of innovative technologies for high power lasers that operate at reduced eye hazard wavelengths thus reducing the potential for collateral eye damage due to scattering off of target surface while still have good atmospheric propagation and target lethality properties. Good atmospheric propagation and target lethality will provide constraints to allowable wavelengths and required beam quality. The proposed architectures and technologies should support propagation of the laser beam for several kilometers while have a reasonable spots size and support coupling the laser energy into military relevant targets. As the mission sets expand for high power laser devices the risk will increase for the potential of collateral eye damage. Early investment in technology that supports efficient, compact, reduced eye hazard wavelength, high power laser research is critical. The purpose of this SBIR is to investigate through laboratory experiments and modeling and simulation and building a scalable prototype in phase III, the potential of high power, reduced eye hazard, lasers to exceed 10kW of average power. The proposal should address such items as potential scalability to 100kW class devices, output laser beam quality, run times, efficiencies, and packaging flexibility to include either volume and weight benefits or constraints.

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

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

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

REFERENCES: 1) W. Koechner, "Solid-State Laser Engineering," Springer-Verlag
2) Annual Directed Energy Symposium Proceedings available at: http://www.deps.org/DEPSpages/forms/merchandise.html
3) D. Garbuzov and M. Dubinskii, “110 W Pulsed Power From Resonantly Diode-Pumped 1.6um Er:YAG Laser”, Applied Phycs Letters, 19 September 2005.
4) Raichlin, E. Shulzinger, A. Millo and A. Katzir, "Fiberoptic Evanescent Wave Spectroscopy (FEWS) System and Its Application in Science, Industry, Medicine and Environmental Protection," 5th International Conference on Mid-Infrared Optoelectronic Materials and Devices, September 8-11, 2002.
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KEYWORDS: Reduce Eye Hazard Laser Wavelength, High Energy Laser, Solid State Laser

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A07-191 TITLE: Photonic Crystal Development for High Power Lasers

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PEO Missiles and Space

OBJECTIVE: To research and develop photonic crystals for high power, high efficiency solid state lasers to continue to advance the state-of-the-art in 10+kW class Solid State Laser (SSL) systems. The objective of this SBIR is to leverage recent advancements in photonic crystal and photonic wave guides and to develop and mature technologies that can support scaling to 100kW class laser systems.

DESCRIPTION: As high energy 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 10+kW to 100kW class solid state laser systems. This SBIR is to focus on enhancing the recent advancements in photonic crystals and wave guide amplifiers for high power laser systems. This includes both system level and component technology. Photonic crystals and wave guide amplifiers have the potential to reduce the thermal management challenges associated with current solid state, slab based, high energy lasers. In, addition there is a great potential to be more efficient thus reducing the input power requirements. High energy lasers are required for a number of military applications including area self protection against rockets, artillery and mortars. This topic seeks proposals for the demonstration of innovative rod-like photonic crystal concepts which would enable and increase performance of high-brightness, high-power operation of a solid state laser. It is envisioned that technologies investigated and developed under this SBIR topic could be inserted into the Joint High Power Solid State Laser (J-HPSSL) program or follow-on efforts to develop a high power, high efficient solid state laser demonstrator. The proposal should address such items as scalability to 100kW class devices, output laser beam quality, run times, efficiencies, and packaging flexibility to include either volume and weight benefits or constraints.

PHASE I: Conduct research, analysis, studies and develop measures of performance enhancement with respect to conventional slab or fiber based solid state lasers and document results in a final report. Run models to predict performance at different power levels and identify the key technical challenges. The phase I effort should include modeling and simulation results supporting performance claims. The effort may also produce a preliminary concept and a draft testing methodology to demonstrate the enhancement during the phase II effort.

PHASE II: During Phase II, a scalable, testable, breadboard will be designed and key components will be built and tested based on the phase I preliminary concept 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: There are many potential applications of a photonic crystal based 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 laser DoD 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 an integrated scalable photonic crystal based breadboard high energy laser device based on the phase II design with a near diffraction limited beam quality and high efficiency will be the goal in a phase III effort. This phase III breadboard would demonstrate the ability to remotely destroy targets for the CRAM mission. Military funding for this phase III effort would be executed by the US Army Space and Missile Defense Technical Center as part of its Directed Energy research.

REFERENCES: 1) W. Koechner, "Solid-State Laser Engineering fifth revised and updated edition" Springer-Verlag, 1999
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KEYWORDS: Solid State Laser (SSL), Photonic waveguide amplifier, Diffraction-limited laser, photonic crystal fiber, rod-like fiber

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A07-192 TITLE: Embedded Virtual Driver Training Technologies

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Develop and demonstrate a prototype visual imaging solution for low-cost, virtual, fully embedded vehicle driver training focused on current force combat vehicle vision blocks and night driving sensors.

DESCRIPTION: A key Army training objective is to incorporate Embedded Training (ET) capabilities (with minimal training unique hardware) into existing combat vehicles. ET is in the requirements documents of current force fighting vehicles such as Abrams, Bradley and Stryker. The initial training focus has been sustainment gunnery training and mission rehearsal. The merits of an ET system are apparent when examining combat data from the Iraq war, where degradation of target engagement capability is noticeable, due to inconsistency in crew composition compounded by the use of combat vehicles drawn from an available pool of vehicles, each with their own idiosyncrasies. Additionally, the opposing forces' ever changing tactics results in the need to conduct mission rehearsal on the fly.

ET demonstrations on current force systems where computer generated imagery is displayed on the vehicle's thermal sights have shown this capability to be adequate for commander and gunner sustainment gunnery training. However, these demonstrations have not addressed the driver's involvement nor enabled the full crew to perform mission rehearsal. The driver's exclusion is due to the difficulty in providing the driver a virtual environment given his dependency on the use of direct view optics such as periscopes, vision blocks, and electronic driver visualization enhancers (DVE). The same issue arises in the commander's use of vision blocks during mission rehearsal.

Recent developments in University and commercial research laboratories have resulted in breakthrough technologies that have potential for addressing this dilemma. Further research must be conducted to determine how to incorporate these technologies into direct view optics that support ET while meeting combat vehicle performance, and environmental, reliability, and maintainability specifications. Component miniaturization and manufacturing methods must be addressed, and a large decrease in component cost must occur. Many of these components have dual use possibilities in automotive, medical and other industries, which is disused in more detail below.

The proposed research has two objectives. First, examine these breakthrough technologies, select those that have most promise, support their continued development, and explore methods for integrating them into an optical system that will support driver visualization of a virtual battlefield. Second, determine a method for combining this capability with night vision technology, thus providing the driver with a single optical device that supports day and night combat operations and ET requirements.

PHASE I: Study current force combat systems driver stations. Identify possible solutions and associated tradeoffs to provide ET to the driver station. Select one combat system and design system concept for driver ET. Demonstrate feasibility of the system concept.
PHASE II: Design and implement prototype Driver ET system for a current force vehicle. Conduct evaluation of the system in a virtual exercise. Evaluate effectiveness of ET systems based on use by SME drivers and systems cost, size, weight and safety metrics.

PHASE III: The products of this research could be used in a broad range of military and civilian applications. Program Managers (PM) for both the Heavy Brigade Combat Team (PM HBCT) (Abrams and Bradley) and Stryker

Brigade Combat Team (PM SBCT) have expressed great interest in utilizing products from this research as part of their required ET solutions since current solutions do not exist. ET is an important part of future vehicle upgrades for these current force systems and this research supports their needs and is a clear transition path for the Phase III products. This research will also directly transition to current DOD S&T programs involving Embedded Training, specifically the Scalable Embedded Training and Mission Rehearsal (SET-MR) Army Technology Objective (ATO). The SET-MR ATO is already working with HBCT and SBCT to address ET technology shortfalls and is a natural transition path and likely funding source. Projection components developed by this SBIR research has great potential to revolutionize the way information is provided to personnel who require an unobstructed view of the external environment simultaneous with the display of critical information. The research could be a precursor to the development of commercial applications such as: automotive situational awareness information from sensors placed on the rear and side of vehicles; data displayed on the windshield to assist in collision prevention, and critical medical information from x-rays and MRI's displayed on physicians' visors while performing operations. In conclusion the military and commercial possibilities for this research are enormous.

REFERENCES: U.S. Army Field Manual FM 21-305: Manual for the Wheeled Vehicle Driver
https://atiam.train.army.mil/soldierPortal/atia/adlsc/view/public/10920-1/fm/21-305/toc.htm

U.S. Army Training Circular TC 21-305-2 Training Program for Night Vision Goggle Driving Operations
https://atiam.train.army.mil/soldierPortal/atia/adlsc/view/public/6484-1/tc/21-305-2/toc.htm

Army Regulation 600-55: The Army Driver and Operator Standardization Program (Selection, Training, Testing, and Licensing)
http://www.armedforces.net/Detailed/19195.html

Main Battle Tank - M1,M1A1, and M1A2 Abrams
http://www.fprado.com/armorsite/abrams.htm

KEYWORDS: Embedded Training, Driver Training, Simulation

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A07-193 TITLE: Battlespace Target Presentation in the Live Training Environment

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: PEO Simulation, Training, and Instrumentation

OBJECTIVE: Demonstrate to Army leadership a targetry system prototype that is capable of realistic presentation of threat behavior in known and anticipated situations and conditions found in the Contemporary Operational Environment (COE).

DESCRIPTION: Target presentation is the ability to present (expose) target(s) in the following manner: coming into and out of the training units field of view; moving, or appearing to move, across the training unit's field of view; moving, or appearing to move, toward the training unit; moving, or appearing to move, away from the training unit; taking evasive action (i.e., bob, weave, take cover).

Current Technical Problem/Challenge:

Current army targetry and associated systems are limited in their ability to act and react in a manner that is very similar to how the actual threats have presented themselves in combat; particularly within unconventional and asymmetrical environments. For example, threats in the current “War on Terror” tend to mix freely with other entities within the battlespace (e.g. hostile and friendly personnel, vehicles, buildings such as churches, mosques and other infrastructure, etc.). Target entities can travel alone, within groups or convoys, start and stop often, use terrain and man made structures to block detection, etc. In other words, in the Contemporary Operational Environment (COE), real threats do not present themselves in the exact same manner in terms of location, direction of movement, posture, etc; neither should training targetry.

Additionally, whether training for deployment or within the theater, the soldier should train against threats that are as realistic as possible, requiring that he use all senses (visual, auditory, olfactory, and tactile, etc.) to gather information and analyze the threat. The soldier must not only identify the immediate threat, but understand the immediate battlespace conditions in which the threat is operating, as well. He must determine whether the identified threat should be engaged or passed off to other weapon system assets or units. Also, if engaged how can the threat be expected to react?

Innovative Solution(s) Sought:

The Army is seeking innovative solutions for "adaptable and smarter" ground targets that exhibit some or all of the following basic capabilities:

* Scale a target's presentation to align with appropriate training objectives and skill levels, e.g. basic marksmanship, sniper, counter sniper, shooting on the move, patrols, ambushes, etc.

* Alter a target's threat profile based on trainee actions and/or reactions, e.g. targets that take evasive actions, shoot-back, surrender, etc.

* Provide for limited target mobility, e.g. stand/kneel/prone-type positions, move forward/backward/sideways, etc.

PHASE I: Provide a feasibility study and system design concept that:

* Generally addresses the integration of current and emerging technologies into existing and planned army targetry systems, for the purpose of providing more realistic battlespace target presentation in the live training environment.

* Specifically addresses the "Innovative Solution(s) Sought" outlined in the "Description" section of this SBIR.

PHASE II: Develop, test and demonstrate to Army leadership a targetry system prototype that exhibits some or all of the "Innovative Solution(s) Sought" outlined in the "Description" section of this SBIR.

PHASE III: Near term projected use of this proposed research will most likely be to the benefit of the Future Army System of Integrated Targets (FASIT) program. Formerly known as the New Generation Army Targetry System (NGATS), the FASIT program has received good industry response to the FASIT Presentation Device ICD and the first baseline of the FASIT Performance Specification. This proposed research will attempt to parallel and as much as possible, track with the PM’s ongoing efforts to design, develop and deliver an Army’s standard targetry system that supports the full scope of live training. As such, opportunities for technology transition will heavily influence the efforts under this research topic.

Mid- to long-term projected use of this proposed research include, targetry requirements for other DoD agencies, federal, state and local law enforcement training managers, private marksmanship training; Allied/Foreign Military Sales (FMS). This technology may also have application in other industries as diverse as, entertainment & theme park systems; paint ball, etc.

REFERENCES: 1) US Army Training Circular (TC) No. 25-8, Training Ranges
https://atiam.train.army.mil/soldierPortal/atia/adlsc/view/public/6851-1/TC/25-8/TOC.HTM
2) US Army Training Circular (TC) No. 25-8-1, Army Special Operations Forces Training Ranges, September 2004
3) US Army Field Manual (FM) 3-06.11, Combined Arms Operations in Urban Terrain

http://www.globalsecurity.org/military/library/policy/army/fm/3-06-11/index.html
4) US Army Field Manual (FM) 3-22.9, Rifle Marksmanship M16A1, M16A2/3, M16A4 and M4 Carbine
http://www.globalsecurity.org/military/library/policy/army/fm/3-22-9/index.html

KEYWORDS: targets, target presentation, target realism, target behaviors, smart targets, targetry, target control, training targets, training ranges, Combat Identification (CID), Real Time Casualty Assessment (RTCA), Contemporary Operating Environment (COE), New Generation Army Targetry System (NGATS), Future Army System of Integrated Targets (FASIT).

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A07-194 TITLE: Modeling Human Interfaces and Behaviors in Dismounted Soldier Training Environments

TECHNOLOGY AREAS: Human Systems

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

OBJECTIVE: Design intelligent human interfaces such as voice recognition, hand signaling/gesturing and other multi-modalities for the command and control of computer generated forces

DESCRIPTION: Past Research in synthetic environments has been primarily focused on quality improvements the 3D graphical presentation and modeling of physical aspects of the geographical environment to make it more sophisticated and life-like. Little Research has gone into the realistic representation of human interfaces and behaviors into these environments. This research will specifically look at the dismounted soldier simulation environment and aim to make significant advances for the command and control of computer generated forces such as Blue Force and unmanned platforms. These advances will use intelligent human interfaces, particularly voice recognition and other multi-modalities such as hand signaling/gesturing.

PHASE I: Conduct innovative research on ability to virtually control subordinate SAF entities (using alternate multi-modalities) to replicate small unit control procedures used during virtual collective training. Provide feasibility study/analysis that addresses the realistic representation of SAF entities in a virtual training system/environment. Implement prototype demonstration in relevant environment that includes some infantry squad behaviors using alternative multi-modalities.

PHASE II: Develop and demonstrate the capability in a realistic dismounted virtual training environment. Conduct testing to validate small team tactics/ procedures. Evaluate prototype capability with more traditional current methods.

PHASE III: This system could be used in a broad range of military and civilian security applications where computer generated forces augment training applications – for example, SWAT team training could employ methods involving verbal and non-verbal communications for small unit/team training. Phase III objectives include transition to acquisition program(s) such as S-CATT or similar PEO STRI program where advanced human interface capabilities are required. Other potential commercial applications include advanced human interface technology insertion into a variety of current and future gaming platforms/engines such as Half-life, Unreal Tournament, etc.

REFERENCES: 1) B. Knerr, P. Garrity, D. Lampton, "Embedded Training for Future Force Warriors: An Assessment of Wearable Virtual Simulators," Army Science Conference 2004.
2) D. Perzanowski, A. Schultz, E. Marsh " Towards seamless Integration in a Multi-Modal Interface," Navy Center for Applied research in AI, NRL
3) M. Singer, S. Grant, "Team performance in Distributed Virtual Environments," US Army Research Institute, August 2001

KEYWORDS: Computer generated forces, multi-modality, synthetic virtual environments.

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A07-195 TITLE: High Fidelity Visual Representation of Crowds

TECHNOLOGY AREAS: Human Systems

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

OBJECTIVE: Research the technology to model and visually represent large, culturally accurate dynamic crowds (over 100) of avatars in a distributed virtual environment.

DESCRIPTION: For many years, the Department of Defense has made a significant investment in virtual simulations as well as in crowd modeling. Soldiers are entering combat in urban areas that are heavily populated with civilians, coalition forces, and enemy combatants. There is a clear gap in virtual simulations with regards to modeling and representing large dynamic crowds of individuals in a small cluttered urban environment. Avatars need to be represented visually, audibly, and behaviorally, such that users can interact with from one to hundreds of avatars. The visual representation needs to support individual cultural behaviors and gestures, movements, and actions (i.e. firing a weapon) in a dense urban environment. The audible representation should include both background noise and person-to-person communication.

PHASE I: Conduct research on available game-based platforms and crowd modeling architectures. Design interfaces to integrate a game-based simulation environment with a crowd modeling architecture that can populate the environment with hundreds of entities. Investigate and design an algorithm to visually and behaviorally represent large numbers of entities within the simulation environment.

PHASE II: Implement and demonstrate an integrated game-based virtual simulation environment with a crowd modeling architecture. Conduct testing and user evaluations to evaluate capabilities and implementation.

PHASE III: This system could be used in a broad range of military and civilian applications where games or virtual simulations are used. Examples include military training, homeland security/defense applications, coalition training and commercial game applications. This research will directly transition to current DOD S&T programs involving Embedded Training, Coalition Mission Training and other game-based environments that lack high fidelity crowds. The results of this research will also be directly applicable to many commercial game applications that are available and being used by the general public.

REFERENCES: 1) Mayo, M., Singer, M. J., & Kusumoto, L. (December, 2005). Massively Multi-Player (MMP) Environments for Asymmetric Warfare. Proceedings of the 27th Interservice/Industry Training Systems and Education Conference. Arlington, VA: National Training Systems Association.

2) Stahl, J., Long, R., Grose, C. (June, 2006). The Application and Results of Using MMOG Technology for Force Protection / Anti-terrorism Training. Euro SIW 2006.
3) Q. H. Nguyen, F. D. McKenzie, and M. D. Petty, “Crowd Behavior Architecture Model Cognitive Design,” Proceedings of the 2005 Conference on Behavior Representation inModeling and Simulation (BRIMS), Universal City CA, May 16-19 2005, pp. 55-64.

KEYWORDS: game-based simulations, crowd-modeling, virtual avatar, visual representation

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A07-196 TITLE: Situational Awareness and localization through Road Signage Recognition for unmanned systems

TECHNOLOGY AREAS: Electronics

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: Provide increased Situational Awareness (SA) to the Warfighter through automated road signage recognition and classification, particularly in GPS-suppressed areas.

DESCRIPTION: Though current GPS technology is sufficient for providing updated map and location information for the Warfighter, the use of this technology becomes severely degraded under canopy or heavy urban scenarios. With future aims at the reduction of crew sizes and use of more “intelligent” computer aids to support ancillary tasks, it could be possible to increase the Warfighter’s situational awareness in such GPS-suppressed areas through use of automated tools to recognize and classify standard and native/regional road signage. Such technology could also be used during peacetime missions to enhance safety and awareness of the vehicle driver. Another possible use of this technology is on unmanned ground vehicles, supporting both autonomous mobility and soldier-assisted teleoperation, for safe operation of the vehicle.

PHASE I: Conduct research on overall systems architecture for achieving the task of road signage recognition and classification using existing techniques, such as pattern recognition methodologies used in image processing and optical character recognition (OCR). Due to the complex nature of processing in real-time, the initial efforts of this project could focus on static controlled environments. Another goal of the Phase I effort would be to research and suggest novel techniques which could be used to achieve this goal. The final goal of the Phase I effort would be to research an architecture combining both existing and novel techniques that could potentially feed a future Phase II effort in a prototype implementation.

PHASE II: Using the research conducted under Phase I, the Phase II effort would focus on a reference implementation of the system and demonstrating initial capability in static controlled environments. Upon successful recognition and classification of basic road signage, the project could increase the complexity of the recognition tasks by varying viewing angles, readability, clarity, etc. of the signs. Further advancement of the system would incorporate the technology onto a moving manned or unmanned platform and enhance the technology to be used while in motion.

PHASE III: Commercial applications for dual-use of this technology are imminent in the automotive engineering sector, particularly in the development of navigational aids and driver enhancements for the OEM and after-market industry. The natural progression of this technology from the research labs in Phase I and II of the SBIR activity is to demonstrate localization and increase in situational awareness thru road signage recognition, particularly in GPS suppressed areas - the civilian application of this technology could directly be transitioned to the automotive industry (a) for use in driver decision aid and warning systems, and into military systems (b) to increase survivability of convoy vehicles in deployment. The predicted path to transition of this technology would be in conjunction with PM support, which would see the military application of the technologies developed under this SBIR. Similarly, there should also be a push on the civilian side of this technology to gain support from leaders in the automotive industry to incorporate technologies for future vehicles. The end-state of this SBIR research is genuinely dual-use, commercially viable, and militarily relevant technology that benefits both the soldier as the end-user and the wider civilian community.

REFERENCES: Research Activities
1) Carnegie Mellon University, Interactive Systems Laboratory
J Yang et al. An Automatic Sign Recognition and Translation System
http://www.is.cs.cmu.edu/papers/multimodal/PUI01/PUI2001_jieyang.pdf
2) University of Massachusetts at Amherst, Computer Vision Laboratory
Marwan Mattar et al. Sign Classification using Local and Meta-Features
http://www.cs.umass.edu/~elm/papers/cvavi05.pdf
3) Road Sign Detection and Recognition
Michael Shneier, National Institute of Standards and Technology
http://www.isd.mel.nist.gov/documents/shneier/Road_Sign_Detection.pdf
4) University Koblenz Landau, Germany
Realtime Traffic Sign Recognition (TSR)
http://www.uni-koblenz.de/~lb/lb_research/research.tsr.html
5) Application of Perception Behavioural Model to the Recognition of Traffic signs in a Cluttered Scene
Dr. Natalia Shevtsova at KRINC of Rostov State University in Russia
http://www.cs.mdx.ac.uk/staffpages/xiaohong/signs.html
6) University of California at Santa Barbara
F Regalado, The Driver Assistance System: sign recognition system
http://www.uweb.ucsb.edu/~franciscomregalado/tech.doc

Commercial Products

1) Seimens VDO/Automotive - speed limit recognition, driver aid
http://www.siemensvdo.com/topics/adas/traffic-sign-recognition/
2) DaimlerChrysler
Driver’s Assistant with an Eye for the Essentials
http://www.daimlerchrysler.com/dccom/0,,0-5-7165-1-464575-1-0-0-464031-0-0-135-7165-0-0-0-0-0-0-0,00.html

Publication References

1) J. Miura et al. An Active Vision System for On-line Traffic Sign Recognition. IEICE Trans. on Information and Systems, Vol. E85-D, No. 11, pp. 1784-1792, 2002.
2) G. Piccioli et al. Robust method for road sign detection and recognition. Image and Vision Computing, Vol. 14, pp. 209–223, 1996.
3) L. Priese et al. Traffic sign recognition based on color image evaluation. In Proceedings of the 1993 IEEE Symp. on Intelligent Vehicles, pp. 95–100, 1993.
4) X.W. Gao et al. Vision Models-based Identification of Traffic Signs. CGIV '2002, First European Conference on Color in Graphics, Image and Vision, April 2-5, Poitiers, France, 2002.
5) X.W. Gao et al. Road Sign Recognition by Means of the Behavioral Model of Vision, Third All-Russian Conference on Neuroinformatics, Moscow, Russia, January 23-25, 2002.

KEYWORDS: traffic, law obeyance, situational awareness, global positioning satellite, GPS, image processing, optical character recognition, OCR

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A07-197 TITLE: Modeling, Simulation, and Design Optimization of Nanocomposites for Applications in Army

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: The main objective of this SBIR topic is to develop a comprehensive modeling, simulation and design optimization tool in order to predict with acceptable fidelity, potential performance improvements which may be obtained with the use of nano-composites. There is a need to devise cost effective approach by using low cost nano-materials and processes in order to address the affordability question to the Army ground vehicle applications.

DESCRIPTION: Functional requirements for the materials and structures used in the Army ground vehicles include: mechanical strength, hardness, durability (fatigue), ballistic and blast impact resistance, heat conductivity, electrical / electronic conductivity, flame retardancy. These requirements become more and more difficult to achieve with conventional materials, partially due to increasing threat levels and lightweight requirements. The recent advances in nano-materials, makes it possible to design and build materials with special properties with ground up. The multi-functional nano-composites can be achieved through optimally distributing and combining low cost nano-materials to further extend the concept developed in the functionally gradient materials.
The behavior of nano-engineered composite materials can be considered as having multi-scale phenomena. At nano-scale, the material behavior is controlled by quantum mechanics theory and molecular dynamics. At macro-scale, the overall material performance reflects averaged behaviors of nano-materials. The work required to be performed in this program includes development of multi-scale modeling, simulation and advanced homogenization and topology methods. The end product will be the application of the analysis tools developed here for a prototype of a nano-composite structures for the Future Combat Systems (FCS) and the fuel cells for engines.

PHASE I: Develop basic analytical tools for describing multifunctional nano-composites, and demonstrate the concept of multi-functional nano-composites on a few simple nano-composite structures using the derived tools. Include critical and representative impact and mechanical material properties within this feasibility analysis effort

PHASE II: Develop comprehensive analytical models for multi-functional nano-composites for various properties such as ballistic and blast impact, mechanical strength, durability, electrical,heat conductivity, barrier, and flame retardancy. Apply these models to a prototype system of Army's ground vehicles such as FCS. The validation of the analytical models can be through simulation or experimental methods. This SBIR research will transition to develop high performance operational capability in the ground vehicles particularly for the armor, structural health monitoring through sensing of the strain, and defects inside the structural armor during the service life of the vehicles and improve stealth properties through thermal management of the vehicles.

PHASE III: These analytical models could be used in a broad range of military and civilian applications where enhanced structural and mechanical performance is required. This includes FCS type of vehicles, fuel cells for engines. The customers for the successful SBIR program includes the DOD organizations, the Army, Air Force & Navy. The most likely path and the customer for the transition of SBIR Program to operational capabilities will be the Army's Future (FCS) program. The FCS program should fund this program to realize the operational capabilities that will be developed in Phase II program. The important concepts for transitioning are the nano-technology's capability for sensing, thermal property and impact property enhancement in materials, particularly composites. The commercial applications for nano materials include a large number of automotive applications [parts] to improve the strength, stiffness, weight reduction, surface finish [more recyclable], flame retardancy, resistance to high temperature and corrosion. Fuel lines made of nanocomposites will be conductive, have good barrier properties, high tensile elongation, chemically resistant. Another important application is electrodes in fuel cell in engine applications. Use of nano-materials in automotive tires reduce weight, wear resistant, low road noise, improve air pressure retention, increased tire life and reduced fuel consumption. Nano lube has applications in automotive transmission, gear box and bearings to reduce friction,wear and temperature while at the same time diminishing galling, seizing and fretting of metal surfaces.

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2) Meyappan, M, 2002 An overview of recent developments in nanotechnology, http://www.ipt,arc.nasa.gov/Graphic/arl_talk.ppt
3) Srivasta D., M. Menon and K Cho," Computational Nanotechnology with Carbon Nano-tubes and Fullerenes," Computing in Science and Engineering, Vol 3 (4): 42-55.
4) H. Fukushima and L. T. Drzal, " Enhancement of the mechanical, electrical and thermal properties of Nylon Nanocomposites via the addition of Exfoliated Graphite nanoplatelets (XGnP), Proceedings of the 12th US-Japan Conference on Composite Materials, September 21-22, 2006 pp. 793-806.

KEYWORDS: , heat conductivity, blast impact, ballistic impact, electrical conductivity, barrier properties, flame retardancy

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A07-198 TITLE: Reconfigurable Structures for Future Force/Future Combat System (FF/FCS) and Joint Force Bridging Applications

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Design, fabricate, and evaluate a C-130 transportable, mission required reconfigurable bridging concept, to deliver optimal load carrying performance for vastly different missions with competing requirements.

DESCRIPTION: New war-fighter requirements (2005) seek a single solution to meet all of the U.S. Army bridging needs including assault, tactical, and logistical operations. Currently, no single bridge solution is available and various, mission-dependent bridging systems are used to span wet and/or dry gaps of different spans and vehicle load ratings. A commercial bridge, the Alvis BR90, has multi-role capability and can be used for assault and tactical wet/dry gaps. However, it requires a large transport vehicle(s), construction is not automated, it is not C-130 transportable, and cannot be upgraded on the fly to meet evolving mission requirements. Also, the BR90's 8m long bridge sections are inefficient because they are designed solely for a worst load case.

Existing bridges are of a fixed configuration, designed for a single vehicle load at maximum span, and require external reinforcement to upgrade capacity. Vehicles above the design load are unable to cross. Research is needed to identify ways of altering bridge capability to expeditiously meet mission requirements. Among the areas to be researched include innovative structural components with the ability to function as building blocks to easily alter the performance of a structure as well as be reconfigurable for easy storage and transport; application of advanced materials to take advantage of their high strength to weight ratios; and automated launch mechanism(s) to meet the constraints of the future Army. Major performance parameters include supporting loads from 10 to 110 tons across spans from 1.5 to 50m with deployment times ranging from 3 minutes for 1.5m gaps to 5 minutes for 20m gaps.

Automated bridge launch and retrieval mechanisms need to be brainstormed and created that launch or retrieve a bridge rapidly without the need for a heavy counterbalance. Traditional bridge solutions rely heavily upon the transport vehicle to counterbalance a bridge during these operations. However, future vehicles will be much lighter than they are today. Results from this part of the effort will be new bridge building methods that are not limited by the span of a gap and reduce or eliminate the need for manpower.

The Army must have the ability to transport bridging assets to locations around the world quickly. The C-130 air transport is the method of choice with a payload limit of 36000 lbs within a 480 x 105 x 102 inch space. Current assets often require extensive disassembly to fit these constraints and must be dismounted from their transport vehicle. This research will include kinematic and finite element analysis of structural components and overall bridge geometry to provide a concept that can meet the severe and rigid transport requirements of the future Army. Operation techniques can also drive the types of critical joints required such as hinges for folding, slip joints for horizontal operations, and other procedures.

Any new component and bridging concept must include research into the most optimized methods of launch and retrieval to take advantage of the materials, concepts, and supporting equipment.

PHASE I: Provide an overall system concept design that includes the specification of bridge materials, geometry, connections, load carrying capacity, and launcher.

PHASE II: Fabricate a prototype concept that shall be tested to demonstrate performance characteristics against multiple mission requirements

PHASE III: The Army is currently faced with supporting multiple, incompatible bridging systems that do not readily lend themselves to air transport or multi-role missions due to their weight, size, and manpower requirements. Bridging technologies developed in this effort will relieve the Army of the logistical burden of supporting multiple systems, while having the flexibility to meet all mission requirements. They will also lead to reductions in maintenance and supportability costs, manpower requirements, and risk to the soldier. Firms selected for this effort will work with the Training and Doctrine Command (TRADOC), the Maneuver and Support Center (MANSCEN), and the Force Projection Project Management Office (PM-FP) through TARDEC Bridging to produce a solution to the Army's multi-role bridging capability gap. Critical user input throughout the effort concluding with a successful demonstration in an operational environment will facilitate moving this technology onto the battlefield.

This system could be used in a broad range of military and civilian mobility and maneuverability applications, where gap and obstacle crossing may be necessary. For example, building bridges to improve public infrastructure, reconstruction efforts, or assist in the movement and delivery of disaster relief supplies.

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2) STANAG 2021 – MILITARY LOAD CLASSIFICATION OF BRIDGES, FERRIES, RAFTS, AND VEHICLES
3) MIL-STD-1791, DESIGNING FOR INTERNAL AERIAL DELIVERY IN FIXED WING AIRCRAFT
4) Alvis BR90 Bridge, http://www.themanufacturer.com/uk/detail.html?contents_id=3443

KEYWORDS: Bridge, Construction, Structures, Civil Engineering, Mechanical Engineering, Automation, Kinematics, Robotics, Mechanisms

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A07-199 TITLE: Advanced Electromechanical Track Tensioner

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: This SBIR shall research track tension and its effects on fuel consumption, track retention and running gear life. The effort will develop and test a track tensioner for vehicle testing.

DESCRIPTION: The electromechanical track tensioner utilizes an electric motor or other electrical energy to motion transducer, to vary the position of a tracklaying vehicle's idler wheel to maintain constant track tension while operating on uneven terrain. The track tensioner moves the idler wheel in accordance with a control algorithm, such as constant track path length or constant force. Sensors measure road wheel positions, idler position, and force with which the track is pushing on the idler, to provide feedback to the control system which in turn, generates commands to the actuator in accordance with the control algorithm. An important design criteria is that this device must hold the idler in position, or move the idler in either direction, against substantial back forces caused by track tension. Because of problems that arise with high pressure hydraulic systems, the actuator must not utilize hydraulic systems to provide the required force and motion. Essentially, the advanced electromechanical track tensioner constitutes an interface between the control system and the idler wheel positioning mechanism. Present track tension adjusters on the other hand do not provide the continuous adjustment of idler wheel position needed to maintain track tension at a desired level.

PHASE I: The initial SBIR phase I will perform essential research to enhance our understanding of the track tension phenomena. Phase I will also explore the advanced issues that currently challenge this technology (i.e., constant force versus constant displacement debate). Phase I will also perform concept exploration work to develop components that will provide the attributes necessary for the future generation of track tensioners. Phase I deliverables will include reports detailing research work and results, computer models, conclusions, and concept development of actual hardware.

PHASE II: The SBIR will research and develop a novel prototype track tensioner and ancillary hardware, for testing on a M113. The objective is to improve fuel economy, track wear and retention.

PHASE III: The test results obtained in the Phase II will be provided to PM HBCT (Project Manager, Heavy Brigade Combat Team) for potential application of technology to upcoming M113 APC Upgrade effort. Another Phase III goal is to transfer of electromechanical track tensioner technology to the commercial sector. Research and development of the required electrical and mechanical components and the accompanying software and position/force sensors, will lead to commercial as well as military applications. Construction, agricultural, forestry, mining and other off-road, tracklaying vehicles all have track tension issues which affect life cycle cost. The advantages that electromechanical track tensioner technology offers in improved fuel consumption, increased track life and track retention, will lead to optimized life cycle costs in both military and commercial tracklaying vehicle applications.

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2) Crimson, Fred W., U.S. Military Tracked Vehicles, Motorbooks International, Osceola, Wisconsin, 1992
3) Tank Design and Development: General Information and Data, Detroit Arsenal, Center Line, Michigan, 1954

KEYWORDS: tracklaying vehicle, track tension, electromechanical, actuator, bushing, track tensioner, track tension adjuster

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A07-200 TITLE: Vehicle Based Exportable Power

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Belt driven alternator systems, replacing the stock alternators on both military and commercial vehicles, are becoming available that are capable of producing power levels far greater than the power required by the vehicle battery system. In order to utilize the output power of these alternators for electrification of a mobile power grid, the Army needs to develop a vehicle mounted controller that would enable smart vehicle hookup. This controller would convert the excess power and export it into a local power grid.

DESCRIPTION: Vehicle engine mounted, belt driven high power density alternators with output of 17kw at engine idle and 35kw at ‘high idle’, (1500 engine rpm) have been demonstrated on HMMWV and FMTV type vehicles. Feasibly, 50 kW could be generated at 2100 rpm, a generally acceptable speed for mid-sized diesel engines. The vehicle battery system itself generally requires 28vdc at less than 1kw. This excess power generation capability would be usable for many operations if controlled and properly exported. With safety as its first requisite, the ‘smart’ controller described would be small and light enough to be fitted to the body or chassis of the host vehicle and generally be transparent to the operator and primary function of the vehicle. The project will address the challenges associated with the ability to recognize and safely handle virtually any situation when it was connected into a local grid.

- Is the grid hot?
- Is the grid capable of receiving power? (Is there a prohibiting condition such as some of the line is underwater?)
- Is the voltage/frequency within range? (Did the operator connect into a high voltage grid by mistake?)
- Is the vehicle capable of providing the power required by the grid?

The ‘smart’ controller could have a number of functions, including:

1. Be in standby or off mode if not connected to a local grid or if connected to a ‘downed’ section of a local grid
2. Be able to be brought up to operating voltage and frequency by a qualified operator if connected to a ‘downed’ section of a local grid
3. Synchronize its output if connected to an operating grid
4. Remove itself from the grid when the host vehicle needed to be used for another mission
5. Regulate its vehicle engine speed to economize fuel while accommodating load changes and other vehicles coming on and off the local grid,
6. Other functions encountered as desirable or required while developing the project.

Examples of practical application: A small repair facility might function with one HMMWV providing 25 to 50kw. At full operation a field kitchen or small command post might require two vehicles to provide the required power with some reserve. A field hospital could have three or four vehicles with good reserve and one coming on or going off the local grid as new missions are engaged.

PHASE I: Design a concept for the desired, vehicle mounted "smart" controller and produce a breadboard proof of concept model to verify its capabilities.

PHASE II: Develop a working model controller based on the breadboard and perform component durability tests sufficient to prove the unit can survive in an Army vehicle environment. Produce two working prototype units for installation and demonstration testing on Army vehicles. Investigate and report on the commercial interest in vehicle-operated energy grids. In order to complete commercialization, produce 25-30 units from production representative sources and tooling. Perform full commercial validation testing, including reliability levels, using the production representative controllers produced.

PHASE III: The military can utilize vehicles equipped with exportable power sources to power local grids in the field. All locations will then have the capability to self power, with existing vehicles; reducing (or possibly eliminating) towed generators. This will allow for a reduction in logistics footprint by reducing the need to take electric generators into theater. Additionally, Army vehicles thus equipped may be then also used in emergency response mode to enable powering of local grids as well as Army only grids (on bases). When the commercialization of mobile power units which can be added to consumer vehicles becomes feasible (thus allowing utility companies to produce stand-by power by utilizing their commercial fleet vehicles), the production of higher numbers of units will allow for increased investment in tooling and production methodologies, thus reducing unit costs. The customer for this project would be PM-TV, who would be able to export power from vehicles equipped to do so, to a local power grid. The project would be transitioned through the incorporation of such a controller onto tactical ground vehicles.

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3) Electric cars that pay By Mark Clayton | Staff writer of The Christian Science Monitor

KEYWORDS: Mobile Power, Power Grid, Exportable Power

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A07-201 TITLE: Tracers in Armor Ceramics

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Evaluate and demonstrate the use of trace elements in ceramics used as part of an armor protection. These trace elements will aid in the removal of ceramic fragments from wounds created by the failure in an armor system where they are used. Producing a process which will provide medical responders a quick effective method of removal of ceramic shards in a wound.

DESCRIPTION: The medical field often utilizes certain products to act as tracers for various testes. Some of these work in conjunction with other test equipment such as x-rays. One of the methods to identify a foreign partial in the eye, for example, is to use a dye and look at the surface of the eye illuminated with a special light. In the area of ceramics, trace amounts of additives are commonly used in ceramic production for a number of purposes including improving their performance. However there will be occasions when armor systems including ceramic tiles or pellets will be overmatched and then ceramic fragments, usually having sharp edges, can become imbedded into the bodies that happen to be behind the armor. If the ceramic armor contained additions of elements or compounds that

would fluoresce under a UV or blacklight, for example, medical personal could distinguish these fragments for removal. Further, if there was an addition of say gadolinium or iron, a subsequent CT scan or MRI could be used to probe more deeply for buried fragments at a suitably equipped central hospital collection center.
A desirable material for use in doping a ceramic must have the following characteristics. 1. Any additive to the ceramic material must not diminish the materials properties as armor. 2. The method of locating the fragments by medical personal must be safe, quick and readably available. 3. It must not add significant costs to the manufacture of the ceramic armor product. 4. The material used must be reasonably obtainable.
Ideally, the final process would include the method for incorporating the trace material, a process or kit for medical personal and a process or kit for complete removal of any material in a hospital setting.

PHASE I: A survey of suitable materials will be made. This survey would be matched against the ease of incorporating them into ceramics of armor interest. A list of probable elements will then be developed taking into account the cost of the material, interaction with the body, ease of adding to the ceramic manufacturing process. This list would be down selected to produce a final selection based on the interaction with the ceramic armor material and an estimate of any change in the ceramics ballistic characteristics. Create a technical report detailing the elements identified, and profiling the most promising approach.

PHASE II: Choosing the most promising elements, test samples will be made to determine any change in physical properties, such as ballistic performance, weight, durability, in the final product, as well as effectiveness of the tracer used and the levels necessary. A final, best choice will be made taking into account the characteristics of the tracers and any change to the final ceramic product, as well as their ease of use by medical personal.

PHASE III: A final product/process will allow medical personal a quick and easy method of removing ceramic shards from a ballistic overmatch of ceramic armor systems. The removal of these shards will help prevent further injury by these pieces cutting further into the wound. This technique would find applications in a variety of commercial applications. Ceramic armor is being used currently in commercial applications such as in law enforcement, commercial armored vehicles. Wherever they are used there is the potential for any fragments of ceramic created by a failure in the material to penetrate anyone in the path of the debris. The work in the topic will aid the medical profession in removal of this debris. The most likely Phase III transition path is the integration of this process into ceramic armors and incorporating the necessary medical tools for the identification and removal of ceramic shards into medical kits for use by medical personal.

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KEYWORDS: ceramics, Tracers, trace elements, composite armor

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A07-202 TITLE: Advanced Technologies to Improve Fire Resistant Fuels

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Utilize advanced technologies and thermodynamic concepts to formulate a JP-8 and diesel fuel capable of self-extinguishing after ignition from an incendiary threat. The formulation must have minimal impacts on engine performance and the logistic fuel supply chain.

DESCRIPTION: Water-in-fuel (JP-8 and diesel) emulsions have been pursued by the U.S. Army to reduce the flammability and hazards associated with transporting a volatile fuel. Water-in-fuel emulsions have demonstrated the ability to self-extinguish after ignition from an incendiary threat earning the term fire-resistant fuels (FRF). Although effective, deploying a water-in-fuel emulsion requires fuel blending equipment and additional storage, distribution, and handling equipment. The U.S. Army is interested in developing advanced or alternative FRF technologies for ground vehicles that provide the self-extinguishing benefit with fewer implications on the logistic supply chain. Several avenues of research have been identified and include anti-misting additives (AMA), encapsulation technologies, heat adsorbents, and tailor-made surfactants. Other innovative technologies will also be considered.

The final FRF formulation shall be self-extinguishing, highly stable, and have minimal effects on fuel properties, toxicity, and engine performance. 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 fire-resistant 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. 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 FRF formulation will not negatively impact engine performance and durability, and is non-toxic. Finally, perform a midlevel-scale demonstration of the FRF technology (the definitive test for fuel self-extinguishment is an incendiary ballistics test).

PHASE III: A fire-resistant JP-8 and diesel fuel formulation could potentially be utilized by military ground vehicles to minimize the occurrence and damage caused by fuel fires. By minimizing the logistical footprint of the FRF technology, the military could more easily implement this technology in field applications. A product successfully developed under Phase II would 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 enabling the self-extinguishing properties of a FRF could potentially be adopted by military and commercial ground vehicle and aircraft fire suppression systems. 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) have ongoing fire suppression programs that could potentially leverage any advancement in encapsulation, surfactant, and other additive technologies developed under this research effort.

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KEYWORDS: Fire-resistant, fire, self-extinguish, fuel, JP-8

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A07-203 TITLE: Rapid Field Test Method(s) to Measure Additive Concentrations in Military Fuel

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop a portable instrument or set of instruments for the rapid measurement of additive concentrations in military fuel

DESCRIPTION: Develop an innovative solution for the rapid measurement of 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 set of instruments with the capability of rapidly analyzing military fuel to measure additive concentrations. The total weight for the solution will be under 30 pounds. The threshold ability of the instrument(s) is being able to detect corrosion inhibitor/lubricity improver (0 – 54 ppm) [1], static dissipater (quantity to be able to provide a measurable conductivity between 0 – 700 picosiemens per meter), and fuel system icing inhibitor additives (0 – 1500 ppm) [2-4]. Additional objective detection goals for the instrumentation include the ability to measure thermal stability improver (0 – 300 ppm), antioxidants (0 – 24 ppm), metal deactivator (0 – 5.8 ppm) [2-3], and ignition improver additives (quantity to be able to provide a measurable ignition quality cetane number greater than 42 or cetane index greater than 43) [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. The developed instrument(s) are required to be able to detect additive concentrations 125% to 150% that of the defined specification limits.

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, potential transition paths include the Army's Petroleum Quality Analysis System or Petroleum Test Kit. The developed technology may also find application in the commercial aviation industry or in commercial fuel analysis.

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KEYWORDS: Additives, JP-8, Diesel, Fuel, Fuel Additives, instrument, corrosion inhibitor, lubricity improver, static dissipater, fuel system icing inhibitor

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A07-204 TITLE: Develop Aluminum Metal Matrix Components (Al MMC) and Manufacturing Applications for both Military and Commercial Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Explore the potential of Aluminum Metal Matrix Composites (Al MMC) for both military and commercial vehicles. The unique characteristics of this class of materials are to be exploited to permit improved performance and lighter weight structures while still meeting or exceeding all other existing vehicle specifications. It is projected that the program team would include materials and manufacturing expertise to assure that an innovative synergy is applied to the development and integration of these advanced vehicle components using Al MMC.

DESCRIPTION: Many military and commercial components are: (1) large, bulky and heavy, (2) non-perishable, non-friction and non-wear and (3) under heavy loads. These types of military and commercial components are ideal candidates for applying AL MMC application. Weight saving will be the number one factor in searching for a program team employing both AL MMC development and cutting edge manufacturing development. Manufacturing development is also a key to this topic since manufacturing must research new processes, advanced tooling and applications which will be needed for a future AL MMC Phase III production base. Al MMC production costs must be competitive with current military and commercial component manufacturing techniques to be truly successful. This technology also has direct relationship to a soon to be released Department of Defense (DOD), Director Defense Research and Engineering (DDRE) Security Integrated Product Team (IPT) Report. This report stresses the development of lightweight, survivable vehicles that increase protection while reducing fuel consumption. Reduced fuel consumption and increased vehicle performance can be improved upon by developing components made of Aluminum Metal Matrix Composites.

PHASE I: In Phase I the AL MMC Program Team shall conceptualize, design and demonstrate a prototype for Ground Vehicle Components (including propulsion) for AL MMC application. At least one current military and commercial component that is: (1) heavy and bulky, (2) non-wear/non-friction and (3) under heavy load will be explored for AL MMC application. A projected weight savings of the selected AL MMC components(s) targeted for development and eventual manufacture will be shown in the predictive model. The model will also show through Finite Element Analysis (FEA) of how the AL MMC components(s) can provide stress-bearing levels equal to present production components they would be replacing. The AL MMC Program Team will conduct a study to show manufacturing cost and differences between current materials and AL MMC. This study shall show manufacturing techniques and processes which could be integrated to make AL MMC manufactured components(s) competitive with present manufactured component materials.

PHASE II: Finalize the approach for military and commercial AL MMC component(s) development based on Phase I results. Design and manufacture at least one (1) AL MMC military and commercial component and conduct lab tests to verify that performance requirements of AL MMC component is equal to existing component it is replacing.

Verify the weight savings of the AL MMC component and improved performance. Re-design the AL MMC component where necessary and repeat lab test verification to harden the design so that all performance and environmental test requirements currently established can be met. Finalize the FEA modeling after any re-design to the AL MMC component to minimize any risk factors. The AL MMC Program Team will continue to finalize the approaches for developing the manufacturing skills, tools and processes needed for applying AL MMC technology for a future Phase III production. This concentrated effort will expand on Phase I manufacturing cost study differences between current materials and AL MMC to assure competitive manufacturing costs.

PHASE III: The AL MMC technology will result in cast iron housings or similar cast materials being replaced with light weight matrix composites as a low weight high strength alternative to cast parts. These light weight components(s) for both military and commercial vehicles will provide increased fuel consumption which will be a major thrust in the soon to be released DOD, DDRE Energy Security IPT Report. Commercial vehicles include off-road construction equipment such as bulldozers and earth graders. Vehicle developers will implement this technology following: (1) successful lab testing of AL MMC component(s), (2) new manufacturing processes and techniques to make AL MMC competitive with current manufacturing costs and (3) field tests to verify proof-of principle in a real world environment.

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KEYWORDS: Aluminum Metal Matrix Composites, Manufacturing Processes, Manufacturing Materials, Light Weight Materials, Machining of Composites, Light Weight Propulsion Components, Light Weight-High Strength Components, Internal/External Vehicle Components

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A07-205 TITLE: Accelerated corrosion simulation and Modeling

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Develop a simulation and modeling tool for corrosion and deterioration over time that has a high degree of correlation to actual accelerated corrosion test.

DESCRIPTION: Efforts to model corrosion and deterioration of complex systems using deterministic, physics-based, electro-chemical models have resulted in limited success because of the amount of uncertainty and ambiguity existing in the data (geometry, material and environment) and in the models themselves.

The potential exists however to develop a simulation and modeling tool using advanced non-deterministic AI methods such as Bayesian Networks that could calculate the breakdown of the material in a complex system over time resulting from various forms of corrosion, materials, coatings, operating conditions and environments. Such a tool would include user defined life cycle profile for the system that could be changed depending on the planned deployment location of the system. Such a system in fact could be used to complement Accelerated Corrosion Testing and even use such test result to calibrate the tool.

PHASE I: In Phase I innovative research and analysis on factors and methods leading to a design concept will be developed. The general software design approach should be created for implementation in Phase II. A description of the proposed design should include the solution architecture, input data sources, the predictive model(s) and the output user-interface. The effort should include a proof-of-concept demonstration of the proposed approach.

PHASE II: The Phase II should focus on the development of the model and the demonstration/test of its capabilities. The design approach proposed in Phase I for the Simulation and Modeling tool should be further developed, implemented in software and demonstrated on realistic use-cases. This includes testing the simulation engine using an operational experiment in a lab or simulation environment to prove feasibility of the approach. If feasible, the developed software should be HLA-compliant to facilitate interaction with other relevant modeling and simulation tools. The final Phase II deliverable should be a working prototype corrosion simulator that can be used for "what-if" analysis of complete vehicle field deterioration. The final Phase II tool should be demonstrated by simulating and reproducing the results of a controlled experiment, such as an Acceleration Corrosion Test. The Technology Readiness Level of this software deliverable should be at 4 or above for rapid transition into Phase III commercialization.

PHASE III: In Phase III the developed Corrosion Simulator should be immediately transitioned for use in evaluating corrosion control materials, treatments, and processes by various Army CAT I procurement programs including Future Combat Systems (FCS), Joint Light Tactical Vehicles (JLTV) and Family of Medium Tactical Vehicles (FMTV). Similar opportunities exist in the Navy and Air Force procurements. It can also be used in the research and development of new environmentally friendly, corrosive-resistant materials and in evaluating alternative corrosion control technologies.

In a broader sense, this system could be used by any agency tasked with monitoring and controlling deterioration of any fleet such as automobiles, trucks, railroad, ships, helicopter and aircraft, commercial or military. It would also have application in the monitoring and maintenance of stationary structures in caustic environments where corrosion, erosion and surface deterioration are issues, such as off-shore oil platforms, drilling rigs, even roads, dams and physical structures could be tracked and maintained with a minor adjustment to the knowledge base.

To insert the technology into aquisition the following will be done.
a. We will at TARDEC Take an existing vehicle design run the program analysis and present our findings to the PEO/PM of tactical vehicles.
b. Once the PEO structure is convinced as to the validity and uses of the program we will put this as a requirement in all future Purchase Description just as we did with demanding that a full accelerated corrosion (ACT) at the Aberdeen Test Center test be done on entire vehiles such as the FMTV and the MTVR. Prior to this we will coordinate our findings with the Society of Automotive Engineers, (SAE) Corrosion experts at Ford Motor Company Research in Dearborn Michigan and the General Motors Test Center at the Milford Proving Grounds. Army Research Labs (ARL) will be involved in the final evaluation and help in the implementation process. The availability of the program will then be posted on the DOD Corrosion Web Site for further dissemination

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KEYWORDS: Corrosion, Deterioration, Expert System, Artificial Intelligence, Automobiles, Vehicles, Computer Modeling and Simulation

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A07-206 TITLE: Detection of Magnetic Signatures of Ground Vehicles Using Spin Wave Generation in Magnetic Films

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Detection of magnetic signatures of ground vehicles by measuring distortions of the magnetic field of the Earth and an estimation of detection range.

DESCRIPTION: The distant detection of ground vehicles is possible based on the magnetic properties of the Fe-based alloys. These alloys form the main part of the mass of a ground vehicle, and always have some residual magnetization. They create substantial distortions in the local value of the magnetic field of the Earth. At the same time, other ground objects, as well as the Earth surface, are magnetically transparent and, therefore, do not create their own magnetic signal and do not mask the magnetic signal created by ground vehicles. One of the possible solutions is detection of magnetic signatures of ground vehicles using spin wave generation in magnetic films. This method is more rugged and less expensive than the standard laboratory method that employs delicate and artificially cooled SQUID devices. Although the changes in the local magnetic field created by ground vehicles are relatively small and difficult to detect directly, this device is expected to detect a commercial vehicle at 100 m.

PHASE I: At the first stage of the project we would like to estimate the small changes of the magnetic field of the Earth caused by the weak magnetic field created by the vehicle, estimate the range of vehicle detection and calculate the maximum distance of vehicle detection. Deliverables: final report that discusses the sensor design, its expected performance, range of vehicle detection and cost.

PHASE II: At the second stage of the project we would like to develop a prototype magnetic detector. Development of an information processing algorithm, which would allow the determination of the type of the detected vehicle, its velocity and direction of motion is also of interest. Investigation into using simultaneously obtained signals from a net of spatially-separated detectors should also be considered. This should allow the detection of the positions of individual vehicles in a group.
Deliverables: component and/or breadboard validation in a laboratory environment; final report discussing experimental research and laboratory tests in Phase II; delivery of the prototype device.

PHASE III: The distant detection and identification of ground vehicles using their magnetic signatures would enhance the Army's capability of threat detection. This technology would be insensitive to weather conditions (rain, fog or sandstorm) and could work in difficult urban conditions. The magnetic sensor would provide a new method of locating vehicles in a convoy and estimating their direction of propagation and velocities.
The most likely path of transitioning from research to operational capability is development of the network of magnetic sensors. These sensors would provide information related to types and coordinates of vehicles, their velocities and directions of propagation. Magnetic sensors could be implemented as unattended sensors on a battlefield, or could be installed on robotics vehicles. The most likely source of Government funding for Phase III is the Future Combat Systems program.
Magnetic signatures of commercial vehicles could be applied in the automotive industry for collision avoidance. They could also be implemented to detect vehicles in parking structures and to provide information on space availability.

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KEYWORDS: magnetic sensor, measurement of small magnetic fields, spin wave generator, superconducting quantum interference device (SQUID), ferrite films

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A07-207 TITLE: Development of an Advanced Heat Exchanger

TECHNOLOGY AREAS: Ground/Sea Vehicles

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

OBJECTIVE: To develop a heat exchanger (radiator) for TWV & Combat Systems that will reduce the weight and pressure drop across the radiator. To spin off this technology to air conditioning systems, electronics, and APUs in the future

DESCRIPTION: Current military vehicle systems have been required to increase the power pack size and output to compensate for weight added to the vehicle for additional armor protection and/or capabilities. However, the size of the hull of these vehicle systems typically remains the same. This drives the power packs to be condensed as possible. The radiator is the area that space can be condensed by reducing the space between the fins. The drawback is that additional horsepower is required to drive the air through the radiator to achieve the proper cooling efficiency. The Bradley FVS is a legacy system that has gone through many power pack iterations. This has resulted in two huge fans being required to properly cool the power pack. The horsepower required to drive the fans is estimated to be as high as 90 hp. Advancement in fin technology has resulted in the capability to reduce the weight of the radiators, the power to drive the air through a tightly finned radiator, and yet provide better cooling efficiency in the same volume of an existing radiator at a cost that should be near the cost of current manufacturing costs. The HMMWV also has a tremendous problem on up-powering the vehicle because of the inability to provide sufficient cooling. Cooling is the number one problem in getting more power out of the existing engine for the HMMWV. We have set a lower benchmark for the HMMWV because a system that could reduce the weight and improve the cooling efficiency the HMMWV may be able to get additional power and that could impact OIF efforts. This technology is applicable across the board and if the prototype is successful, anticipation of spin-out technology may occur for TWV platforms and potentially some combat systems. The Phase II would focus on optimizing the technology for future force such as JLTV, FCS, & other future tactical vehicles. The technology would be demonstrated to all competitors and they would determine if they would want to include it into their proposals.

PHASE I: Develop one HMMWV radiator concept that could be developed that would provide a reduction in weight of at least 10%, with the same space claim or less, 15% less pressure drop across the radiator, and an overall cooling efficiency of at least 10% over the current production radiator. Selection criteria shall focus on cooling efficiency, but all factors are important. A phase I plus program, if approved, would produce a prototype of the phase I concept. A radiator from the HMMWV 1907R1 or R2 shall be provided for reverse engineering. Drawings may be released with approval from the legal office (this has already been reviewed, but will recertify). The contractor shall provide all data and any prototype to TARDEC to determine the optimum cooling efficiency required for up-powering the engine.

PHASE II: Develop two heat exchangers (radiator) for the HMMWV that would result in a 20% reduction in weight, with no increase in space claim, and a reduction in pressure drop across the radiator of 25% with a cooling efficiency improvement to 25% as the current production radiator. Contractor shall use the radiator fan for the HMMWV 1097R1 vehicle for base lining the system. The contractor shall provide all data to TARDEC's propulsion team to determine the optimum cooling efficiency required for up-powering the engine.

Develop one radiator for the Bradley M2A3 that would reduce the pressure drop across the radiator by at least 20%, increase overall cooling efficiency by 10%, and the weight and size must not be larger than the current production radiator. A radiator from the M2A3 shall be provided for reverse engineering. Drawings may be released with approval from the legal office.
In the event that the Bradley M2A3 radiator effort can not be done for proprietary issues, the Stryker radiator shall be done in place of the Bradley. The extent of the effort is to identify any integration issues that exist for Phase III efforts for development and fielding of hardware.

PHASE III: This goes across the fleet. The HMMWV, Stryker and the Bradley would benefit the most for now, but all systems would benefit. I would expect this to become part of the Stryker power pack if successful and expect it to be integrated to other systems such as the Bradley, HMMWV, JLTV, LAV, FMTV, and other systems as the technology matures. This would also spin off into the commercial market for systems that require advanced heat exchangers due to size or weight. The military application is the most logical because of requiring the power pack to be under armor thus requiring it to be compact and poor airflow. Another huge problem that is arising is keeping systems power train cool with the addition of underbody armor kits.

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Materials Development Research)

5. Analytical methods in conduction heat transfer analysis, Myers 1987

KEYWORDS: Heat Exchanger, radiator, stryker, hmmwv, bradley

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A07-208 TITLE: Development of small fuel efficient multi-fuel capability engine

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Design, develop, and test a relatively low cost small engine with rated power output range of 5 to 30 HP, the engine should be able to function unattended, and operates on DF-2, JP-8, JP-5, and on commercial grade unleaded gasoline alcohol, bio-diesel and ethanol. The engine should be designed to use conventional components and parts (COTS), be quiet in operation, easy to start, easy to maintain, reliable, and durable. In addition, the proposed engine is to meet the technical requirements of auxiliary power units (APU) of Abrams, Bradley, and Stryker vehicles as stated below in the description section of this topic.

DESCRIPTION: There is a military and commercial demand for small engines, that are lightweight, reliable, durable, fuel efficient, and with low cost, for a wide range of applications. These applications can be for mobile power, portable power, power plants for unmanned air and land vehicles, small compact generating set, and charging deployed batteries in the field. The multi-fuel capability of the engine will enable operation under varying range of conditions.

Technical Requirements of APU for Abrams, Bradley, and Stryker vehicles:

Operating in ambient air temperatures of -46   to + 52

Providing 8 KW net power with continuous operation for 12 hours
Complying with MIL-STD-1275

The APU fuel consumption shall be no more than 21 gallons for 12 hours of operation.

The APU is to operate on JP-8 as primary fuel from the vehicle's fuel cell as source.
The fuel Standards are: MIL-T-83133, VV-F-800E, and MIL-T-5624.

Lubricant selection shall be in accordance with AR70-12

The size and weight, cooling, air filtration, and exhaust systems of APU-engine shall be coordinated with vehicle managers.

The mean time between failures is 500 hours minimum.

The noise level can not exceed that of the main engine.

The engine shall operate without performance degradation during and after exposure to hot humid conditions as per MIL-STD-810E.

The engine is to operate without power degradation up to elevations of 2000 ft, and with power degradation up to 10,000 feet, and during and after exposure to 1120 watts/m normal incident solar radiation at 49 Deg C.

The APU-engine shall be capable of operating without performance degradation or damage in heavy sand environments, during and after exposure to blowing sand/dust, during and after exposure to heavy rainfall, salt fog concentration of 5 percent as per MIL – STD 810F, during and after exposure to icing rain, and glazed ice up to 6 mm thick, and from effects of vibration during conductance of mission or transport.

PHASE I: Develop a physics-based analytical model of proposed small engine concept design, validate through computer simulation the feasibility of the proposed engine for wide range of applications. Validate via bench top hardware testing of the engine key components.

PHASE II: Provide detailed analytical derivations, and complete engineering design of the proposed engine. Develop a full scale engine hardware prototype, and perform extensive testing of its performance, operating characteristics, and endurance. Validate the engine for various military and commercial field applications.

PHASE III: The newly developed engine could be used in a broad range of military and civilian applications where small engine with lightweight, reliable, fuel efficient, low cost, multi fuel capability are necessary characteristics. When available, the engine could be fielded and deployed with the army, navy, marine, and air force.

The design work should be materialized as actual engines for military and commercial applications as follows:
1. Small auxiliary power unit for Future Combat System (FCS), Abrams, Bradley, and Stryker.
2. Small compact generating set
3. Small engine for unmanned air vehicle

REFERENCES:

Proceedings of the 1999 SAE Small Engine Technology Conference
September 1999, 80 Papers, 776 pages, paper bound

KEYWORDS: Small compact engine, multi fuel, DF-2, JP-8, lightweight, portable, compact generator, unmanned aerial vehicle, COTS components, military and commercial applications.

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A07-209 TITLE: Designed-by- Reliability Zero-Maintenance Air Filtration System

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: This effort will be a foundation for the next generation in air filtration technology. Its main focus will be on the modernization of military air filtration systems for ground vehicles. Also, this effort will focus on reducing operation and support costs associated with air filtration by increasing the service life of existing systems by 65%. The new system will demonstrate the elimination of particles above 7 microns without need for filter replacement.

DESCRIPTION: Supporting data from military operations has shown the need for advancements in dust and dirt damage prevention in ground vehicle systems. Vehicles are continually being run even when they are not moving. For example, convoy operations may run for five hours or so, but the vehicle will be run continually for up to 20 hours of the day – leaving little downtime for repairs and prolonging exposure for component wear. To compensate for this increased wear on the engine and other components, it is critical that a more reliable and robust air filtration system be developed. The new system will require a complete removal of particles above 7 microns without need for filter replacement, while maintaining a high level of efficiency under simulated desert conditions of two-times zero-visibility. A high reliability must be considered and reported on when designing this system. The system must also be capable of adapting to its environment in order to reduce energy consumption. It should be noted that this proposed system is not the standard pre-cleaners on the market today.

PHASE I: As a product of this phase the military will gain a fully designed air filtration system, including all specification, that is capable of adapting to its environment, is highly reliable, and free from the burden of time-consuming maintenance.

PHASE II: A fully developed and prototyped system will be demonstrated through testing in relevant environmental conditions.

PHASE III: Phase III expectations are to partner with the Army, OEM, and commercial industry to commercialize this technology. Transition would be a combination of actions by the RDE side together with the user and PEO/PM Tactical Vehicles. Phase II results would direct the most promising vehicle systems (Light, Medium or Heavy) that would benefit from an advanced air filtration system. This system will provide the military with an air filtration system that will significantly reduce operation and support cost and will boost readiness. It will provide the commercial industry with highly needed technology that will reduce maintenance cost, and will result in better fuel economy. Concept transition would be based on technology maturity at the end of Phase II and the needs of the PEO/PM-TV organization matching user needs or directly addressing a requirement and/or capability gap, which would be funded at that time. This technology advancement can be integrated into current and future vehicles for specific applications. Trucks, construction, forestry, mining, and marine engines would benefit from this innovative research.

REFERENCES:

1.) MIL-STA-721C (http://www.er.doe.gov/sc-80/pdf_file/gpg04.pdf)
2.) SAE J2554 Engine Intake Air Water Separation Test Procedure (http://www.sae.org/technical/standards/J2554_200304)

KEYWORDS: air, filtration, precleaner, pre-cleaner, reliability, maintenance, designed by reliability, demonstrates

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A07-210 TITLE: Control of High Speed Unmanned Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles

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

OBJECTIVE: A system that facilitates the control of a high-speed unmanned ground vehicle (UGV) in urban or off-road environments.

DESCRIPTION: Controlling a UGV via teleoperation can be difficult even in mundane situations. It is nearly impossible in complex environments where the operator may want to drive fast and still be aware of the vehicle's status and immediate environment. This topic seeks to provide tools to assist in those situations. We are interested in enhanced vision to allow the operator increased field of view, similar (or more) to what they would have while personally driving a vehicle. We are interested in sensor feedback, where the operator would hear vehicle and ground noises, feel the roughness of the terrain and the effects of ground steering. We are interested in proprioceptive sensing, where the vehicle will anticipate that it is in danger of overturning or becoming unstable and automatically take appropriate action. Many of these technologies have been demonstrated in other environments or have been implemented separately on ground vehicles. In this topic we are seeking the implementation and integration of a subset, if not all, of these capabilities into a small UGV and a demonstration of higher speed control, enhanced situational awareness, and more effective operation. The vehicles we are interested in weigh 100 Kg or less and can travel at speeds up to 40 Kph. A key research issue in this topic is integrating and wirelessly communicating the various sources of data and presenting it to the operator in a robust and effective manner with low latency. It is anticipated that the system would be used from a fixed installation or from within a vehicle, either stationary or moving.

PHASE I: Develop the initial design for the control system. Implement and demonstrate one part of the control system. Documentation of design tradeoffs, feasibility analysis, and predicted performance shall be required in the final report.

PHASE II: Complete the design of the control system and build a prototype system. Deliverables shall include the prototype system and a final report, which shall contain documentation of all activities in this project, a user's guide, and technical specifications for the prototype system. Vehicle performance shall be demonstrated in an outdoor environment.

PHASE III: The end goal of this project is technology that can be integrated or attached to a variety of military and commercial UGV platforms. Commercial applications include many UGV applications, such as security and inspection, hazardous waste monitoring, and law enforcement. Military applications include security, inspection and reconnaissance. The most likely path to operational capability will involve implementation and testing on Government UGV's and subsequent demonstrations to interested users.

REFERENCES: 1) http://www.ri.cmu.edu/pubs/pub_3768.html ("Vehicle Teleoperation Interfaces")
2) http://www.chattenassociates.com ("Human/Robotic Interfaces: Vision Systems")
3) http://www.cse.unr.edu/~mircea/Research/Globeall/glb.html ("GlobeAll: Panoramic Video for an Intelligent Room")
4) http://biorobotics.harvard.edu/pubs/vibrotactile.pdf ("Vibrotactile Feedback for Industrial Telemanipulators")
5) http://web.cs.wpi.edu/~gogo/papers/Lindeman_VR_2006.pdf ("Wearable Vibrotactile Systems for Virtual Contact and Information Display")
6) http://www.eurohaptics.vision.ee.ethz.ch/2003/76.pdf ("Exploring Dynamic Haptic Cues in Vehicle Teleoperation")
7) http://watcar.uwaterloo.ca/mechatronics/control.html ("Intelligent Vehicle Control")
8) http://www.vti.fi/en/products-solutions/solutions/automotive/ ("Automotive Sensors")
9) http://www.ri.cmu.edu/projects/project_576.html ("Vehicle Stability Prediction")

KEYWORDS: Robotics, haptic, stability control, vision, immersive

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A07-211 TITLE: Autonomous, Real-time, 3D Change Detection System

TECHNOLOGY AREAS: Electronics

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: Develop a vehicle-mounted, 3D anomaly and change detection system that compares 3D profiles of the terrain with previously mapped 3D profiles, in real-time while moving, in order to locate potential hazards on and along a road. The anomaly detection feature will complement the change detection system in areas were there are no previously mapped terrain profiles. The system should be adaptable for downward looking air vehicles, as well as forward looking ground vehicle applications.

DESCRIPTION: Although no change detection system can discriminate between benign clutter and potentially hazardous obstacles, they do serve as a "perfect memory" that helps the operator focus their attention only on new hazards. How the operator, be it a convoy driver or combat engineer, uses this reduced target set would depend on their specific mission and Tactics, Techniques & Procedures. Change detection systems typically use 2D color or Infra-Red (IR) cameras to compare previously stored images with the current terrain view to determine changes that may be indicative of new hazards. However, real-time autonomous 2D change detection is challenging due to the enormous amount of image correlation involved to account for image differences due to: time of day (i.e. shadows, lighting), location & orientation offsets, camera color shifts, Field of View (FOV) and magnifications. In contrast, 3D imaging systems would provide the relevant profile information directly for easier comparison. However, most 3D imaging systems scan a point across the scene, which makes it difficult to accurately capture an entire scene, while mounted on a fast moving platform. The challenge is to develop the fast, high-resolution ranging hardware and the accompanying real-time comparison & anomaly detection algorithms. The system should be capable of functioning while mounted on a vehicle traveling between 15 km/h and 100 km/h objective max speed (threshold max speed is 50 km/h), both on (e.g. asphalt/concrete) and off-roads (e.g. gravel/packed soil). Depending on the specific ground vehicle and mounting location, the sensor height will vary between 2 and 4 m above the ground and will be forward facing. For aerial vehicle applications, the flight height will be 500 m with the sensor mounted downwards, perpendicular to the ground. The system shall implement image stabilization, either in hardware or software, to mitigate the effects of vehicle vibrations & movement, in order to generate smooth, accurate and repeatable profiles. At a minimum, the system must be capable of scanning a 10 meter cross-range swath throughout the longitudinal range of interest of 10 m to 350 m objective max range (threshold max range is 150 m). The system shall be coupled with a color video camera and overlay/highlight detected differences & anomalies on the video image. The detected area should also be magnified and displayed in a picture-in-picture window for manual object identification. The cross-range resolution and spot size should be sufficient to detect 50 mm object features at 350 m. The system should be sufficiently robust to account for differing camera heights and vehicle lateral locations when comparing with the previously stored database. The change detection algorithm should be sufficiently robust to compare static changes only and be able to reject pop-up/moving cues (e.g. moving cars and people/animals). The anomaly detection algorithm should have the capability to either detect or ignore pop-up/moving cues and also function when there are no previously stored profiles to compare with. Whatever sensor is employed must be safe for the operator and dismounted personnel, animals and common electrical devices (i.e. eye-safe and minimal/non-ionizing). The expected deliverable is a robust & safe, vehicle mountable, 3D change & anomaly detection system that could detect road hazards (i.e. potholes, craters, ditches, boulders, etc) and possibly even disturbed soil.

PHASE I: During phase I, the contractor shall lay out the system design, list required hardware/parts & algorithms, determine optimal hardware/software parameters and estimate unit production costs. They should perform sufficient laboratory component testing and/or modeling & simulation to determine technical merit and feasibility of their proposed concept. They should identify all development risk areas and recommend risk mitigation plans. The expected deliverable for this phase is the final technical report that captures the details of the proposed design and a quantitative feasibility/risk assessment for making a Phase II selection recommendation.

PHASE II: During phase II, the contractor shall develop a full-up prototype and interface kit for a M1114 HMMWV. The contractor shall evaluate the performance of the system on and off roads and assess performance at various speeds and standoff detection ranges. Metrics include probability of detection and false alarm rate for both the change and anomaly detection algorithms. The system shall be sufficiently ruggedized against shock, vibration, temperature extremes, humidity and dust. The expected deliverable for this phase is the prototype 3D change & anomaly detection hardware, operator manual, training package, and an intermediate & final report that captures the detailed design, performance specifications, test plan, test results, system limitations, and unit production cost.

PHASE III: During phase III, the system would be militarized and made fully interoperable with vetronics, communication, and electronic countermeasures. The user interface will be enhanced based on limited user testing and the detection/anomaly algorithms will be further tweaked to reduce false alarms. The end-state will be a robust change detection hardware/software tool that would support PM Assured Mobility Systems' and PM Close Combat Support's mission. A civilian application may be for high-speed detection, location marking and characterization of road defects for road repair planning. This may also be an enabler to advance both military and civilian autonomous navigation systems.

REFERENCES: Minefield detection using ground-based 3D Laser scanner:
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Use of dual CCDs for topographical mapping:
http://www.nasatech.com/Briefs/May01/NPO18812.html
Long range 3D imaging using sliding time/range gate:
http://adsabs.harvard.edu/abs/2006OptEn..45c4301A
Automated 3-D feature extraction from terrestrial LiDAR:
http://www.commission4.isprs.org/obia06/Papers/12_Object-based%20approach%20generic%20issues%20-%20IC%20I/OBIA2006_Opitz_Rao_Blundell.pdf
Automated registration of point clouds from terrestrial laser scanners:
http://adt.curtin.edu.au/theses/available/adt-WCU20060921.094236/unrestricted/01Front.pdf

KEYWORDS: LiDAR, Change Detection, Anomaly Detection, 3D profile, Target Detection, algorithms, autonomous navigation systems

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A07-212 TITLE: Application of Spot Cooling Technologies for the Thermal Management at the Source

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: To study and pursue a novel thermal management approach to actively cool or manage key localized hot spots in the power devices, so that the system level cooling requirements are lower.

DESCRIPTION: Conventional & advanced (phase change) thermal management techniques are not well suited to the specific problem of cooling highly localized concentrated discrete heat sources since they generally cool the whole board. Instead of optimally reducing or spreading the localized heat source, we end up designing a thermal management system to handle high heat flux for the entire board thereby increasing cooling module size, weight and power requirements.

The specific problem of spot cooling of power devices can be effectively solved using a combination of advancements in nano scale fluid transport and nano engineered substrate materials.

The cooling approach considered here is based on discrete nano-liter droplet formation and electrowetting based droplet manipulation and transport, under clocked voltage control over an array of electrodes for high heat dissipation. With electrodes facilitating pumping of cooling fluids, Inherent thermo capillarity, facilitates local hot areas to have increased cooling applied locally, and electro wetting for transport, it is self regulated. Few nano-liters of liquid transported at high speed holds the key for faster heat dissipation.

In addition, another aspect of this study is to determine the feasibility to further enhancing this mechanism by facilitating superior heat transport by employing nano engineered substrates based on existing Carbon Nanotube composite structures to demonstrate superior thermal conductance.

The technical challenge and scope here is to understand the feasibility of packaging a thermal management module incorporating complex flow control mechanism, employing these specific nano based technologies for cooling power devices in a hybrid vehicle.

With no external components required for fluid reconditioning, and no moving parts and only a small quantity of liquid required and no power requirement for thermo capillarity, this is a low power & highly reliable solution to handle thermal management of hot spots.

To summarize, the proposed study focuses on identifying the emerging technologies for cooling localized hot spots in the power electronics module of an inverter or converter employed in the Hybrid & FCS vehicles and investigate the applicability of emerging technologies for thermal management at the source. The spot cooling techniques enable the power converters to handle high transient conditions which are the main causes for failure, thereby increasing their reliability.

PHASE I: Define the problem of localized hot spots in the power electronics employed in Military Hybrid vehicles (HMMWV). Identification of key technologies and understand their heat transfer mechanism and determine their validity and feasibility through published research and numerical techniques. Prepare an experimental plan for the selected concept verification. Prepare a detailed report on the study.

PHASE II: Develop a prototype of the thermal management module for a motor drive controller employed in a Hybrid HMMWV based on the technology determined from the feasibility studies from the Phase 1 effort. Perform evaluation tests to confirm the projected improvements in cooling capacity and reliability representing all vehicle conditions. Following these tests a technical assessment will be made to determine any final modifications to the design if required. At the conclusion of Phase II the contractor will deliver at least one prototype.

PHASE III: Thermal management challenges are common across a wide range of electronic products. Thermal management is one of the key challenges for sustained improvement in the power densities of power electronics.

The technology identified has several Military applications in all power electronic devices employed in an Hybrid Vehicle (HMMWV), namely DC-DC Converter, Motor Drive controllers where elimination of hot spots in high power devices (IGBT and Mosfet junctions) will significantly lower system level cooling requirements, there by contributing to significant improvement in the power densities, reliability and weight subsequently leading to better fuel economy & power that is more in tune with the representative operating conditions of a combat vehicle. The same applies to commercial Hybrid vehicles.

If successful this technology(advanced thermal management module) will be integrated in to an inverter of Govt. furnished Hybrid HMMWV, and field tested and fine tuned to address any further design issues to transition from the SIBR research phase to operational capability. Vehicle platforms FCS & FTTS will work with the contractor involved in Phase II during this transition to operational use. The most likely source of funding is the Govt. R & D Fund from Hybrid Electric FCS team.

Commercially, all the Electronic Packaging Industries and manufacturers of high powered devices can employ this technology for thermal management at the device level to significantly improve their power densities. The same technology can be employed cooling next generation Chips employed in supercomputing. Success of the program discussed above will provide a direct link to commercial or military endeavor.

REFERENCES: http://es.epa.gov/ncer/publications/nano/pdf/rama.pdf
Nano-Scale Thermo Electric Materials for Solid state cooling and direct thermal to electric energy conversion by Center For Thermoelectronics Research and Research Triangle Institute. Inter-agency meeting on Nano Technology and Environment, Applications And Implications, Sept.15, Washington D.C

http://download.intel.com/technology/itj/2005/volume09issue04/art03_nanoandmicro/vol09_art03.pdf
INTEL TECHNOLOGY JOURNAL, Electronic package technology development.
"Nano and Micro Technology - Based Next Generation Package - Level Cooling Systems"
Published by Technology and Manufacturing Group, Intel Corporation.

http://www.ee.duke.edu/research/microfluidics/documents/GLSVLSI-P1-6-Pamula.pdf
Paper on Cooling of integrated circuits using droplet-based microfluidics by Vamsee K. Pamula and Krishnendu Chakrabarty, Duke University, Dept of ECE, Durham, NC

http://web.mit.edu/ronggui/www/PDF/B1.pdf
"Nano Scale Heat Transfer", G.Chen, D.Borca-Tasciuc, R.G.Yang, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA. (Encyclopedia of Nano Science & Technology).

http://128.102.216.35/factsheets/view.php?id=116
" Nano Engineered Heat Sink Materials", NASA, Ames. Shyam Venkatesh, Ames technology partnership division.

http://www.gaasmantech.org/Digests/2004/2004Papers/10A.1.pdf
" Thermal Management of High Power Devices ", by J.Laskar, S.Nuttinck and S.Pinel, Georgia Electronic Design Center, School of E.C.E, Georgia Institute of Technology, Atlanta, GA.

Keywords: thermal management, spot cooling, power electronics and Hybrid vehicles.

KEYWORDS: thermo-capillarity, electrowetting, electrodes , voltage

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A07-213 TITLE: Non Focal Plane Laser Protection Technologies

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO Ground Combat Systems

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

OBJECTIVE: To develop an innovative frequency-agile laser protection technology which protects eyes and sensors aboard ground combat vehicles without the use of a focal plane. The end product of Phase II will be a proof-of-principal/breadboard non-focal-plane laser protection system.

DESCRIPTION: Current frequency-agile technologies for laser protection of eyes and sensors rely on nonlinear optical materials (nonlinear absorbing dyes, nonlinear scattering suspensions, etc.) which must be located at the focus of an optical system in order to obtain the high fluences necessary to trigger the nonlinear mechanism. Focusing optics carry with them a host of limitations and integration issues (e.g. field-of-view, image quality, space claim, cost and complexity, etc.) and may not be desirable or applicable for many military optical systems. In many cases, frequency-agile laser protection technologies which do not require the use of a focal plane may be preferred or required. This SBIR topic solicits new, innovative approaches to provide frequency-agile laser protection for eyes and sensors throughout the visible spectrum without the use of a focal plane.

The proposed technology should allow ample transmission of ambient visible light and be of high optical quality so as not to significantly degrade normal (human) vision or optical system performance (CCD). It should have a fast response time when exposed to dangerous fluence levels, sufficient to react to and block an incident laser pulse. It should block incident laser pulses to a high optical density. It must have a broadband response—blocking any visible wavelength (i.e. 400-700 nanometers) which has sufficient irradiance to damage eyes or sensors. The concept should be capable of changing from a high transmission state to a very low transmission state within sufficiently short time to block—nearly entirely—all of the light contained in a light pulse emitted from a Q-switched laser. When harmful radiation is no longer incident, it must recover to a high transmission state in a short amount of time so that the user's vision is not interrupted or significantly degraded after exposure. Both powered and unpowered non-focal-plane technologies will be considered.

The proposal should discuss in detail the spectral transmittance in the linear (non-blocking) state, spectral transmittance in the attenuating state, activation threshold, response time, optical density in the attenuating state, and recovery time of the technology, as well as any other important technical details. If the technology is capable of exceeding any of the above requirements, the proposal should note this as well. For example, if the technology also has the capability to block laser energy on other timescales (femtosecond pulses to continuous wave), or if the technology could easily accommodate a wider bandwidth (e.g. 400-1000 nm) the proposal should note this.

Likewise, the proposal should note any limitations (e.g. angular sensitivity, etc.) inherent to the proposed technology.

PHASE I: Design/develop a non-focal-plane laser protection concept. Identify the critical technologies for realizing this concept. Conduct theoretical analysis and limited laboratory testing on sample materials or devices to prove the feasibility of the concept. Phase I deliverables will be progress reports, a final technical report, and sample materials or devices.

PHASE II: Develop and demonstrate a non-focal-plane laser protection prototype system. Such a prototype should be built in the form, fit and function of, or integrated for use in conjunction with, common periscopes or vision blocks on ground combat vehicles. This prototype system shall be tested for laser protection performance and degradation to optical system performance (e.g. from haze, etc.) in a laboratory environment.

An iterative approach may be necessary in order to improve the performance characteristics of the materials or devices, or to scale up their size. Factors to be considered include, but are not limited to, optical density upon laser illumination, response time, recovery time, linear optical properties (e.g. haze, induced wavefront distortion, etc.) under normal daylight illumination, manufacturability, and environmental stability (e.g. minimization of optical property variations with temperature).

Phase II deliverables will include a prototype non-focal-plane laser protection system, interim sample materials or devices (if applicable), test data, progress reports, and a final report.

PHASE III: Potential Phase III military applications for this technology include laser safety devices for non-focal-plane (e.g. periscopes, vision blocks) and focusing (e.g. sights, cameras, sensors) optical devices on ground combat vehicles. Other potential military applications include laser safety eyewear for dismounted soldiers or laser safety visors for aviators. Potential commercial applications include improved welding shields, broadband industrial laser safety eyewear, optical data storage, and optical switching. The most likely Phase III transition path is integration of this technology into the unity vision periscopes on Future Combat Systems through coordinated effort with TARDEC, FCS Manned Systems Integration, and the FCS periscope designer.

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KEYWORDS: laser protection, non focal plane, optical limiting, optical, laser, optical attenuation

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A07-214 TITLE: Innovative Simulation and Analysis Tool for Vehicle Thermal Management

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Design and develop a predictive modeling and simulation tool for rapid thermal analysis in order to evaluate and optimize the performance of propulsion cooling systems in conventional and hybrid military ground vehicle.

DESCRIPTION: To provide assured mobility of the future force throughout the theater of operation a proper design of military vehicle cooling systems is vital since a deficient cooling system can immobilize the vehicle jeopardizing lives and mission success. This effort responds to the increasing heat loads military vehicles are experiencing due to additional armor, power upgrades, extremely hot environments, heat loads associated with hybrids and adverse operating conditions.

The overall goal of this project is to enhance the evaluation and optimization of propulsion cooling systems by developing a novel design and simulation tool for rapid thermal analysis and assessment of cooling system adequacy. The tool would be used for decision making purposes to facilitate design, reduce testing time, solve field problems, evaluate multiple approaches, conduct parameter studies and attain design cost-savings. Current methods for determining the capability of cooling systems are not automated and include a time and resource intensive process.

Combat and tactical vehicles undergo cooling system tests which capture data from cooling components to determine if the cooling system meets Army requirements. An innovative approach would complement the testing process in order to combine multi-dimensional analysis with smart testing to evaluate cooling system adequacy. The approach would also allow the analyst to select optimum components from multiple options to permit effective solutions from a time/cost basis and determine conformance with or establish specifications from the prediction of cooling system performance.

The Army would benefit from an innovative approach that is totally automated and has the ability to collect, analyze, store, retrieve, filter, fuse, and display information from a variety of sources in order to ensure that the right information reaches the right decision-makers in an actionable format in order to support superior decision-making. It is sometimes critical that analysts be able to access past information to derive maximum benefit from the current findings. The use of open architecture principles for future tool development is a desired feature.

Assessing the cooling system performance of existing and concept military vehicles within different environment and load scenarios is an essential aspect of the model. A method to simulate cooling system performance in a variety of combat and tactical vehicles under a number of different constraints, including transient, steady state, full load and full power, high ambient temperatures as well as other considerations faced in the military environment is a basic feature desired in the model.

A process for maintaining component and module libraries databases for available military vehicle resources would benefit the analyst. Thermal simulations will simplify complex inputs using completely automated preprocessing for component data. Given a known performance level, the performance prediction capability should quantify the expected amount of change in performance. Rapid and accurate analysis of heat exchanger options for multiple vehicle variants is critical in the evaluation and optimization process.

A major challenge is to provide the user with an approach that has the flexibility to assess combat and tactical, conventional and hybrid military vehicle cooling systems and can attain an effective balance between vehicle level, system level and component level evaluation capabilities while also meeting or exceeding high-speed operational effectiveness, cost, accuracy, reliability and maintainability goals.

The capability to perform at steady state and transient conditions assessing cooling system performance for several system design configurations in various warfighting scenarios is a plus. An innovative solution would incorporate graphical user interfaces (GUI) to allow an analyst the ability to support quick analysis trade studies early in the design process, determine solutions to conventional cooling systems field problems or optimize cooling system designs for future concept vehicles.

PHASE I: Conceptualize, design and demonstrate a prototype of an automated predictive modeling and simulation tool aimed at evaluating the capabilities of military vehicle propulsion cooling systems. The prototype should demonstrate the feasibility of evaluating and optimizing propulsion cooling systems complementing the testing process for military ground vehicles. Establish goals and metrics to validate and analyze the feasibility of the proposed solution(s). Provide a Phase II development approach and schedule that contains success criteria and key component technological milestones for product development.

PHASE II: Finalize the approach and fabricate the tool based on the results in Phase I. In a laboratory environment, perform baseline tests to validate the analytical tool(s) which factor in real world conditions, representative inputs/data and vehicle cooling requirements to demonstrate the viability of the product. Develop testing procedures to measure the effectiveness of the tool. For example, it is not known how the orientation of stacked heat exchangers at specific angles from vertical effect heat rejection, dust accumulation on fins, fan power variations and shroud/fan layouts when compared to heat exchangers positioned in the normal vertical orientation. Provide a detailed plan for software certification, final validation testing and method of implementation for the evaluation of propulsion cooling systems as applicable.

PHASE III: The end-state of this research will result in an effective tool to facilitate thermal management in conventional and hybrid military combat and tactical vehicles. Military vehicle cooling systems are experiencing increasing heat loads that cause cooling system degradation and ways must be found to evaluate and optimize current and future vehicle systems to ensure mobility. Vehicle cooling systems, such as the up-armored M1114 HMMWV that has experienced overheating in the field, may be evaluated and solutions identified through use of this tool. Concept vehicle cooling systems can be rapidly analyzed to assess cooling system adequacy. R&D engineering and testing efforts can use this technology to complement the testing process and support superior decision making. Successful lab testing will result in field testing to verify accuracy in a real world environment.

This technology has application in the automotive industry for the design of propulsion cooling systems. New vehicle designs as well as retrofits of systems in vehicles operating in more severe conditions than planned for world benefit from this technology. The concept developed in Phase I and II would be expanded in Phase III. The goal would be to work with Army and industry for certification and implementation of this technology with conventional and future combat and tactical vehicles. Private sector commercial potential lies in this technologies direct application to thermal management system of commercial vehicles.

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KEYWORDS: Propulsion Cooling Systems, Thermal Analysis, Modeling & Simulation, Heat Exchangers, Thermal Management, Engine Cooling Performance

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A07-215 TITLE: Develop Smart Material Technology for improved Protection of Vehicles

TECHNOLOGY AREAS: Electronics

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 new concepts and design methodologies for blast-protective structures that can be implemented on combat and light tactical vehicles for improved protection of crew and vehicles. Assess potential applications of the new technology and its commercial limitations

DESCRIPTION: Smart material represents a material that has one or more properties which can be significantly altered in a controlled fashion by external stimuli. Fundamental challenges in applying smart material and adaptive structure technologies to the vehicle protection problem are: 1) reaction speed, 2) available actuation force, and 3) energy supply. To protect a vehicle from blast, an active structure requires microseconds to react with sufficiently large force, which is relatively an impossible task with the existing techniques.

Smart material technology considered in this research is defined as a new class of material that can react to external excitations, such as vibration, crash, blast, and ballistic impact in a designed way to counter such excitations without an external energy supply and perform the desired action utilizing energy from the excitation. Based on their design with imbedded sensing mechanisms, smart materials will be able to reconfigure so to mitigate the damaging effect of threat. Smart materials and adaptive structures have been used increasingly in advanced military vehicles. Adaptive (smart, or active) structure represents a mechanical structure with the ability to alter its configuration, form, or properties in response to changes in the environment based on three integral components (sensors, processors, and actuators), besides the load carrying capacity. Three major differences between the proposed new reactive structure and a traditional active structure are; 1) it acts in a reactive way without requiring an external energy supply; 2) it can be destroyed for energy absorption or other predefined purposes; and 3) its post-damage behavior plays an important role in its functionality.

PHASE I: Identify and determine the feasibility of mitigating blast effects using smart material technology to protect vehicle occupants from the expected kinetic energy due to blast. Develop concepts of smart material structure for the underbelly of tactical vehicles which can change shape from normal to blast protective configuration in nanoseconds. The smart material structure shape will be designed to meet following criteria:
1) Optimize vehicle performance in normal working conditions;
2) Maximize protection against blast overpressure and fragment penetration, in blast protective mode.
Phase I deliverables should include interim progress reports and a final report outlining the down select methodology of the Phase I effort, and an assessment to phase II technical approach.

PHASE II: Based on the feasibility studies in Phase I, develop analytical and computational simulation code of such system. Also, develop a prototype test model of smart material structure system prepared for live demonstration against underbelly AP mines and small IED charge threats. Assess the potential to defeat larger mines and underbelly IED charges. Investigate the use against side attack mines, roadside IEDS and penetration type mines, and assess the capabilities beyond a single blast event.
Required Phase II deliverables will include; 1) interim progress reports, the prototype test model and a final report outlining the test procedures; 2) conclusions and the down select methodology of the Phase II studies, and an assessment to Phase III technical approach; 3) the computational simulation code of the developed system provided with the instructional manual and sample problems.

PHASE III: If this program is successful the technology can be applied to build a prototype model of smart material structure for demonstration against underbelly AP mines and small IED charges on a light tactical vehicle system.

Military Applications: Tithe smart material system would be useful for application on virtually all military ground vehicles especially those with minimal ground clearance. All ground vehicle programs within PEO CS&CSS, PEO GCS could have interest in such a smart material system to combat underbelly IED and landmines. The developed design methodologies and advanced adaptive structure concepts will provide direct benefits to U. S. Army future ground vehicle programs, such as FMTV, FTTS, and JLTV.

Commercial Applications: The technology will have potentials to enhance the aftermarket vehicles used by law enforcement, SWAT teams, bomb squads, and diplomatic officials. In Addition it may includes improved comforts and safety for the automotive and transportation industry along with reduction in weight and fuel consumption.

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A07-216 TITLE: Determination of Human Injury Mechanism, Mechanical Response and Tolerance for Improved Virtual and Physical Biomechanical Test Devices for Vehicle Crashworthiness Applications in Rollover Crash Scenarios

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: PEO Combat Support & Combat Service Support

OBJECTIVE: Define injury mechanisms, enhance adult injury assessment reference values and develop vehicle system and sub-system level test standards for implementation in both virtual (computer models) and physical test devices (crash test dummies) for use in the crashworthiness applications to assess injury risk in vehicle rollover crashes.

DESCRIPTION: The purpose of this Small Business Innovation Research (SBIR) is to enhance the existing injury criteria for automotive crash protection and to implement the findings in virtual computer models and instrumented physical test devices (crash test dummies). These sophisticated tools will help in better understanding of the injury risk in a wide variety of crash scenarios and help in developing effective occupant protection restraint systems. In particular, rollover crash events need to be addressed; they are complex because a multitude of factors could trigger such events [1]. So, when developing occupant protection safety restraints to be effective in rollover crashes, appropriate test devices or tools whether virtual or physical need to be utilized.

Current research indicates that harm to occupants in rollover crashes are mainly due to head and neck injuries [2, 3]. According to 2001 Fatality Analysis Reporting System (FARS), 10,138 people were killed as occupants in light vehicle rollover crashes, which represent 32% of the occupants killed that year in crashes. Of those, 8,407 were killed in single-vehicle rollover crashes [4]. Rollovers in the U.S account for less than 5% of all vehicle crashes (NHTSA 1999), but they contribute to approximately 15% of serious (AIS 3+) injuries and 20-25% of fatalities [5]. Despite significant ongoing research in this area [6], the injury assessment tools – computer models and crash test dummies – are currently inadequate to predict injury due to the complex loading in rollover crashes. One plausible reason is that there is typically a lag between research findings and commercialization of products for general public use. The head injury currently is assessed based on Head Injury Criteria (HIC), which takes into consideration only linear head acceleration values in the calculations and is suited for mostly frontal collisions using a Hybrid III Anthropomorphic Test Device (ATD). However, the criteria needs to be critically reviewed for complex loading other than longitudinal (frontal) and enhanced if needed for rollover crashes. The HIC for the Hybrid III ATD was developed using data originally generated by Hodgson and Thomas [7] of Wayne State University (WSU). Embalmed cadaver heads were dropped from certain heights on a variety of rigid and padded surfaces and responses such as peak force, acceleration were obtained as a function of height.

Similarly, other body regions of the human surrogates, such as neck, thorax and lumbar need to be enhanced to produce improved injury risk assessment values. For instance, a better understanding of cervical spine injuries needs to be established. Also injury criteria for thorax is based on blunt impact experimental data, but seat belt loading, which is more concentrated, could initiate injuries that are unlikely to be captured with the current human surrogate assessment tools. The findings need to be translated to mechanical responses to be incorporated into Hybrid III ATD and computer models. These advanced tools will be beneficial in designing safer vehicles for occupants involved in vehicle crashes.

Now, the Federal Motor Vehicle Safety Standards 208 (FMVSS 208 -Occupant Crash Protection) specifies injury criteria for head, neck and thorax and femur for frontal vehicle crash of impact speeds up to 35-mph into a fixed rigid barrier. It is intended that with this SBIR effort, enhanced injury criteria will be developed for rollover crashes also.

Another relevant aspect with regard to rollover crashes is the development of vehicle system level and sub-system level test standards. Government test regulations to evaluate occupant protection in rollover crashes do not exist currently. In the U.S, the 208 Dolly test (SAE J2114) is commonly used to evaluate rollover crash safety. In view of the many pre-crash conditions that lead to a variety of rollover crashes [8, 9], there is a vital need for vehicle level and sub-system level standardized test procedures.

This SBIR is intended to generate research efforts to develop more advanced injury criteria and to implement the biomechanical responses into human surrogates for injury risk assessment in virtual and physical assessment tools.

PHASE I: Conduct an epidemiological review for occupant injury (occupant size, type, body region, severity, causation, occupied position, vehicle type, and so on) from soldiers involved in military ground vehicle rollover crashes. Conduct a literature search and review human injury mechanism and tolerance and critically review the found data for appropriateness for injury risk assessment in rollover crashes. Access to the Government Furnished Information (GFI) from relevant sources within the Department of Defense organizations, such as ARI-SLAD, USAARL, NAWC Pax River and Natick Soldier Center will be coordinated along with the HQ USAMRMC by the sponsoring unit, TARDEC.

Identify existing tools - virtual and physical test devices - and critically evaluate their applicability for injury risk assessment in rollover crashes. Identify current rollover test procedures and their shortcomings and develop a plan to reconcile the various rollover crash modes to a limited set of vehicle level and/or sub-system level standardized rollover test procedures for application in military vehicles.

PHASE II: Based on the research efforts and an understanding gained in Phase I, a systematic approach should be undertaken to validate the hypothesis/hypotheses established. Develop new or modify existing analytical math-based tools, such as lumped-parameter method (LPM) and/or finite element (FE) method to assess dominant injury mechanisms observed in the field. Validate the math-based models to show correlation to field data and/or laboratory tests for injury causation and mechanism for pivotal and selective cases. Subsequently, develop new metrics for injury mechanism and tolerance for occupant protection in rollover crashes. In addition, identify and recommend enhanced instrumentation for the ATD to capture the injury mode and mechanism. Also, recommend a physical test procedure or a suite of physical test procedures – sub-system or full-system - based on studies conducted using math-based models to evaluate occupant injury protection in rollover crashes. Determine influence on occupant injury values with and without safety restraint systems. The outcome of Phase II effort shall be the injury assessment reference value(s), the injury assessment tool(s) (virtual ATD), virtual model of the sub-system/full-system test configuration(s), recommendations for improved instrumentation for existing ATD (physical test device) and the recommendations for physical test procedure(s).

PHASE III: The tools developed in the Phase II effort will be utilized by the crashworthiness community (Government and industry) to evaluate ground vehicle occupant crash protection in rollover crash events. The collaborative effort is intended to lead to a rollover crash occupant protection test standard proposal with automotive industry wide application. The Phase III effort will consist of the validation of the tools and procedures and an effort to gain acceptance as a Government and industry standard by Department of Defense, National Highway Transportation Safety Administration, Society of Automotive Engineers and the Insurance Institute of Highway Safety.

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KEYWORDS: Human Injury Mechanism, Biomechanical Response, Human Injury Tolerance, Anthropomorphic Test Devices, Finite Element, Lumped Parameter, Computer-Aided-Engineering Models, Vehicle Crashworthiness, Vehicle Crash Safety, Occupant Crash Protection, High Speed Dynamic Events

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A07-217 TITLE: Self Contained Two-Phase Thermal Management System

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PEO Ground Combat Systems

OBJECTIVE: Develop a self contained, two-phase thermal management system capable of dissipating at least 3.0 kW of waste heat.

DESCRIPTION: Two-phase thermal management technologies have been identified as a potential solution for electronics thermal management issues in next generation ground vehicles. They provide many advantages over the traditional single phase systems. The biggest advantage of a two-phase system over a single phase liquid system is the substantially higher heat transfer coefficient or lower thermal resistance in the evaporators. Typical two-phase evaporators have heat transfer coefficients an order of magnitude greater than traditional liquid cooled cold plate solutions. Another advantage of the two-phase system is the substantially lower flow rate requirement, mainly due to the large heat of vaporization of the working fluid.

An innovative solution is required to produce a two-phase thermal management system capable of point cooling multiple heat sources while maintaining scalability and low power consumption. The system will be required to dissipate at least 3.0 kW of total waste heat generated from a minimum of four discrete locations. The surface area of each location will be between 25.4 cm2 and 30.5 cm2. A thermal bus may or may not be used. The device will not be able to access the vehicle cooling loop and will require an innovative method to dissipate the waste heat to a desired ambient range of -51oC to +60oC. The interface temperature between the evaporator and electronics will be required to be maintained at a maximum of 75oC. The cooling device will be able to interface directly with the electronics.

The proposed solution may be active, passive or both with the goal of maximizing the efficiency of energy transportation compared to energy consumption over the operating temperature range. The system must be of minimum weight and volume and be modular for future requirements. The system must be capable of being externally mounted and be tolerant of the relatively harsh environment of a military combat vehicle. The system should be able to function under conditions of shock and vibration encountered in off-road mobility operations.

The development of this technology would benefit both the Army and the commercial automotive industry. It addresses the current and future electronics thermal management issues of combat vehicles and can be applied to electric vehicles in the commercial realm.

PHASE I: Goals for phase I should include a feasibility demonstration (e.g. concept analysis and subscale experiment) of the proposed thermal management concept, address integration issues, and provide sufficient analysis to demonstrate system level payoffs.

PHASE II: Goals for phase II should include sufficient demonstration of the proposed thermal management concept to show integration viability into a vehicle platform. This should be accomplished by building a prototype system and testing it in a relevant environment. Another objective of the phase II program is to elevate the Technology Readiness Level of the proposed solution to Level 5 (component and/or breadboard validation in a relevant environment).

PHASE III: Goals for phase III include the development of a system that is applicable to various heat sources including electronics, power electronics, and other distributed vehicular loads. This system would primarily be utilized externally on legacy and future combat vehicles to remove waste heat from electronics. It could also be used as an internal solution where access to the vehicle cooling loop is not possible. If this technology is proven successful it should have a relatively easy transition into the field. It would be able to be integrated into existing systems to provide waste heat removal on an as needed basis. There would be several potential funding agencies for phase III, including several PM offices, TARDEC Research Business Group, and major Government contractors. On the commercial side, this technology has the potential to benefit many sectors including automotive, aerospace and power and energy generation.

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A07-218 TITLE: Nano-material Conducting Wires With Enhanced Electric/Thermal Conductivity and Mechanical Strength

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop nano-material conducting wires that have enhanced electrical/thermal conductivity and mechanical strength for functionality improvement.

DESCRIPTION: Future Army vetronics will require all of its electrical and electronic components to operate at higher efficiencies with reduced dimension so that the devices can be further miniaturized. Therefore, all electrical cables, wires, circuit leads and contacts/interconnects need to have improved electrical and thermal conductivity, as well as mechanical strength at a high current density. Traditional methods used to strengthen metals, such as alloying, dislocation hardening, phase transformation hardening, etc., cause a pronounced decrease in electrical conductivity, requiring a tradeoff between conductivity and mechanical strength. Research indicates that nano-grained pure copper, with a higher density of nano-scale growth twins, provides a tensile strength about 10 times higher than conventional coarse-grained pure copper. Furthermore, the nano-grained pure copper retained an electrical conductivity comparable to that of pure copper. The finding provides a new opportunity for Army vetronics applications.

PHASE I: 1) Investigate the unusual conductivity of nano-sized metals that show promising properties for significantly improving the mechanical properties of copper-based conductors without sacrificing conductivity; 2) Develop a material processing technique for producing nano-copper materials at various dimensions from tenths of a micrometer to several millimeters at an affordable cost so that mass production of such materials for Army applications is viable. Phase I deliverables should include incremental progress reports and a final report outlining the down select methodology of the Phase I effort, and a roadmap of how Phase II will be executed.

PHASE II: The Phase I technique will be implemented and the production of copper wires with improved mechanical strength (via nanotechnology) and no loss in conductivity will be demonstrated. An Army vehicle electrical component shall be produced to demonstrate the applicability of the new technique. Finally, the offeror shall build a prototype electrical system, including items such as motors, electro-magnetic coils/sensors, and electronic interconnects, to completely verify the methodology developed during Phase I. Phase II deliverables should include the prototype electrical system and a final report outlining the test and validation procedures of the Phase II effort.

PHASE III: Phase III will include application of advanced nano-material wiring into a system-level military application such as JLTV rollover safey sensing or a commercial application such as freight railcar weight sensing. This effort will further demonstrate both the military and commercial applications (i.e. sensor wiring and diagnostic wiring for condition-based maintenance). The project would provide significant potential to the Army and the commercial automotive Industry. Primary sources of additional Government funding in Phase III could include PEO-CS/CSS or PM-FTS. The concept of transitioning this technology into operational use is as an enabler for further miniaturization from macro-scale electronics to micro- and nano-level scale.

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